Appendix 2- Technical Reports

Appendix 2.1.1 SL/001 and SL/002 Milltimber Charcoal Analysis - Angela Walker and Catherine Longford

Introduction

Milltimber (SL/001 and SL/002) spanned the north and south banks of the River Dee and formed part of a landscape that has been extensively utilised, occupied and settled throughout the span of human presence in the area. Charcoal analysis was undertaken on 657 fragments from 78 samples, taken from a range of features dating to from the Mesolithic to the Historic periods.

Methodology

Charcoal and charred plant remains were extracted from bulk soil samples processed by flotation in a Siraf-style flotation tank. The floating debris (flot) was collected in a 250 µm sieve and, once dry, scanned using a binocular microscope. Any material remaining in the flotation tank (retent) was wet-sieved through a 1mm mesh and air-dried.

The following criteria were considered when selecting charcoal samples for species identification:

- Those that contained fragments of a size suitable for identification
- Type and security of the context, feature or stratigraphy

A minimum of 10 charcoal fragments were randomly selected from each sample for species identification with a minimum fragment size of 2mm.

Wood charcoal fragments were fractured manually, and the resultant anatomical features observed in transverse (TS), radial (RLS) and tangential planes TLS), using high power binocular reflected light (episcopic) microscopy at magnifications of x 50, x 100 and x 400. Identification of each fragment was carried out to as high a taxonomic level as possible by comparison with material in the reference collections at the Department of Archaeology, University of Sheffield and various reference works (eg Schweingruber 1978, 1990; Hather 2000). Where possible a record was made, of the ring curvature of the wood as well as details of the ligneous structure, in order to determine the part of the woody plant which had been burnt and the state of wood before charring (Marguerie & Hunot 2007).

Certain genera, for example gorse (Ulex sp.) and broom (Cytisus sp.) or members of the Maloideae sub family; hawthorn (Crataegus sp.), apple (Malus sp.), rowan, service tree and whitebeam (Sorbus sp.) etc, cannot be distinguished on the basis of wood anatomy and so are recorded as Ulex/Cytisus or Maloideae (Hather 2000).

The charcoal was also examined for evidence of biological degradation in the form of fungal hyphae. It was also inspected visually for any irregular patterns of channels which could result from boring insect or woodworm degradation (Marguerie and Hunot 2007).

Results

Tables showing the charcoal data and analysis undertaken can be found within the environmental excel file.

Mesolithic

Charcoal analysed derived from four pits: [2C-0143], [2D-1008], [2D-1092] (recut in 1127), [2D-1117] (recut in [2D-1089]) and one hearth: [2D-1715].

The charcoal assemblage from the pits was predominantly hazel (Corylus sp.) and birch (Betula sp.). Variations in species present can be observed in pit [2C-0143] which contained maple (Acer sp.) and willow (Salix sp.) and a low number of birch fragments. Pit [2D-1008] comprised birch only and pit [2D-1117] was predominantly gorse/broom (Ulex/Cytisus) with rare fragments of hazel (Corylus sp.). Ring curvature of the fragments from all pits assessed ranged from moderately curved rings to weakly curved rings which suggest the use of a larger calibre of wood for example larger branches or possibly trunks.

The assemblage from hearth [2D-1715] was predominantly hazel with rare fragments of Maloidae. The weak ring curvature on fragments of both taxa suggests that larger branches or trunks were utilised.

Early and Middle Neolithic

Charcoal analysis was undertaken on deposits from pits, hearths, a post pit and a post-pipe.

The charcoal assemblage from pits [2D-1575], [2D-1267], [2D-1137] were predominantly hazel and oak (Quercus sp.) with rare birch. Ring curvature of the fragments included moderately curved rings and weakly curved rings which suggest the use of branches or possibly trunks.

The charcoal assemblages from the three hearths assessed were all different in terms of species composition and type of wood used. Hearth [2D-1234] comprised hazel with rare oak. The predominance of fragments with moderately curved rings indicates the use of a larger calibre of wood ie branches. Hearth [2D-1638] was predominantly hazel with rare fragments of gorse/broom, birch and oak (Quercus sp.). The ring curvature on the fragments indicates the use of branches. The assemblage from hearth [2D-1210] was primarily plum/cherry (Prunus sp.) with rare hazel. The ring curvature of the fragments suggests that smaller branches/twigs of plum/cherry were used.

Pit [2D-1714] was predominantly willow (Salix sp.) with rare occurrences of hazel and oak. The ring curvature of the fragments suggest the use of smaller willow twigs and branches and larger branches of hazel and oak.

Post-pipe within post-hole [2D-1433] comprised larger branches and potentially trunk of oak.

Late Neolithic/Chalcolithic

Charcoal analysed derived from post-pipes and a pit.

The charcoal assemblages from post-pipe within post-hole [2C-0135] and post-hole [2C-0157] comprised oak with a weak ring curvature indicating the use of larger wood sections such as branches or trunk whereas the remnant of post-pipe in [2C-0154] was predominantly gorse/broom with rare occurrences of oak and heather (Calluna vulgaris). Ring curvature suggests the use of smaller twigs/branches of heather and gorse/broom and larger branches of oak.

The charcoal from pit [2C-0075] comprised fragments indicative of larger branches and potentially trunk of oak.

Bronze Age

The charcoal from pit [2C-0127] comprised fragments indicating the use of mixed sizes of twig and branches of birch.

Roman

A total of 88 features relating to Roman activity were recorded at Milltimber; these features were interpreted as ovens. Charcoal analysis was undertaken on 57 samples from 41 ovens. The ovens were classified into 13 groups with two additional ovens classed as outliers. The 13 groups were then further grouped together based on their location.

Ovens cut into the western bank of palaeochannel - Group 1 (A7-A10), Group 3 (B18-B21), Group 4 (B13-B17), Group 6 (B1-B4, B9-B12), Group 12 (F5-F19), Group 13 (G1, G2, G4, G7, G8).

The ovens in this area were dominated by heather and gorse/broom with occasional oak, hazel and birch as well as rarer occurrences of plum/cherry, alder (Alnus sp.) and Maloideae. Ring curvature observed on the fragments demonstrated a diversity of wood sizes amongst the species represented. Large branches/possible trunk are represented in the fragments of oak, hazel, birch, alder and gorse/broom. Smaller twig/branches were observed in birch, gorse/broom and heather.

A total of 12 ovens from this area yielded multiple contexts which were interpreted as separate firing events. The ovens with multiple events derived from across the groups located within this area.

Fill (2A-0022) from Oven B13 [2A-0130] (Group 4) contained charcoal fragments of birch and oak. The ring curvature if the fragments suggested the use of larger branches/possibly trunk. Context (2A-1160) comprised fragments suggesting the use of larger branches/possibly trunk of birch and gorse/broom and smaller twigs/branches of heather.

Fill (2A-0052) from Oven B20 [2A-0044] (Group 3) comprised gorse/broom of mixed sizes ranging from small twigs to larger branches whereas context (2A-0062) included large branches/possible trunk of oak and birch with larger branches of hazel and plum/cherry.

The charcoal from sampled contexts (2A-0105) and (2A-0108) from Oven B21 [2A-0095] (Group 3) comprised entirely oak ranging from small branches to larger branches/possibly trunk.

The charcoal assemblage from sampled contexts (2A-0124) and (2A-0125) from Oven B14 [2A-0131] (Group 4) contained gorse/broom and heather. Ring curvature of the fragments indicated the use of small twig/branches of heather and larger branches of gorse/broom.

Oven B15 [2A-0132] (Group 4) provided samples from two contexts; (2A-0139) and (2A-0141), both of which produced fragments of heather charcoal only. The ring curvature indicated the use of small twigs/branches.

Oven B17 [2A-0148] (Group 4) yielded three sampled contexts (2A-0149), (2A-0153) and (2A-0123) all of which contained heather charcoal only. The ring curvature of the fragments suggested small twigs were utilised.

Oven B9 [2A-0076] (Group 6) comprised sampled three contexts; (2A-0079) contained charcoal of Maloidae and heather, context (2A-0081) comprised fragments indicating small twig/branches of heather and larger branches/possibly trunk of birch and plum/cherry, and context (2A-0083) contained charcoal of small twig/branches of heather and larger branches of birch.

Oven B10 [2A-0021] (Group 6) had two contexts sampled; (2A-0024) and (2A-0027). Context (2A-0024) contained charcoal representing small twig/branches of heather and larger branches of gorse/broom. In contrast fill (2A-0027) contained charcoal representing larger branches of hazel, plum/cherry and oak as well as small twig/branches of heather.

Oven F6 [2B-2061] (Group 12) contained two sampled contexts. Context (2B-2240) comprised charcoal fragments representing larger branches/possibly trunk of hazel, and oak with small twig/branches of heather, whereas fragments from context (2B-2242) were predominantly larger branches/possible trunk of oak and small twigs/branches of heather.

Oven F17 [2B-2123] (Group 12) yielded samples from three contexts. Context (2B-2131) comprised fragments indicating larger branches/possibly trunk of alder and birch with smaller branches of gorse/broom. Context (2B-2136) was predominantly larger branches of birch with small twig/branches of heather and Context (2B-2139) comprised twig/branches of heather and larger branches of gorse/broom.

Two contexts were sampled from Oven F19 [2B-2151] (Group 12). Context (2B-2177) comprised fragments of large branches/trunk of birch and mixed branch sizes of gorse/broom, whereas Context (2B-2180) contained fragments indicating mixed sized branches of hazel, gorse/broom and heather.

Two contexts from Oven G7 [2B-2182] (Group 13) were samples; (2B-2185) and (2B-2191). Both contexts contained charcoal fragments of gorse/broom and heather. Ring curvature of the fragments indicates the use of mixed sized twig/branches of both species.

Ovens cut into the flat sands south of palaeochannel - Group 7 (C1-C10)

The ovens from this group and area primarily contained oak and birch with hazel and gorse/broom. Ring curvature suggests a preference of larger branches and possible trunk of oak and birch, with smaller branches of hazel and gorse/broom.

Oven cut into north-east bank of palaeochannel - Group 8 (D6)

Oven D6 [2B-2036] was predominantly oak with rare occurrences of heather and alder. Ring curvature suggests the use of larger branches of oak and alder with smaller branches/twig used of heather.

Ovens cut into the southern bank of palaeochannel - Group 10 (E1-E4)

The ovens in this group predominantly comprised birch and oak with occasional heather. Observation of the ring curvature on the fragments indicated the use of small branches/twig of heather and larger branches possibly trunk of birch and oak.

Two contexts were sampled from Oven E4 [2B-2076] (Group 10). Context (2B-2078) comprised fragments indicating the use of larger branches/possibly trunk of birch and oak with small twig/branches of heather, and Context (2B-2080) attested the use of mixed sized branches of birch and oak.

Ovens cut into the north and south-eastern banks of palaeochannel - Group 11 (Ovens E6 and E9)

Charcoal from Oven E6 [2B-2327] comprised birch, hazel, heather and gorse/broom. Ring curvature on the fragments suggests the use of twig/small branches of heather and larger branches of gorse/broom, hazel and birch.

Oven E9 [2B-2026] comprised fragments indicating large branches/possibly trunk of Oak.

Ovens cut into the earlier ditch [2B-2075] - Group 2 (Ovens A1-A6), Group 5 (Ovens A11-A15)

The dominant species in the ovens cut into ditch [2075] was heather (Calluna vulgaris), followed by oak and hazel with rarer occurrences of birch. The ring curvature exhibited on the fragments suggests the use of larger branches of oak and mixed size branches/twig (large, medium and small) of hazel and heather.

Charcoal from the two sampled contexts (2B-2014) and (2B-2019) from Oven A5 [2B-2009] (Group 2) was entirely comprised of twig/small branches of heather.

Oven A11 [2B-2025] (Group 5) provided samples from two contexts. Context (2B-2047) comprised fragments of hazel twig and Context (2B-2049) contained fragments indicating the use of birch and hazel branches.

Ovens to the north

Oven B5 [2B-2516] comprised fragments indicating larger branches of birch. Oven [2C-0106] was predominantly heather with a rare occurrence of birch. Ring curvature suggests the use of smaller twig/branches of heather and larger branches of birch.

Early Historic

Charcoal analysed derived from two pits and a kiln.

Pit [2C-0009] was primarily hazel with rare occurrence of willow. The ring curvature on fragments of both species suggest the use of larger branches possibly trunks. Pit [2B-0105] comprise hazel with a rare occurrence of birch. The ring curvature on fragments indicates the use of small branches /twigs of hazel and larger branches of birch.

Charcoal from kiln [01-0015] was predominantly hazel with rarer occurrences of birch and oak. The ring curvature suggests the use of both small and larger twigs/branches of hazel and birch but the use of a larger calibre of wood when using oak.

Discussion

The Mesolithic charcoal assemblage was principally hazel and birch with rarer occurrences of willow, gorse/broom and hazel. The species present in the assemblage is in keeping with vegetation characteristics highlighted in pollen analyses undertaken at Nethermills (Ewan 1981).

The Neolithic charcoal assemblage was characterised by hazel and oak while the Neolithic/Chalcolithic was predominantly oak with low occurrences of gorse/broom. The charcoal assemblage derived from the Bronze Age pit was composed of birch.

The charcoal assemblage from the Roman ovens as a whole indicates the utilisation of a wide range of species and wood types ranging from small twigs to large branches/possible trunks. Given the distribution of the ovens within the Milltimber landscape the foremost question concerning the ovens relates to whether there is sufficient evidence in the charcoal assemblage to distinguish deliberate species selection for fuel from opportunistic foraging of available local resources. While it is apparent that some species dominate the charcoal assemblages more than others and that a small number of ovens contain evidence of only having utilised a single species for fuel, there is nothing to suggest that this selection is anything other than the practical utilisation of the available resources within the immediate vicinity of the ovens. This conclusion is further supported when taking into consideration the nature of the Milltimber landscape. The woodland vegetation around the palaeochannels would still have been influenced by altitude, climate change, pedogenesis and fluvial activity and so the landscape in this period would still have been susceptible to oscillations in woodland density and species present, the area at this time would also have featured the addition of heather moorland (Tipping, 1994).

The charcoal indicates the presence of fungal hyphae on a number of the fragments analysed which indicates the use of deadwood as opposed to fresh green wood. The use of deadwood was not confined to a single species but was present in a range of species from a number of ovens across all groups. The presence of deadwood in the charcoal assemblages from the ovens again suggests the practice of opportunistic foraging of available local resources.

Fifteen ovens spanning eight groups contained multiple contexts that were interpreted as separate firing events. Analysis of the charcoal from a number of these firing events revealed a number of different fuel types used and, in some cases, revealed a difference in species use between firings in individual ovens. There is no reason to suggest that this indicates more than the utilisation of the available resources in the surrounding environment.

The Roman ovens at Milltimber shared similar physical characteristics, such as size and shape, to those of a similar date excavated at the site of Kintore, Aberdeenshire (Cook et al 2008). Interestingly the charcoal data from Kintore suggested the construction of an alder superstructure to the ovens which may have been covered with turves, though there was no evidence to confirm the latter. It was argued that this type of construction would have acted as insulation and a windbreak during cooking. Alder was recorded in only two of the Milltimber ovens (Oven F17 [2B-2123] and Oven D6 [2B-2036]) and in such small numbers as to dismiss the idea of an alder superstructure to the ovens. The majority of the ovens were cut into the banks of the palaeochannel and so it is therefore possible that this would have enabled to bank itself to act as a windbreak for the ovens and would have negated the need for an alder superstructure.

The charcoal assemblage from the features dating to the Historic period were predominantly hazel and birch.

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Appendix-2.1.2 AMA09 Milltimber Charcoal Analysis – Angela Walker and Karen Stewart

Introduction

As part of the archaeological mitigation for the construction phase of the road scheme an additional area of 23,410m² was stripped of topsoil under archaeological supervision at Milltimber. The excavation area was split into three arbitrary zones surrounding an area (SL/002D) that had previously been the subject of archaeological investigation as part of the AWPR road scheme. As a whole these additional areas contained over 60 archaeological features including over 50 pits or post-holes and 9 linear cuts. Forty-four bulk sediment samples, ranging in size from two to 40 litres, recovered during excavation were subject to an initial assessment (Giorgi 2017) to determine the suitability of the material for analysis. Charcoal analysis was undertaken on 90 fragments from nine samples from a range of features dating from the Mesolithic and Neolithic.

Methodology

Charcoal and charred plant remains were extracted from bulk soil samples processed by flotation in a Siraf-style flotation tank. The floating debris (flot) was collected in a 250 µm sieve and, once dry, scanned using a binocular microscope. Any material remaining in the flotation tank (retent) was wet-sieved through a 1mm mesh and air-dried.

The following criteria were considered when selecting charcoal samples for species identification:

- Those that contained fragments of a size suitable for identification
- Type and security of the context, feature or stratigraphy

A minimum of 10 charcoal fragments were randomly selected from each sample for species identification with a minimum fragment size of 2mm.

Wood charcoal fragments were fractured manually, and the resultant anatomical features observed in transverse (TS), radial (RLS) and tangential planes TLS), using high power binocular reflected light (episcopic) microscopy at magnifications of x 50, x 100 and x 400. Identification of each fragment was carried out to as high a taxonomic level as possible by comparison with material in the reference collections at the Department of Archaeology, University of Sheffield and various reference works (e.g. Schweingruber 1978, 1990; Hather 2000). Where possible a record was made of the ring curvature of the wood as well as details of the ligneous structure, in order to determine the part of the woody plant which had been burnt and the state of wood before charring (Marguerie & Hunot 2007).

Certain genera, for example gorse (*Ulex* sp.) and broom (*Cytisus* sp.) or members of the Maloideae sub family; hawthorn (*Crataegus sp.),* apple *(Malus* sp.), rowan, service tree and whitebeam (*Sorbus sp*.) etc., cannot be distinguished on the basis of wood anatomy and so are recorded as *Ulex/Cytisus* or Maloideae (Hather 2000).

The charcoal was also examined for evidence of biological degradation in the form of fungal hyphae. It was also inspected visually for any irregular patterns of channels which could result from boring insect or woodworm degradation (Marguerie and Hunot 2007).

Results

Mesolithic

Charcoal analysed derived from five pits; [AMA09-2028], [AMA09-2149], re-cut [AMA09-2268], [AMA09-2164] and [AMA09-2241]. Pits [AMA09-2164] and [AMA09-2149] contained oak (*Quercus* sp.) charcoal only. The ring curvature of the fragments from pit [AMA09-2164] suggests the use of larger branches (possibly trunk). Pits [AMA09-2028] and [AMA09-2241] were predominantly hazel (*Corylus* sp.) with a low number of fragments of oak in pit [AMA09-2028]. Ring curvature of the fragments suggests the use of smaller branch wood of hazel and slightly larger branches of oak. The charcoal from pit re-cut [AMA09-2268] was predominantly linden (*Tilia* sp.) with a low number of fragments of hazel and willow/poplar (*Salix* sp./*Populus* sp.).

Neolithic

The charcoal assemblage dating to the Neolithic derived from 4 features; post-hole [AMA09-2011], hearth [AMA09-2078] and Pits [AMA09-2080] and [AMA09-2018].

Charcoal from pits [AMA09-2080] and [AMA09-2018] and post-hole [AMA09-2011] was predominantly oak with a low number of fragments of hazel in post-hole [AMA09-2011] and pit [AMA09-2018], and alder, linden and elm (*Ulnus* sp.) in pit [AMA09-2080]. Ring curvature of the fragments suggests the use of hazel branch wood and larger branches (possibly trunk) of oak.

The charcoal from hearth [AMA09-2078] was predominantly hazel with ring curvature suggesting the use of a range of wood sizes from twigs to possible trunks.

Discussion

The charcoal assemblage from the Mesolithic pits comprised hazel branch wood and a larger calibre of oak wood. Also present but in smaller numbers were fragments of linden and willow/poplar. The assemblages from the individual pits appear to show a dominance of a particular species type for different pits, for example pits [AMA09-2164] and [AMA09-2149] contained oak only, pit re-cut [AMA09-2268] was predominantly linden and pits [AMA09-2028] and [AMA09-2241] were mostly hazel. It is likely that this pattern reflects the utilisation of the available local resources within the vicinity of the pits rather than individual species being selected for a specific purpose/use.

Charcoal from the Mesolithic pits recorded during the previous excavation work at Milltimber (Areas SL/002C and SL002D) was principally hazel and birch with rarer occurrences of willow and gorse/broom. The charcoal assemblages from the Mesolithic pits from the various excavation areas (AMA09, SL/002C, SL/002D) did not contain sufficient diagnostic material to suggest a function for the pits.

The Neolithic charcoal assemblage displayed a similar pattern to the Mesolithic assemblage, with certain species appearing dominant in particular features. For example, charcoal from pits [AMA09-2080], [AMA09-2018] and post-hole [AMA09-2011] were predominantly oak and hearth [AMA09-2078] was predominantly hazel. Post-hole [AMA09-2011] and pit [AMA09-2018] also contained low concentrations of hazel and Pit [AMA09-2080] contained alder, linden and elm.

The presence of these species in the Mesolithic and Neolithic charcoal assemblages are in keeping with the data from pollen analyses (Timpany 2012) and regional reviews by Tipping (1994) and indicates continued exploitation of available local resources throughout both periods of occupation.

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Appendix-2.1.3 SL/003B Nether Beanshill Wood Charcoal Analysis – Laura Bailey and Angela Walker

Nether Beanshill (SL/003B) comprised two areas of broadly contemporary Middle Bronze Age activity; a roundhouse and associated enclosure in the south-west, and a cremation complex in the north. Charcoal analysis was undertaken on 190 charcoal fragments from 19 samples from features directly associated with burning activities.

Methodology

Charcoal and charred plant remains were extracted from bulk soil samples processed by flotation in a Siraf-style flotation tank. The floating debris (flot) was collected in a 250 µm sieve and, once dry, scanned using a binocular microscope. Any material remaining in the flotation tank (retent) was wet-sieved through a 1mm mesh and air-dried.

The following criteria were considered when selecting charcoal samples for species identification:

- Those that contained fragments of a size suitable for identification
- Type and security of the context, feature or stratigraphy

A minimum of 10 charcoal fragments were randomly selected from each sample for species identification with a minimum fragment size of 2mm.

Wood charcoal fragments were fractured manually and the resultant anatomical features observed in transverse (TS), radial (RLS) and tangential planes TLS), using high power binocular reflected light (episcopic) microscopy at magnifications of x 50, x 100 and x 400. Identification of each fragment was carried out to as high a taxonomic level as possible by comparison with material in the reference collections at the Headland Archaeology and various reference works (e.g. Schweingruber 1978, 1990; Hather 2000). Where possible a record was made, of the ring curvature of the wood as well as details of the ligneous structure, in order to determine the part of the woody plant which had been burnt and the state of wood before charring (Marguerie, & Hunot 2007).

Certain genera, for example gorse (*Ulex* sp.) and broom (*Cytisus* sp.) or members of the Maloideae sub family; hawthorn (*Crataegus sp.),* apple *(Malus* sp.), rowan, service tree and whitebeam (*Sorbus sp*.) etc., cannot be distinguished on the basis of wood anatomy and so are recorded as *Ulex/Cytisus* or Maloideae (Hather 2000).

The charcoal was also examined for evidence of biological degradation in the form of fungal hyphae. It was also inspected visually for any irregular patterns of channels which could result from boring insect or woodworm degradation (Marguerie and Hunot 2007).

Results

The features sampled were associated with two areas of broadly contemporary activity and the results from the charcoal analysis are presented according to the activity area they were associated with.

Roundhouse and associated enclosure

Features sampled from the roundhouse structure included fills from slots excavated through ring-ditches [3B-0306] and [3B-0307] as well as the fills of two post-holes [3B-0130] and [3B-0138].

Charcoal analysis was undertaken on fragments from six contexts from five slots excavated across ring-ditch [3B-0306] and one context from one slot from ring-ditch [3B-0307]. The most commonly occurring species from these contexts was hazel. The ring curvature of the fragments indicated the use of twig/small branches. Other species present in ring-ditch [3B-0306] included heather twig in fill (3B-0034) of slot [3B-0032], small/medium branches of alder in fill (3B-0034) of slot [3B-0032], fill (3B-0127) of slot [3B-0125], birch twig in fill (3B-0127) of slot [3B-0125] and oak twig/medium branches in fill (3B-0091) pf slot [3B-0088]. In addition to hazel twig, fill (3B-0031) of slot [3B-0030] through ring-ditch [3B-0307] also contained fragments indicating medium alder branches.

The sample from fill (3B-0131) of post-hole [3B-0130] contained charcoal fragments indicating the use of medium sized branches of hazel with alder, oak and Maloidae. The sample from fill (3B-0139) of post-hole [3B-0138] comprised hazel twig.

Cremation complex

The cremation complex comprised a central cremation burial, surrounded by a miniature ring-ditch. Features sampled from the cremation complex included slots excavated through two ring ditches; [3B-0005] and [3B-0043], two pits; [3B-0036] and [3B-0132] and three cremation related pits; [3B-0003], [3B-0104] and [3B-0100].

The charcoal assemblages from ring ditches [3B-0005] and [3B-0043] were predominantly alder with smaller proportions of hazel. The ring curvature visible on the fragments indicated the use of twig and small branches of both species.

Pits [3B-0036] and [3B-0132] yielded charcoal assemblages similar to that of the ring ditches with a predominance of alder with rarer numbers of hazel. Ring curvature suggests the use of hazel twig but medium sized branches of alder. The assemblage from ring-ditch [3B-0005] also contained willow twig.

The charcoal assemblages from the cremation related pits [3B-0003], [3B-0104] and [3B-0100] were similar in composition to those from both the ring ditches and the pits with a predominance of alder and lower numbers of hazel. As with the fragments from the pits the ring curvature from charcoal fragments from the cremation related pits indicated the use of medium sized alder branches and hazel twig. The assemblage from cremation related pit [3B-0100] also included fragments of a medium sized oak.

Discussion

The wood charcoal assemblages from both the roundhouse and the cremation complex were primarily composed of alder and hazel with rare occurrences of birch, oak, heather, willow and Maloidae.

Observation of the physical characteristics of the charcoal indicates the presence of fungal hyphae on a number of the fragments analysed which indicates the use of deadwood as opposed to fresh green wood. The use of deadwood was not confined to a single species but was present across all features in both areas of activity. The presence of deadwood in the charcoal assemblages suggests the practice of opportunistic foraging of available local resources.

Problems arise when trying to reconstruct the nature of the local vegetation during the Bronze Age at Nether Beanshill. There are no pollen records that cover the immediate environs of the site, the nearest record being 40km west from the Howe of Cromar, at Loch Davan and Braeroddach Loch (Edwards 1979) and so are unsuitable due to differences in woodland ecosystems, soils and topography. It is possible that some insight may be gained through observation of the species and calibre of wood utilised across the two areas of activity but without the availability of proxy data such as pollen records it is difficult to determine if the material selected constitutes all that was available in the area at the time of selection or whether specific species and wood type were being deliberately chosen.

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Appendix-2.1.4 SL/004 Gairnhill Charcoal Analysis – Laura Bailey, Sarah-Jane Haston and Angela Walker

Eight charcoal-rich deposits from two areas of Gairnhill were selected for analysis. This included four deposits from an Early Bronze Age burnt mound located in the south-eastern corner of Gairnhill, several hundred metres from other prehistoric activity at the site, and four Late Bronze Age deposits from Gairnhill 1 (a roundhouse) located in the north-western corner of the site.

In addition to the bulk samples, contexts with carbonised wood representing possible structural elements within Gairnhill 2, 3 and 4 (further roundhouses) were also sampled. A more detailed analysis of the physical characteristics of the carbonised wood from Gairnhill 4 was the subject of a separate report (A2.1.15).

Methodology

A minimum of 10 charcoal fragments were randomly selected from each sample for species identification with a minimum fragment size of 2mm.

Wood charcoal fragments were fractured manually and the resultant anatomical features observed in transverse (TS), radial (RLS) and tangential planes TLS), using high power binocular reflected light (episcopic) microscopy at magnifications of x 50, x 100 and x 400. Identification of each fragment was carried out to as high a taxonomic level as possible by comparison with material in the reference collections at the Headland Archaeology and various reference works (eg Schweingruber 1978, 1990; Hather 2000). Where possible a record was made of the ring curvature of the wood as well as details of the ligneous structure, in order to determine the part of the woody plant which had been burnt and the state of wood before charring (Marguerie & Hunot 2007).

Certain genera, for example gorse (*Ulex* sp.) and broom (*Cytisus* sp.) or members of the Maloideae sub family; hawthorn (*Crataegus sp.),* apple *(Malus* sp.), rowan, service tree and whitebeam (*Sorbus sp*.) etc, cannot be distinguished on the basis of wood anatomy and so are recorded as *Ulex/Cytisus* or Maloideae (Hather 2000).

The charcoal was also examined for evidence of biological degradation in the form of fungal hyphae. It was also inspected visually for any irregular patterns of channels which could result from boring insect or woodworm degradation (Marguerie and Hunot 2007).

Results

Burnt mound

Three samples from deposit (4A-0003) were composed of hazel and alder. The ring curvature of the fragments suggests the use of smaller branches and twig of both species.

The charcoal assemblage from deposit (4A-0027), the basal deposit in trough [4A-0010], comprised small branch/twig fragments of hazel and alder as well as a small proportion of oak.

Gairnhill 1: hearth [4D-0013]

Context (4D-0014), the primary fill of hearth [4D-0013], was predominantly oak with hazel. Ring curvature of the fragments indicates the use of a larger calibre of oak wood ie medium branches and hazel twig/small branches.

The other contexts associated with the hearth and pit cut; (4D-0015) the secondary fill of hearth [4D-0013], (4D-0016) fill of pit [4D-0013] and (4D-0030) primary fill of pit [4D-0013], contained a similar assemblage comprised predominantly of hazel with alder and oak. The ring curvature of the fragments suggests the use of smaller branches/twig of hazel and alder with medium branches of oak.

Gairnhill 2

Context (4D-0210) contained fragments of small branches of hazel.

Gairnhill 3

Context (4D-0314) contained a tentatively identified fragment of hazel.

Gairnhill 4

The charcoal assemblage from context (4D-0314) was predominantly hazel with alder and Maloidae as well as rarer numbers of oak and birch. The ring curvature of the fragments suggests the use of small branches of alder and Maloidae and the use mixed sizes of hazel, oak and birch.

A more detailed analysis of the physical characteristics of the carbonised wood from Gairnhill 4 was the subject of a separate report (A2.1.15).

Discussion

The wood charcoal assemblages from the burnt mound and Gairnhill 1 and 4 were predominantly hazel, alder and oak, with Gairnhill 1 having a higher proportion of oak fragments than the other two. Ring curvature on charcoal fragments suggests the use of twig or small branches of hazel and alder with a larger calibre of wood such as medium sized branches of oak. Maloidae was recorded in the charcoal assemblage of Building 4 only and displayed evidence of being worked and modified (A2.1.15).

Difficulties arise when trying to reconstruct the nature of the local vegetation during the Early and Late Bronze Age at Gairnhill. There are no pollen records that cover the immediate environs of the site, the nearest record being 40km west from the Howe of Cromar, at Loch Davan and Braeroddach Loch (Edwards 1979) which would be unsuitable to use due to differences in woodland ecosystems, soils and topography.

It is possible that some insight regarding the composition of the local vegetation may be gained through observation of the species and calibre of wood used as fuel and structural material and the fact that the same species were utilised throughout the Bronze Age certainly attests to their continued presence. Without the availability of proxy data such as pollen records it is difficult to determine if the material selected constitutes all that was available in the area at the time of selection or whether specific species and wood type were being deliberately chosen for their suitability as structural elements, walls and roofing etc. and for fuel.

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Appendix-2.1.5 NL/001C Chapel of Stoneywood Charcoal Analysis – Laura Bailey

Excavations at Chapel of Stoneywood revealed the remnants of a middle Bronze Age round-house (Structure A). Charcoal analysis was undertaken on 10 charcoal fragments from context (1C-0002) the basal fill of possible pit/hearth [1C-0001]. The feature was charcoal rich and had evidence of charcoal lensing as well as containing fragmented indeterminate burnt animal bone.

Methodology

Charcoal was extracted from bulk soil samples processed by flotation and wet sieving in a Siraf-style flotation. The floating debris (the flot) was collected in a 250 µm sieve and, once dry, scanned using a binocular microscope. Any material remaining in the flotation tank (retent) was wet-sieved through a 1mm mesh and air-dried.

The following criteria were considered when selecting charcoal samples for species identification

- Samples were chosen from those observed in the assessment stage that had the greatest potential to contain fragments of a suitable size for identification,
- Type and security of the context, feature or stratigraphy

A minimum of 10 charcoal fragments were randomly selected from each sample for species identification with a minimum fragment size of 2mm.

Wood charcoal fragments were fractured manually, and the resultant anatomical features observed in transverse (TS), radial (RLS) and tangential planes TLS), using high power binocular reflected light (episcopic) microscopy at magnifications of x 50, x 100 and x 400. Identification of each fragment was carried out to as high a taxonomic level as possible by comparison with material in the reference collections at the Headland Archaeology and various reference works (eg Schweingruber 1978, 1990; Hather 2000). Where possible a record was made of the ring curvature of the wood as well as details of the ligneous structure, in order to determine the part of the woody plant which had been burnt and the state of wood before charring (Marguerie and Hunot 2007).

Certain genera, for example gorse (*Ulex* sp.) and broom (*Cytisus* sp.) or members of the Maloideae sub family; hawthorn (*Crataegus sp.),* apple *(Malus* sp.), rowan, service tree and whitebeam (*Sorbus sp*.) etc, cannot be distinguished on the basis of wood anatomy and so are recorded as *Ulex/Cytisus* or Maloideae (Hather 2000).

The charcoal was also examined for evidence of biological degradation in the form of fungal hyphae. It was also inspected visually for any irregular patterns of channels which could result from boring insect or woodworm degradation (Marguerie and Hunot 2007).

Results

Oak (*Quercus* sp.) was the most frequently identified taxon. None of the oak charcoal fragments possessed tyloses, which develop in wood once the tree is roughly 50 years in age, which suggests that it was from immature wood. Many of the oak fragments were highly fissured and partially vitrified, a characteristic associated with exposure to extremely high temperatures (Prior et al 1983). Hazel (*Corylus avellana*) charcoal was also present in small numbers. The hazel charcoal was of small roundwood of less than 10mm in diameter. The hazel charcoal fragments were covered in mineral deposits, visible as orange brown accretions. These are believed to accumulate through post-depositional leaching of minerals through the soil profile (Austin 2007). This suggests some fluctuation in the water table.

Discussion

Pit [1C-0001] has been interpreted as a possible hearth; hazel charcoal from basal fill (1C-002) produced a radiocarbon date of 70 – 218 AD (SUERC – 57932). It is possible that this hearth was set in an earlier feature relating to the construction of the roundhouse, but the deposits clearly belong to the later period.

The vitrified oak charcoal suggests that high temperatures were maintained in this feature. Oak provides good fuel wood of high thermal capacity. Despite the large volume of charcoal recovered, only two species were present, which suggests that oak and hazel may have been deliberately selected for fuel wood. Therefore, little comment can be made on the wider landscape and the trees within it. However, the pollen diagram (Timpany 2014) certainly suggests that oak and hazel were locally available during this period.

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Appendix-2.1.6 NL/003B Standingstones Charcoal Analysis – Laura Bailey and Angela Walker

Excavation at Standingstones revealed activity dating to the Late Mesolithic period. The site comprised a number of pits and a spread containing a substantial lithic assemblage. Although there was no clear evidence for the function of the pits, significant concentrations of hazelnut shell and lithics were recovered from the pits, raising the possibility that the site may have functioned as a hazelnut processing site. Charcoal was analysed from the basal fill (3B-0027) of pit [3B-0023] and from a burning deposit (3B-0028) at the base of pit [3B-0025].

Methodology

Charcoal was extracted from bulk soil samples processed by flotation and wet sieving in a Siraf-style flotation. The floating debris (the flot) was collected in a 250 µm sieve and, once dry, scanned using a binocular microscope. Any material remaining in the flotation tank (retent) was wet-sieved through a 1mm mesh and air-dried.

The following criteria were considered when selecting charcoal samples for species identification

- Samples were chosen from those observed in the assessment stage that had the greatest potential to contain fragments of a suitable size for identification,
- Type and security of the context, feature or stratigraphy

A minimum of 10 charcoal fragments were randomly selected from each sample for species identification.

The charcoal was broken or fractured to view three sectional surfaces (transverse (TS), tangential (TLS) and radial (RLS) necessary for microscopic wood identification, The charcoal fragments were then mounted onto a slide and examined using an incident light microscope at magnifications of 100x, 200x and 400x where applicable. Identifications were made using wood keys by Schweingruber (1978, 1990) and IAWA (1989), and Headland Archaeology's reference collection.

It is usually possible to identify the charcoal as to genus, and in some instances to species, but in the case of the Pomoideae group the cell structure of the different genera and species cannot be differentiated. The Pomoideae group includes *Cratageus* sp. (hawthorn), *Malus* sp. (apple), *Pyrus* sp. (pear) and *Sorbus* sp. (rowan, service tree and whitebeam). The identified pomoideae from this site resemble the *Sorbus* sp. group and is therefore probably rowan (Schweingruber 1978, 124).

The morphology of the charcoal fragments was also recorded in order to identify roundwoods. Where possible, roundwood diameters or radial stem measurements were recorded. Ring curvature has been measured using the key by Marguerie and Hunot (2007), where weak curvature is thought to denote large timbers, medium curvature, medium sized timbers and strong curvature represent small timbers. Where curvature could not be viewed they are noted as indeterminate.

The charcoal was also examined for evidence of biological degradation in the form of fungal hyphae. The presence of fungal hyphae in wood is revealed by colour changes, by physical-mechanical characteristics and by the hyphae themselves (Schweingruber 1978). It was also inspected visually for any irregular patterns of channels which could result from boring insect or woodworm degradation (Marguerie and Hunot 2007).

Results

Charcoal present in the fill (3B-0021) of pit [3B-0023] comprised hazel, pomaceous fruitwood (*Sorbus* type) and a small amount of oak. All charcoal was relatively unabraded and derived from small diameter (<10mm) roundwood.

Charcoal recovered from the fill (3B-0025) of pit [3B-0025] comprised hazel and bird cherry (*Prunus avium*) charcoal. Again, all charcoal was relatively unabraded and derived from small diameter roundwood.

Many of the fragments exhibited features suggestive of biological degradation, in the form of fungal hyphae. It has been suggested that the presence of fungal hyphae indicates the collection of dead-wood as opposed to recently felled wood (Salisbury *et al* 1940).

Discussion

The only direct evidence of plant exploitation at Standingstones consists of charcoal, which indicates the use of a variety of woods for fuel, and charred hazelnut shell. The abundance of light demanding taxa identified is notable, with the presence of hazel, Sorbus type charcoal and bird cherry. Overall, hazel was the most abundant taxon suggesting that it was a very important aspect of the Mesolithic economy. Although hazel is moderately shade-tolerant, it requires open conditions for successful nut production (Austin 2007). The abundance of hazel nutshell on site suggests that it was locally available and that open conditions must have prevailed.

The pollen diagram from Hare Moss Wetland (Timpany 2014) also suggests that hazel scrub woodland was locally present during this period. There was also evidence for oak, pine, elm and sorbus type (rowan/whitebeam/ apple/ pear) within the regional environment. A general rise in hazel is seen in pollen diagrams across Scotland occurring between 9500 and 9000 BP (Birks 1989).

Although oak, a large deciduous tree capable of forming closed canopy woodland, was present it was only identified in small amounts. Given that oak is an excellent fuel wood its relative absence may be explained either if wood was selectively collected, or if hazel and the other trees and shrubbier taxa were more easily accessible.

The charcoal assemblage indicates that small branches were being gathered. Fungal hyphae was present on many of the fragments suggesting that deadwood may have been collected from the ground, or that the wood was exposed to the elements and had started to degrade prior to burning.

It is likely that open hazel communities constituted the principal form of vegetation at Standingstones.

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Appendix-2.1.7 NL006A and NL006B Goval Charcoal Analysis – Angela Walker

Introduction

Direct evidence of plant exploitation at Goval consists of charcoal, which indicates the use of wood for fuel, and charred plant remains including cereal grain. Three phases of activity dating to the prehistoric, early historic and post-medieval periods were identified at Goval. The prehistoric phase was represented by the remains of two round-houses (Structures A and B), two metal-working furnaces and various isolated pits and postholes. These demonstrate activity between the middle Neolithic and middle Iron Age. The early historic phase is represented by a curvilinear gully. Post-medieval activity is indicated by a system of rig and furrow cultivation.

Charcoal analysis was undertaken on 70 charcoal fragments from seven samples from features containing evidence for in situ burning or directly associated with burning activities. The charcoal data was evaluated against the information on regional woodland composition provided by a pollen core taken from Hare Moss Wetland (Timpany 2014). By combining the results of charcoal identification from the site and pollen analysis from nearby, information was provided on the contemporary and regional environment.

In addition to the charcoal analysis an assessment of eighty 10 litre soil samples taken during excavation revealed the presence of plant remains that had the potential for providing information on the palaeoenvironment, cereal crop choices in the area and foci of activity.

Methodology

Charcoal and charred plant remains were extracted from bulk soil samples processed by flotation and wet sieving in a Siraf-style flotation. The floating debris (the flot) was collected in a 250 µm sieve and, once dry, scanned using a binocular microscope. Any material remaining in the flotation tank (retent) was wet-sieved through a 1mm mesh and air-dried.

The following criteria were considered when selecting charcoal samples for species identification

- Samples were chosen from those observed in the assessment stage that had the greatest potential to contain fragments of a suitable size for identification,
- Type and security of the context, feature or stratigraphy

A minimum of 10 charcoal fragments were randomly selected from each sample for species identification.

The charcoal was broken or fractured to view three sectional surfaces (transverse (TS), tangential (TLS) and radial (RLS) necessary for microscopic wood identification. The charcoal fragments were then mounted onto a slide and examined using an incident light microscope at magnifications of 100x, 200x and 400x where applicable. Identifications were made using wood keys by Schweingruber (1978, 1990) and IAWA (1989), and Headland Archaeology's reference collection.

It is usually possible to identify the charcoal as to genus, and in some instances to species, but in the case of the Pomoideae group the cell structure of the different genera and species cannot be differentiated. The Pomoideae group includes *Crataegus* sp. (hawthorn), *Malus* sp. (apple), *Pyrus* sp. (pear) and *Sorbus* sp. (rowan, service tree and whitebeam). The identified pomoideae from this site resemble the *Sorbus* sp. group and is therefore probably rowan (Schweingruber 1978, 124).

The morphology of the charcoal fragments was also recorded in order to identify roundwoods. Where possible, roundwood diameters or radial stem measurements were recorded. Ring curvature has been measured using the key by Marguerie and Hunot (2007), where weak curvature is thought to denote large timbers, medium curvature, medium sized timbers and strong curvature represent small timbers. Where curvature could not be viewed they are noted as indeterminate.

The charcoal was also examined for evidence of biological degradation in the form of fungal hyphae. The presence of fungal hyphae in wood is revealed by colour changes, by physical-mechanical characteristics and by the hyphae themselves (Schweingruber 1978). It was also inspected visually for any irregular patterns of channels which could result from boring insect or woodworm degradation (Marguerie and Hunot 2007).

Results

The results of charcoal analysis are discussed below. Contexts selected for analysis included; (6A-0050) from hearth [6A-0049] in Structure B, (6A-0124/0122), (6A-0130), (6A-0128) and (6A-0126) from smelting furnace [6A-0118] (Furnace B) and contexts (6A-0099) and (6A-0102) of metal working furnace [6A-0096] (Furnace A). All features were dated to the Middle Iron Age.

Hearth [6A-0049], Structure B

Alder and bird cherry (*Prunus avium*) were identified in the fill (6A-0050) of hearth [6A-0049] together with low quantities of oak charcoal. The majority of charcoal was from small diameter roundwood. However, the oak charcoal contained Tyloses, suggesting that it was from mature wood (tyloses develop when the tree reaches approximately 50 years of age).

Furnace B

Four samples from the fills (6A-0124/0122), (6A-0130), (6A-0128) and (6A-0126) of smelting furnace [6A-0118] were analysed. It is likely that the furnace would have taken the form of an upright clay cylinder in which charcoal and ore were placed in alternating layers (Edlin 1973) and burnt to produce a metal bloom which would have collected in the base or been tapped out of a hole near the base. Deposit (6A-0128) was one of the principle fills. It was rich in iron slag, possible ironworking residues, daub and charcoal. Deposit (6A-0126) represents the waste material from inside the furnace.

Oak, willow, alder, hazel and birch were all identified in the furnace deposits. All fragments were from unabraded small branchwood. Oak was the most commonly identified taxon, present in all deposits. Willow twigs were particularly abundant in deposit (6A-0126). The majority of fragments had evidence of fungal hyphae, which suggests that dead wood was collected, as opposed to recently felled wood (Salisbury *et al* 1940).

Furnace A

Two samples from the fills (6A-0099) and (6A-0102) of metal working furnace [6A-0096] were analysed. The furnace contained slag and fired clay fragments, similar to those recovered from Furnace B, though in smaller quantities. It has been suggested (van Wessel 2015), given the abundance of barley within the feature, and the limited evidence for smelting, that the feature may have had a different function. Certainly, the charcoal assemblage was very different to that in furnace [6A-0118]. Hazel charcoal, deriving from small diameter roundwood was present in deposits (6A-0099) and (6A-0102). Small amounts of alder and birch were also recovered. No oak charcoal was present in this deposit.

Discussion

There is evidence for activity in the Goval area from the Neolithic, Bronze Age and Iron Age periods through to the early medieval at Goval. There is however little evidence to suggest that the occupation was continuous, and it is more likely that the same area was settled due to the good, fertile land by the River Don.

The taxa present indicate that both carr and dryland woodland existed nearby during the Iron Age. Alder, willow and birch may have been gathered from along the banks of the River Don and dryland taxa, such as hazel, oak and bird cherry may have been gathered from further up the valley.

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Appendix-2.1.8 NL/012 Blackdog Charcoal Analysis – Angela Walker

Introduction

Excavations at Blackdog (previously NL/12) revealed seven cut features. All but one of these features contained prehistoric material including lithics and Neolithic pottery. Charcoal analysis was undertaken on 40 charcoal fragments from four samples. Samples were from the fills (12-0006) and (12-0036) of pits [12-0001] and [12-0034] respectively and two samples were from the fills (12-0014) and (12-0016) of pit [12-0002].

Methodology

Charcoal and charred plant remains were extracted from bulk soil samples processed by flotation and wet sieving in a Siraf-style flotation. The floating debris (the flot) was collected in a 250 µm sieve and, once dry, scanned using a binocular microscope. Any material remaining in the flotation tank (retent) was wet-sieved through a 1mm mesh and air-dried.

The following criteria were considered when selecting charcoal samples for species identification

- Samples were chosen from those observed in the assessment stage that had the greatest potential to contain fragments of a suitable size for identification,
- Type and security of the context, feature or stratigraphy

A minimum of 10 charcoal fragments were randomly selected from each sample for species identification.

The charcoal was broken or fractured to view three sectional surfaces (transverse (TS), tangential (TLS) and radial (RLS) necessary for microscopic wood identification. The charcoal fragments were then mounted onto a slide and examined using an incident light microscope at magnifications of 100x, 200x and 400x where applicable. Identifications were made using wood keys by Schweingruber (1978, 1990), IAWA (1989) and Headland Archaeology's reference collection.

It is usually possible to identify the charcoal as to genus, and in some instances to species, but in the case of the Pomoideae group the cell structure of the different genera and species cannot be differentiated. The Pomoideae group includes *Cratageus* sp. (hawthorn), *Malus* sp. (apple), *Pyrus* sp. (pear) and *Sorbus* sp. (rowan, service tree and whitebeam). The identified pomoideae from this site resemble the *Sorbus* sp. group and is therefore probably rowan (Schweingruber 1978, 124).

The morphology of the charcoal fragments was also recorded in order to identify roundwoods. Where possible, roundwood diameters or radial stem measurements were recorded. Ring curvature has been measured using the key by Marguerie and Hunot (2007), where weak curvature is thought to denote large timbers, medium curvature, medium sized timbers and strong curvature represent small timbers. Where curvature could not be viewed they are noted as indeterminate.

The charcoal was also examined for evidence of biological degradation in the form of fungal hyphae. The presence of fungal hyphae in wood is revealed by colour changes, by physical-mechanical characteristics and by the hyphae themselves (Schweingruber 1978). It was also inspected visually for any irregular patterns of channels which could result from boring insect or woodworm degradation (Marguerie and Hunot 2007).

Results

The results of charcoal analysis are discussed below.

Pit [12-0001] had been recut and contained 11 fills. It had been used for several different purposes including dumping and *in-situ* burning. Charcoal deriving from *in-situ* burning (12-0006) was analysed in order to see what types of fuel wood were present. Oak and hazel charcoal were identified. All charcoal was relatively unabraded and derived from small and medium sized branchwood.

Pit [12-0002] was situated some 12m to the east-south-east of pit [12-0001]. The morphology and sequence of deposition was similar to that of pit [12-0001]. Charcoal and heat-affected sand present in deposit (12-0006) in pit [12-0001] corresponded well with deposit (12-0014) and (12-0016) and may have been the result of *in situ* burning. Charcoal identified in deposit (12-0014) included hazel and alder. Charcoal in deposit (12-0016) included oak, hazel and a small amount of heather. All charcoal derived from small diameter branchwood.

A third large pit [12-0034] was located 12.5m west of [12-001]. Although several phases of use were recorded in the feature, the sequence of deposition was different to those in pits [12-0001] and [12-0002]. Charcoal from deposit (12-0036), the result of an in-situ burning event, was analysed. Oak and hazel charcoal were identified. Again, all charcoal derived from small diameter branchwood.

Discussion

The majority of pits from Blackdog date to the Neolithic period. The charcoal evidence suggests that oak, hazel, alder and heather were all locally available during the Neolithic period. Oak and hazel were the most abundant taxa suggesting that that fuel wood was gathered from dryland oak-hazel woodland. Alder was also present, suggesting that wood was collected from wetland areas or from along the banks of streams. The presence of heather charcoal suggests that mire was also exploited. Palynological evidence from a pollen core taken at Hare Moss Wetland, on the southern leg of the bypass, at NGR NO 91410 99511, provided information on the wider environment for this period (Timpany 2015). Pollen analysis indicates that burning was taking place in the local and regional woodland and was suggested to represent anthropogenic activity in the vicinity during the Early to Middle Neolithic period. Charcoal fragments suggested that birch/ alder and hazel were being burnt together with grasses. Small dips were also seen in the pollen of birch, alder and willow together with Cyperaceae and Poaceae suggesting the burning of local wetland. Similarly, there was a decrease in the oak, elm and pine pollen indicating some decline in these species in the local woodland. During this period there was a corresponding increase in cereal pollen indicating cereal agricultural activity in the area. This corresponds with the recovery of barley, all be it in small amounts, on the site.

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Appendix-2.1.9 AMA22 Wester Hatton Charcoal Analysis - Angela Walker and Karen Stewart

Introduction

The excavation area at Wester Hatton covered an area of approximately 9,000m² and was located on a south facing slope centred on NJ 9568 1505. Features recorded at the site included the remains of five structures and a series of small and large pits. Ninety bulk sediment samples, ranging in size from three to 40 litres, were recovered during excavation and were subject to an initial assessment (Giorgi 2017) to determine the suitability of the material for analysis. Charcoal analysis was undertaken on 100 fragments from 10 samples from a range of features dating from the Neolithic and Early/Mid Bronze Age.

Methodology

Charcoal and charred plant remains were extracted from bulk soil samples processed by flotation in a Siraf-style flotation tank. The floating debris (flot) was collected in a 250 µm sieve and, once dry, scanned using a binocular microscope. Any material remaining in the flotation tank (retent) was wet-sieved through a 1mm mesh and air-dried.

The following criteria were considered when selecting charcoal samples for species identification:

- Those that contained fragments of a size suitable for identification
- Type and security of the context, feature or stratigraphy

A minimum of 10 charcoal fragments were randomly selected from each sample for species identification with a minimum fragment size of 2mm.

Wood charcoal fragments were fractured manually and the resultant anatomical features observed in transverse (TS), radial (RLS) and tangential planes TLS), using high power binocular reflected light (episcopic) microscopy at magnifications of x 50, x 100 and x 400. Identification of each fragment was carried out to as high a taxonomic level as possible by comparison with material in the reference collections at the Department of Archaeology, University of Sheffield and various reference works (e.g. Schweingruber 1978, 1990; Hather 2000). Where possible a record was made, of the ring curvature of the wood as well as details of the ligneous structure, in order to determine the part of the woody plant which had been burnt and the state of wood before charring (Marguerie, & Hunot 2007).

Certain genera, for example gorse (Ulex sp.) and broom (Cytisus sp.) or members of the Maloideae sub family; hawthorn (Crataegus sp.), apple (Malus sp.), rowan, service tree and whitebeam (Sorbus sp.) etc., cannot be distinguished on the basis of wood anatomy and so are recorded as Ulex/Cytisus or Maloideae (Hather 2000).

The charcoal was also examined for evidence of biological degradation in the form of fungal hyphae. It was also inspected visually for any irregular patterns of channels which could result from boring insect or woodworm degradation (Marguerie and Hunot 2007).

Results

Neolithic

Charcoal analysed derived from two pits that were part of the Cluster 1 Pit group: [AMA22-6051] and [AMA22-6053]. Residue from a pottery fragment from Pit [AMA22-6051] produced a radiocarbon determination of 3341-3095calBC (SUERC-74400).

The charcoal assemblage from the pits was predominantly alder (Alnus sp.). In addition to alder, Pit [AMA22-6051] also contained plum/cherry (Prunus sp.) while Pit [AMA22-6053] contained a low number of fragments of hazel (Corylus sp.). Ring curvature of the fragments from both pits assessed suggests that small diameter branch wood was utilised.

Early/Middle Bronze Age

Charcoal analysis was undertaken on samples from eight features associated with Early/Middle Bronze Age occupation at the site, including four separate structures (Wester Hatton Structures 1-4) and two pits. Radiocarbon determinations indicated that Wester Hatton 2 (1692-1626calBC; SUERC-73583) was the earlier structure followed in turn by Wester Hatton 3 (1280-1132calBC; SUERC 73584) and Wester Hatton 4 (1215-1114calBC; SUERC 73586). No date was obtained for Wester Hatton 1.

Wester Hatton 1

The charcoal from Ring ditch [AMA22-6096] was predominantly alder, with a low number of fragments of hazel and oak (Quercus sp.). The ring curvature of the fragments suggests the use of small diameter branch wood of alder and hazel but a larger calibre (potentially trunk) of oak wood.

Wester Hatton 2

Pit [AMA22-6240] comprised charcoal of small diameter branches/twigs of hazel, birch and willow/poplar (Salix sp./Populus sp.) and larger branch wood of oak.

Wester Hatton 3

The charcoal assemblage from Ring ditch [AMA22-6179] was predominantly large diameter branch wood (possibly trunk) of alder with oak and beech (Fagus sylvatica). The assemblage also contained fragments of hazel. These fragments exhibited a strong ring curvature suggesting the use of small diameter branch wood of hazel.

Wester Hatton 4

Wester Hatton 4 comprised three sampled features; Pit [AMA22-6144], Cut [AMA22-6155] and spread of sand (AMA22-6025) overlying the structure. The charcoal assemblages from the samples features was predominantly alder. Pit [AMA22-6144] and Cut [AMA22-6155] also contained oak whereas spread (AMA22-6025) contained hazel and plumb/cherry but no oak. The ring curvature of the fragments suggests the use of mixed branch wood sizes of all species represented.

Pits

Pit [AMA22-6160] was predominantly larger branch wood (possibly trunk) fragments of oak with a low number of fragments of smaller hazel and alder branch wood. Pit [AMA22-6188] contained the same tree species as Pit [AMA22-6160] but the ring curvature of the fragments from this pit suggests the use of a larger calibre of wood.

Discussion

The Neolithic charcoal assemblage was principally small alder branch wood; the presence of alder was also recorded in the Mesolithic/Neolithic Pit [12-0002] at Blackdog.

The charcoal assemblage from the Bronze Age structures and associated pits was predominantly mixed diameter alder with larger calibre of oak wood and small hazel branch wood. Evidence for these three species was noted in all structures selected for analysis (Wester Hatton 1-4) as well as in pits [AMA22-6160] and [AMA22-6188]. This not only suggests continuity in the availability of these species types throughout the Bronze Age occupation phases at Wester Hatton, but also that there is a lack of clear evidence confirming one species being preferred over another.

The charcoal assemblages from the Neolithic and Bronze Age also contain evidence for the presence of birch, plum/cherry, beech and willow/poplar. The presence of these species alongside hazel, alder and oak is in keeping with the data from pollen analyses (Timpany 2012) and regional reviews by Tipping (1994, and Dingwall et al in press, Chapter 1).

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Appendix-2.1.10 SL/002D Milltimber Hazel Nutshell Analysis – Angela Walker

Introduction

Milltimber spanned the north and south banks of the River Dee and formed part of a landscape that has been extensively utilised, occupied and settled throughout the span of human presence in the area. In total 155 of the contexts sampled produced fragments of hazel nutshell, of these only 11 contexts yielded quantities that were deemed significant for analysis. The contexts analysed derived from a number of pits and hearths that ranged in date from the Mesolithic to the Middle Neolithic.

Methodology

Bulk samples were subjected to flotation and wet sieving in a Siraf-style flotation machine. The floating debris (the flot) was collected in a 250 µm sieve and once dry, scanned using a binocular microscope. Any material remaining in the flotation tank (retent) was wet-sieved through a 1mm mesh and air-dried. All samples were scanned using a stereomicroscope at magnifications of x10 and up to x100. Identifications, where provided, were confirmed using modern reference material and seed atlases including Cappers et al (2006) and Zohary et al (2012) nomenclature for wild taxa follows Stace (1997).

In total 155 of the sampled contexts produced fragments of hazel nutshell. The selection criterion for analysis was determined by the quantity (relative abundance) of nutshell present and its weight in grams. Only samples that demonstrated and abundance of nutshell were selected. Application of this criteria determined that only 11 contexts were suitable for analysis.

Results

The features that produced hazel nutshell quantities significant for analysis included pits, two hearths and an indeterminate feature (Table 1). The features were dated via a combination of established ceramic and lithic typologies and AMS dates and included a date range spanning the Mesolithic and Early and Middle Neolithic.

Table 1: Features with hazel nutshell quantities significant for analysis.

Sample Number	Context Number	Feature	Hazel nutshell abundance	Weight (g)
2D-1245	2D-1777	Pit [2D-1776]	xxxx	8.5
2D-1052	2D-1101	Feature [2D-1098]	xxxx	11
2D-1076	2D-1128	Pit [2D-1092], recut in Pit [2D-1127]	xxx	7.7
2D-1078	2D-1093	Pit [2D-1092], recut in Pit [2D-1127]	xxxx	10.4
2D-1257	2D-1796	Post Pit [2D-1714]	xxx	5.3
2D-1087	2D-1150	Pit [2D-1137]	xxxx	20.4
2D-1088	2D-1151	Pit [2D-1137]	xxx	12.8
2D-1089	2D-1149	Hearth [2D-1137]	xxxx	17
2D-1145	2D-1297	Pit [2D-1295]	xxxx	13.8

2D-1258	2D-1751	Hearth [2D-1822] in Pit [2D-1821]	xxx	7.1
2D-1259	2D-1849	Hearth [2D-1822] in Pit [2D-1821]	xxx	8.1

Key: xxx = common (16-50) and xxxx = abundant (>50)

Discussion

In terms of spatial distribution Hearths [2D-1137] and [2D-1822] and Feature [2D-1098] were located within a relatively close proximity to each other with Pit [2D-1092], recut in Pit [2D-1127] and Pit [2D-1776] located further away but still within the same area of the site. In order to be able to ascribe actual significance to the spatial distribution of the hazel nutshell concentrations within these features it would be necessary to explore the presence/absence of hazel nutshell in all features present across all period represented.

Hearths [2D-1137] and [2D-1822] formed part of a hearth complex comprising three possibly four hearths that had been cut into or had utilised the hollow created by a fallen tree. Hearth [2D-1137] was the best preserved of the hearth features in the hearth complex and may have been the last one in use, this suggests that the hazel nutshell for this feature is potentially in a primary and undisturbed deposit.

Pit [2D-1714] contained basal deposits of eroded geological material. Towards the centre of the pit were two charcoal and hazel nutshell rich deposits collected in a hollow which may have been created by a removed post. In addition to a range of other deposits the upper deposit contained carinated bowl pottery dating to the Early Neolithic, however the relationship between this deposit and the ones below was not clear.

Pit [2D-1092] was a later feature that was cut into the complex stratigraphy of Pit [2D-1127]. The later pit comprised 3 deposits which produced Late Mesolithic and Early Neolithic dates which supported the supposition of a very complex sequence of construction, use and reuse.

The complex stratigraphic sequences revealed in pits [2D-1714] and [2D-1092] are of particular importance as they provide evidence of the dynamic nature of site formation processes. Within the deposits of these features there is evidence of both natural and anthropogenic actions at work at the site. These actions would not have been restricted to these particular features but would have been at work across the site as a whole. These transformation processes would not have been restricted to a particular time period either. This area of the site also revealed evidence of later agricultural activities in the form of plough marks. Given that these ‘marks’ cut across these earlier features it is possible that the concentrations of hazel nutshell revealed during excavation could have been the result of relocation during later activity thus creating the impression of concentrations of material at a particular area of the site. Such observations highlight the need to consider very carefully the reliability and integrity of the hazel nutshell remains present within these features.

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Appendix-2.1.11 Hazelnut Ethnography - Sarah L R Mason

Introduction

Largely because of their taphonomic advantages, nut remains of many species have a long history of recovery from archaeological sites of both foragers and farmers, and hazelnuts - particularly in European Mesolithic sites - are a prime example of this. A number of publications have addressed the potential role of hazelnuts as a food resource in European prehistory, particularly during the Mesolithic, from a number of different angles. Many of these make reference to the ethnographic and ethnohistoric record of nut use in general, both by hunter-gatherers and horticulturalists, particularly in North America. The increasing sophistication of archaeobotanical analyses - which have increased the recovery and identification of other potential, but less archaeologically visible, food resources - as well as attempts to address their interpretation in more sophisticated ways, means that oversimplified assumptions that high representation of nutshell automatically equals high representation of nuts in the diet are no longer sufficient. Together with the increasing numbers of archaeobotanical discoveries of particularly well-preserved or abundant deposits of nut remains this means that the extent to which nuts formed a potentially important past food source has received increasing attention within the archaeological literature in recent years.

A number of recent overviews or analyses which have addressed the role of nuts (or regionally relevant species) in different temperate forest regions or ecosystems, and which have drawn on a range of evidence including ethnographic or historic sources, direct archaeobotanical remains (including phytolith, starch grain or chemical residue analyses of possible processing tools or cooking or storage vessels) from both dryland and waterlogged sites, their relation to contexts interpreted as storage, processing or cooking facilities, and experimental archaeology. As it is not possible here to discuss these in full the reader is directed to some overviews which form valuable starting points for closer examination of regional nut exploitation: East Asia - Fuller *et al*. 2007 (Lower Yangtze), Hosoya 2011; Takahashi & Hosoya 2002; Kawashima 2016 (cited in Antolin 2016a) (Japan and Korea), Sergusheva & Vostretsov 2009 (Russian Far East); Eastern North America - Scarry 2003, Messner 2011; Carmody & Hollenbach 2013; North Africa - Morales *et al*. 2015; Europe - Antolin & Jacomet 2015; as well as Borojevic 2009 (for a review of the ethnographic and archaeological evidence for water chestnut across Eurasia (*Trapa* spp.). Particular interpretive aspects of the archaeobotany of nut use which have been discussed in recent reports include the impact of differences in taphonomy between wetland and dryland sites (Out 2012; Antolin & Jacomet 2015 (see also Colledge and Connolly 2014; Little 2014); variability in nut processing techniques and modes of consumption in relation to nutshell fragmentation (Hosoya 2011) or species selection (Moreno-Larrazabal *et al*. 2014); geographic variability in the archaeobotanical record of nut remains in relation to food preparation and processing preference or requirements (Antolin & Jacomet 2015); interpretations of archaeological features related to nut processing, storage or cooking (Crombe et al. 2015; Out 2012; Hosoya 2011); interpretations (of cooking or processing methods) from differences in the proportions or size of nut components (e.g., shell vs kernel; fragment size) Zapata *et al*. 2008, Fritz *et al*. 2001; taphonomy and quantification Peles & Scarry 2015; theoretical models relating to storage and settlement/mobility models (Cunningham 2011b); experimental archaeology (Cunningham 2005); and the antiquity of nut use and nut-processing technology (Goren-Inbar et al. 2002), some of which are discussed in more detail below.

Any brief examination of the discussion of the potential role of hazelnuts in the European Mesolithic suggests that a limited number of original sources are frequently referred to, and that interpretations tend to be generalised and relatively uncritically repeated; while the value of interpretative information relevant to the archaeological record which can be obtained from detailed ethnographic accounts, as well as the need to apply these critically to the archaeological record, has been increasingly emphasised recently in regard to the potential role of nuts (e.g., Antolin et al. 2016a; Barlow & Heck 2002; Fiorentino & Primavera 2014; Fritz *et al*. 2001; Hosoya 2011; Mason & Nesbitt 2009; Regnell 2012). The focus of this report is to examine whether there are sufficiently detailed ethnographic accounts of the use of hazelnuts which might enable more precisely defined hypotheses about the relationship of archaeological finds and features to the past use of hazelnuts, in terms of activities such as harvest, transport, storage, processing, consumption and their role in subsistence and beyond.

The ethnographic record of hazelnut exploitation

Unfortunately, the ethnographic record for the use of hazelnuts by either hunter-gatherers or agrarian peoples is somewhat limited, and most information which I have been able to locate comes from North America. Here, hazelnuts of both available species are frequently recorded as having been used for food. Moerman's (2003) Native American Ethnobotany online database, which, though by no means exhaustive, is widely regarded as one of the best compilations of ethnobotanical information from the continent records 63 instances of use as a food of *Corylus* nuts, of which 27 records are for *Corylus americana* (widely distributed over the eastern half of the continent) and 36 for *C. cornuta* (more widely distributed in both the east and the west, and including the *californica* subspecies confined to the west coast). This compares very favourably to 56 records for species of hickory and related nuts (several species of *Carya,* though with over half of the records for the most commonly-used *Carya ovata*); 15 for *Fagus americana* (beechnuts); 14 for *Castanea dentata* (chestnuts); 11 for *Aesculus* spp. (horse chestnuts or buckeye); with 61 for *Juglans* spp. (like *Corylus* including species with a western as well as eastern distribution, probably boosting the genus' representation in ethnographic records). 277 instances of “acorn” (*Quercus* spp.) for food are listed; with 92 for *Pinus* nuts. (Note that figures derived from Moerman's database should be used as a very rough guide, since the assignation to particular species is not always clear in original sources, and where several tribes were present within the region covered by the original source the same use originally recorded is sometimes duplicated for each tribe).

Though the number of recorded uses of *Corylus* in North American ethnographic reports is initially encouraging, closer examination of the sources often reveals that, while relatively detailed information is often recorded for other nut species (often *Carya*, *Juglans* or *Quercus* in the east; or acorns or pine nuts in the west) references to hazelnuts often record simply that they were “gathered”, “eaten” (fresh or dried), or sometimes “stored for winter use”. This seems to be the case even in reports written by ethnographers with a particular interest in plants. As roasting of hazelnuts is frequently postulated in relation to European Mesolithic finds of charred hazelnut shell it is instructive to find that, of the 63 food uses recorded for *Corylus* spp by Moerman, only one mentions the use of roasting; while roasting in general is recorded in relation to 79 food uses of plants of all types. Fifteen of these are for nuts of several *Pinus* species, two for *Quercus* spp. acorns, and one for *Aesculus* nuts – the majority are for small seeds, with about a quarter for starchy roots, tubers or other vegetative organs.

Though by far the greatest number of records of the use of hazelnuts as a food resource in situations which may have some analogies in prehistoric Europe come from North America some factors should be borne in mind when seeking comparisons with these ethnographic records. Though some of the earlier historic records made in North America relate to uses of nuts by populations who had had a relatively short exposure to European influences, many of the more detailed ethnobotanical surveys were carried out as late as the early twentieth century among populations who had experienced, at the least, significant acculturation, depopulation, geographic displacement and/or restriction, as well as the introduction of European foodstuffs and technologies. For instance, Palmer (1871, p. 411) in his compilation of *Food Products of the North American Indians* simply noted that nuts of *Carya* spp., *Juglans nigra* and *Corylus americana* were common east of the Missouri river, and that “in former years they furnished the food for a much larger number of Indians than at present, the greater portion of the tribes having been removed farther west. The quantity consumed at one time seems incredible and would certainly be unsafe for civilized stomachs”. Huron Smith (1928 p. 180), who wrote several ethnobotanical accounts of peoples originally from the Great Lakes area, specifically to record the past uses of plants in Wisconsin, noted in his introduction to the *Ethnobotany of the Meskwaki Indians,* that not only were the informants he interviewed now living in Iowa, but he was also “handicapped in that he must deal entirely with the older members of the tribe for the younger people are not interested in retaining the lore of their grandparents” and the older people were fast dying out. (He also commented that the frequent lack of teeth in the older generation meant that their pronunciation of botanical and ethnobotanical terms was less succinct than it might have been, leading to difficulties in transcribing names which could be compared with those supplied by other informants!]. Often the informants themselves in ethnobotanical accounts are referring back to memories of practices carried out by older people at the time of their youth.

Many ethnographically-recorded peoples, though having considerable reliance on foraged, fished or hunted wild resources, incorporated horticulture of cultivated or domesticated plant resources to a greater or lesser extent in their diet, and this may have affected the role that nuts played in subsistence compared to European Mesolithic populations who may have been reliant solely on hunting and gathering. Records of nut use from less acculturated populations often derive from peoples living towards the margins of the distribution of nut species, along prairie margins or towards the borders with boreal forest in the east, or in the high mountains or plateaux of the west. Nuts seem to have been used even at the margins of their distribution, however. For example, Gilmore (1919), in one of the seminal works of North American ethnobotany, focussed on the Plains Indians of Nebraska, recorded that nuts of *Corylus americana* "were used for food as were other nuts, being eaten raw with honey, or used as body for soup". However, though the context in which ethnobotanical accounts were made could be problematic, it is worth pointing out that, though discussions of European Mesolithic hazelnut often focus on idealised hunter-gatherers, categorized largely by their lithic technologies, often with high mobility, and low visibility - if any - of plant use (let alone intensive or specialised use of plant resources), situations more akin to those in ethnographic accounts may have applied to populations at some time or other in prehistoric Europe.

Because it was soon apparent that the detailed evidence on hazelnut use was relatively sparse, I have chosen to include information on the use of other nuts where these were also recorded, in part because they provide some indication of the relative role of hazelnuts to other nuts, which in some case may have analogies with the European situation. Thus, some information on acorns, *Carya* spp. and *Pinus* spp. Is included in the discussion below, but as these are relatively well-known (both ethnographically and archaeologically) and the former two in particular are regularly referenced in discussions of Mesolithic European nut use there is no attempt to be exhaustive; whereas others, such as beechnuts are rarely discussed, and as much detail as possible has been included. A review follows, focussing first on Eastern North America, an area with one of the closest analogies with temperate forested European environments.

Eastern North America

The ethnobotanical work of H H Smith on native peoples from the Great Lakes area in the early twentieth century has already been referred to above, and he recorded uses for both the hazelnut species present in the region. Beaked hazelnut was the only species recorded for the Forest

Potawatomi, and was a favourite food, especially when the nut was just about mature or “in the milk”, and it was also gathered for winter use (Smith 1933). The Ojibwe (or Chippewa) from the Lake Superior area used both species “as food”, and Smith (1932 pp. 397-8) again noted that one group was particularly fond of the newly gathered nuts of *C. americana* before the kernel hardened (he also mentions eating the sweet nuts of the beech tree). The Meskwaki (Smith 1928 p. 256) and the Menomini (Smith 1923) both collected *C. americana* nuts in the milk stage as well as when ripe, as well as saving them for winter use. The Menomini were described as drying the nuts first.

Other major uses of nuts recorded by these groups were of hickory and walnuts, used by the Ojibwe (Smith 1932) and the Menomini, the latter “in the same way that the white man does” (Smith 1923, p. 69). The Potawatomi were also described as using “all kinds of acorns indiscriminately”. They made lye (an alkali solution made from ashes and water which neutralises the tannic acid) from hardwood ashes and water to remove tannins and “swell the acorns”. These were then put in bark bag or reticule which was washed through a series of hot and cold waters to remove the lye. They were then dried in the sun after which they “became perfectly sweet and palatable”. They were “ground in depressions of rocks which served as a sort of primitive mortar with a stone pestle, to a flour, which is cooked as a gruel” (Smith 1933, p. 101). Much the same process is described for the Ojibwe (Smith 1932), where they were again used primarily as a basis for soup stock. They similarly used all oak species available, which were all described as requiring lye treatment. The Menomini too prepared “any kind of acorns that were available” (Smith 1923. p. 67) and it was additionally recorded here that they were “first parched to aid in flailing off of shells”, then boiled, subjected to lye treatment, and then simmered to remove the lye. They were then ground with a mortar and pestle and sifted with a birch-bark sifter, before cooking to a soup with deer meat broth, or a mush with bear oil seasoning. One acorn species was roasted and ground to make coffee.

Some of the most detailed accounts relating to the use, and particularly the detailed preparation, of plant foods in a northern temperate woodland environment come from Parker's (1910) and Waugh's (1916) accounts of the Iroquois, drawing on historic accounts and well as direct evidence from living informants. Unfortunately, though nut foods in general are discussed (including several species of hickory, walnut and acorn, together with chestnut, beechnut and both North American species of hazelnut) they are less thoroughly documented in these accounts than some other categories of plant foods, as nut use in particular seems to have become less important with the introduction of European foods. In particular it is not often specified which particular nut species are referred to. However, as these reports often detail elements of technology and material culture which are often missing from, e.g., Smith's accounts, it is worth including some details here.

Parker (1910, p. 99) noted that the favoured nuts of the Iroquois were hickory and chestnut, though other nuts (including *Corylus*) were valued. Waugh (1916 pp. 123-124) recorded one informant who noted that "the older people used to crush the meats of hickory, walnut, butternut and chestnut, and mix them with the cornmeal for bread. Beans or berries were added in the usual way. Any kind of nut, except acorn, might be used." Acorns were, however also used by the Iroquois, principally the sweeter acorns - but in times of necessity also the more "bitter" species - by boiling in water, sometimes with the addition of lye, and "were considered very good" (Waugh 1916 pp. 122-3). Parker also records their use roasted, after boiling in lye (1910 p. 101)

Many of the early historic accounts of nut use from eastern North America refer to the "oil-boiling" of nuts, which is recorded by both Parker and Waugh. Waugh reported (1916, p. 124) that the kernels of "hickory, walnut and several other" were pounded, boiled slowly in water, and the oil skimmed off with a bowl, to be used mixed with other foods, "to improve the flavour". A similar process could also be used for oily seeds, such as sunflower (Parker 1910, p.101). The cooked kernels were "often seasoned and mixed with mashed potatoes". Parker (p.100) noted that the liquid remaining once oil and kernels had been removed was drunk. I have been unable to locate any references to this method used specifically for hazelnuts. A very detailed account of present-day processing and consumption of hickory records the production and storage of balls of sifted and pounded hickory nut kernels mixed with small fragments of nut shell, which are subsequently made into hickory nut soup (*ku-nu-che*) by Cherokees in eastern Oklahoma using a combination of ancient and modern technologies (Fritz *et al*. 2001). They note that though early ethnohistoric records make no mention of these ku-nu-che balls, and that production of "milk" and oil have thus been emphasised in archaeological discussions of past practices, it is highly likely that ku-nu-che balls were produced in the past close to nut groves, particularly by populations who lived at some distance from hickory trees, or were not fully sedentary as they reduced the weight of nuts for transport by this process – transport of ku-nu-che balls was likely to have been much easier than carrying bags of whole nuts or pots or skins of oil. Though the balls can spoil relatively quickly if warm weather persists through the autumn they point out that in much of the Eastern Woodlands it is cool enough by November for them to survive for at least several weeks.

Pounded kernels of unspecified nuts, apparently without any further treatment, could also be added directly to soup made from corn, "to make it rich". Both Parker and Waugh recorded that nut-cracking stones had been regularly used until recently, according to Waugh consisting of a couple of stones with pitted centres (1916, p. 123), while Parker (1910, p. 101) noted that "cuplike depressions, the size of the nut were picked into small boulders or slabs of shale" and that nuts were placed in the depression and cracked or crushed with a suitable hammer stone. These large slabs were still commonly to be found near "large old nut trees" or where nut trees were particularly plentiful.

Another use recorded by Parker (1910, p. 101) from one Iroquoian group was the pulverization of dry nuts (hickory, *Carya ovata* and butternut, *Juglans cinerea*) which were then mixed with dried bear or deer meat similarly pulverized in a mortar. The whole was then boiled together in water to produce a baby food.

Both Parker (1910, pp. 46-49) and Waugh 1916 (pp. 58–60) recorded and illustrated much detail on pestles and mortars, both of wood and stone, as well as cracking and grinding stones, apparently used for processing both corn and nuts, amongst other foods. Specific tools for nuts are rarely mentioned, though Parker (1910, p.100) notes the use of a "wooden bowl" for pounding nuts. Various cooking methods used by the Iroquois are also described, and Waugh (pp. 54-57) noted that since the introduction of European metal cooking pots the making of pottery vessels, which had formerly been used as cooking pots, had been discontinued. However, historical records suggest that the use of wooden and bark cooking vessels had been at least as common as the use of the more fragile pottery, and that though boiling seemed the preferred cooking method for many foods, others, including baking on flat stones or roasting in embers, and cooking of some foods in earth ovens or by stone-boiling in pits were also used. Though wood and bark vessels were sometimes used for stone-boiling (cooking by adding stones heated in a fire to a liquid in various water-tight receptacles or facilities), bark "kettles" made of elm bark slabs held together with inner bark could be used for cooking in direct contact with fire, enabling food to be cooked before the bark vessel burned through. Parker (1910, p. 52) also mentioned cooking on the fire in bark vessels which remained intact if the flames were kept away from the rim. Amongst other technologies which may be relevant to the European Mesolithic Parker (1910, p.100) refers to the practice of drying the nuts of hickory "upon a mat over a hurdle", recorded by John Smith in the seventeenth century.

Both Parker (1910, pp. 34-35) and Waugh (1916, pp. 41-44) also describes storage facilities for plant foods, including above-ground granaries of bark, principally for corn, and storage pits used for corn and other plant foods, including apples. Though nuts are not mentioned as having been stored in these pits, the descriptions, as well as the capacities, may be of interest in relation to archaeological features identified as possible storage pits in the European Mesolithic. Pits were 4 to 5 feet deep and might be lined with bark slabs (usually of elm), grasses, *Carex* (sedges), or hemlock (*Tsuga canadensis*) branches, and covered with soil. These protected stored products from excessive heat or cold, animal or pest incursions, or theft. Another indication of the size of storage pits used in the Eastern Woodlands comes from a description in *Peter Kalm's Travels in North America* (Benson 1937) of pits used by Indians in Pennsylvania and New Jersey, again for storing corn – after reaping "they kept it in holes under ground during winter; they seldom dug these holes deeper than a fathom, and often not so deep; at the bottom and on the side they put broad pieces of bark. If bark could not be had, the *Andropogon bicorne* … [possibly *Andropogon gerardii*, a long-stemmed grass with many technological uses (see e.g., Moerman 2003)] supplied the want of the former. The ears of corn were then thrown into the hole and covered to a considerable thickness with this grass, and the whole again covered by a sufficient quantity of earth. Corn was kept extremely well in these holes, and each Indian had several such subterranean stores". Though these examples come from peoples with some reliance on cultivated crops storage facilities for nuts recorded in western North America (described below), often by groups with a heavier reliance on gathered resources, are similar in size and construction, and are also indicative of the overall quantities of plant foods stored by peoples with varying degrees of mobility.

Though the comparative lack of detail on the use of nuts, and in particular the species of nuts used is somewhat frustrating, one further source of information indicates the significance these resources may have had as a whole in the subsistence system – linguistic evidence - Parker (1910, p.100) in particular recorded a wide range of terms relating to nuts and their use, which included specific words for nut meats, oil, and "milk", and differentiated words for pitted nut stones, hammers and complete nut-cracking "outfits", ripe, rancid and "good" nutmeats, for ripe nuts both on the tree and on the ground, as well as for components including "nuts", meats, as well as "entire nut meats" shells, and "shucks". Though Parker also recorded the names of the various nut species used (see above), he did not record any specific differences in these terms, which all seem to refer to nuts in general.

Several other groups have been recorded as having used, and occasionally stored, nuts of both American species (see Kuhnlein & Turner 1991 and Moerman 2003 for lists) but there appear to be few further details; with the only exception, interestingly, being a report that the Iroquois roasted the nuts of *Corylus cornuta* (Rousseau 1945, cited by Moerman 2003). There are also some recent accounts of the use of hazelnuts not focussed on Native Americans. Fernald and Kinsey (1958 p.151) who compiled their *Manual of Edible Wild Plants of Eastern North America* in the 1940s, stated that the nuts of both species were popular in country districts, and that the nuts were gathered for winter use, eaten fresh, or ground as an ingredient of cake or cake-like bread (though they recorded no further detail). They also pointed out an important distinction between the nuts of *Corylus americana* (thick-shelled) and *C. cornuta,* with the shell "comparatively thin and usually easily cracked between the back teeth" (though this is not mentioned elsewhere). Ulysses P Hedrick the botanist and horticulturalist known most widely as the editor of *Sturtevant's Edible Plants of the World* wrote in an account of his childhood in the late nineteenth century in Northern Michigan (Hedrick 1948, p. 129) that while living in northern Indiana "we had a great abundance of walnuts, butternuts and hickory nuts – delicious viands especially for winter evenings with cider and apples", but that "none of these grew in the forests about our new home. The beaked American hazelnut grew sparingly, but the nuts were so small and so well protected by burs that we seldom bothered with them except to fill our pockets in autumn for schoolroom consumption". Beechnuts were, however in great abundance. "In a beechnut year, we children could quickly gather a bushel, so thickly were they spread over the garden carpet of beechnut leaves. We picked beechnuts only after heavy frosts, when the four nutlets...dropped from their round spiny burs. The kernels had a rich creamy flavour, very delicious, but slow eating because of difficulty in getting the meats out of the husks...the nuts began to sprout even under the snow, but we ate their shoots and rootlets, until the sprouts were an inch or two long; no doubt they were full of vitamins". Despite their recorded periodic abundance, there are few references to the use of beechnuts from North American ethnobotanies. Among the Ojibwe "the sweet nuts of the beech tree" were appreciated and eaten fresh, but "there are never plentiful enough to store for winter" (Smith 1932, p. 401); while the Menomini gathered and stored them for winter use (Smith 1923). A more recent Algonquian ethnobotany recorded that in south west Quebec beechnuts were used for food, "mainly by men working in the bush" (Black 1980, cited by Moerman 2003). Gilmore (1933, p. 128 cited in Moerman 2003) recorded the following about Chippewa use; "Nuts used for food. People sought for stores of beechnuts which had been put away by chipmunks. These hoards saved the labor not only of gathering, but also of shucking and were certain to contain only sound nuts. The people had observed that chipmunks never stored any that were not good." Smith (1933, p. 100), regarding the Potawatomi similarly noted "Beechnuts used for food. The hidden stores of the small deer mouse was what the Indians relied upon. The deer mouse is outdone by no other animal in laying up winter stores. Its favorite food is the beechnut. It will lay up, in some safe log or hollow tree, from four to eight quarts, shelled in the most careful manner. The Indians easily find the stores, when the snow is on the ground, by the refuse on the snow." (Note similar practices are also recorded by Stahlberg & Svanberg (2010, p. 194) across Siberia and the European Far North, undertaken by "indigenous peoples and immigrant peasants" for a wide range of nuts (including hazel and pine), plus underground storage organs. They cite Linnaeus' observation that "wild hazelnuts … taken from mice were the best nuts that could be found".)

Western North America

Both Moerman (2003) and Kuhnlein & Turner (1991) include compilations of several references to the use of hazelnuts from the west, but again, detailed information is often sparse.

Kuhnlein & Turner (1991) regarding use of the nuts in Canada record summarised their findings: "Hazelnuts were usually harvested from late August to October, and stored until completely ripe. The prickly husks of beaked hazelnut were sometimes removed by burying the nuts in damp ground for several days or placing a sack of them in a hole and pounding them with a pole. Caches of the nuts made by squirrels and other small mammals were also sought. The nuts were an important trade article." They cite trade between several groups, including the Blackfoot/Nlaka'pamux described below. They also noted that "today, most people use commercial filberts, but within the memory of contemporary elders, the wild nuts were especially used around Christmas time, and were relished by children. One Pemberton Lillooet woman remembered picking "sacks and sacks full" when she was a girl". Turner (1975) noted that among coastal populations the nuts were eaten raw after ripening "whenever available".

Gunther (1945 p. 27) recorded quite varied use of Californian hazel nuts from studies undertaken in western Washington in the 1930s. The "Cowlitz bury nuts for winter in a cylindrical type of fish trap. The Chehalis and Puyalup eat the nuts fresh and also store them for winter. The Skagit eat the nuts fresh and crack them with a stone; they never store them. The Lummi, Snohomish and Swinomish also eat them fresh." She also (1945, p. 27-28) describes the differing uses of acorns by different tribes, ranging from eating without preparation, through roasting on hot rocks; simple burial in mud to leach; to roasting and storing overwinter in a basket buried in mud of a slough overwinter (after which, when taken out in the spring "they look spoilt but are delicious"). One tribe never ate acorns. Gunther comments that because they were eaten only in small quantities the amount of tannic acid was not dangerous and "the elaborate leaching process used in northwest California, where the acorn is a basic food, is not necessary."

Teit (1930 pp. 491-492) who recorded some detail on the processing of *Pinus albicaulis*, reportedly the favoured nut of the Thompson Indians (or Nlaka'pamux*)* of interior British Columbia, who relied extensively on root foods, noted that *Corylus californica* nuts were eaten and that Upper groups traded nuts of *P. albicaulis* for hazelnuts from Lower groups. He noted that *Corylus* nuts were "often shelled in small quantities by putting them inside the moccasins and running on them" (which seems unlikely! Possibly this refers to the removal of husks). Kuhnlein & Turner (1991) also cite evidence suggesting that some Nlaka'pamux people practiced controlled burning of hazelnut bushes to enhance their nut production.

Another group, the Okanagan-Colville people "as well as eating the nuts whole, like peanuts... mixed the kernels with bear oil, or pieces of bear meat or grease, or sometimes berries or cooked roots, then formed them into cakes and dried them, or stuffed them into a length of intestine. This mixture was eaten as a relish, like butter" (Turner et al., 1980, cited in Kuhnlein & Turner 1991).

In coastal California, in an area with foggy summers and wet winters, where hazel (*C. cornuta* var. *californica*) grew along streams they were used by the Sinkyone tribe (Nomland 1935), along with acorns (most important) and buckeyes/horse chestnuts (*Aesculus*). While the latter two required intensive processing using a combination of grinding, leaching and parching, and were stored in dried or parched form; hazelnuts were simply husked, "broken" and cooked into a lumpy mush, or dried and stored. Kniffen's (1939) *Pomo Geography*, also relating to coastal northern California, reports simply that hazelnuts were available locally and were kept all winter – contrasting with buckeye (horse chestnut) which "were baked, leached and eaten with salty kelp or seaweed", but he noted buckeye did not keep well so were not stored for winter use (a statement which is contradicted by other ethnographic sources).

DuBois **(**1935 p.20) gives detailed descriptions of acorn and *Aesculus* preparation (the latter second in importance to the former) by the Wintu (again in the coastal ranges of northern California). She recorded that hazelnuts were "gathered in hills in July and August. Hulled at leisure in village by hand, or by beating nuts with willow switch. Shelled during evenings like acorns. Stored, often in same container as pine nuts". Two types of pine nuts were collected (from digger and sugar pines) (p.21). Unripe digger nuts were eaten late in May, unshelled, while ripe nuts were gathered in autumn, stored shelled or unshelled, and eaten with acorn soup. Sugar pine nuts were used only when ripe, in the autumn. Groups travelled to the mountains, where they also hunted deer at the same time. Men climbed the trees and "switched" down cones, which were then roasted and pounded to release nuts. These were then winnowed. Nuts were boiled to remove their pitch flavour. The nuts were stored in baskets lined with maple leaves and eaten with salmon flour in which salmon eggs were also mixed. This second process matches closely many other ethnographic reports of pine nut processing.

Ethnographies from California often focus their discussion of plant foods on the use of acorns, undoubtedly a major food resource. Studies with very detailed information on acorn preparation often simply mention that hazelnuts were gathered, e.g., "in considerable quantities in the mountains" by the Shasta of the mountainous California/Oregon border (Dixon 1907, p.423; see also Dixon 1905).

Beal's report of the Southern Maidu (or Nisenan) (1931, pp. 351-352) included some information on storage, including descriptions of acorn storage facilities recorded elsewhere in some of California. Hazelnuts were gathered in quantities and kept, like pine-nuts, in sack-like containers, whereas most other foods were stored in baskets. Acorns, however, were stored in long cedar-bark tubes or more commonly in large above-ground granaries, 4-5ft in diameter (supported on wooden posts), or, when leaving camp, concealed in underground caches lined with bark and leaves, which were also used to store reserve supplies in good years.

Hazelnut exploitation in the European Mesolithic

The potential role of hazelnuts in subsistence in the European Mesolithic is a topic that has been regularly addressed, often with a focus on the potential yields available in terms of calories and depending on estimates of potential productivity derived from the ecological literature, as well as harvesting and processing costs derived from a combination of ethnographic or ethnohistoric accounts and experimental studies. Studies have also focussed on the potential impacts of Mesolithic peoples, either positive or negative, on hazelnut productivity and the consequences for their utilization, as well as the implications this may have had for their continuing use or disuse in the Neolithic; or on the potential impacts climate change may have had on patterns of use. The consensus view is that, on the basis of their potential abundance and widespread availability in the environment, potential yield, harvesting efficiency, nutritional and caloric value, and potential storability, in combination with abundant archaeological finds of hazelnut shell from the period, they are highly likely to have been a dietary staple or major contributor to the diet of Mesolithic peoples, though the extent to which this continued in the Neolithic is less certain. As recent reviews have covered these issues in detail (Bishop *et al.* 2009, 2013, 2015; see also Cunningham 2011a; Holst 2010; Regnell 2012) I will not attempt to repeat the reasons for these conclusions here, but instead will address particular aspects of the utilisation of hazelnuts in the light of the ethnographic data which has been presented above.

1. Harvesting

Data on yields and harvesting of North American hazelnuts are often used as direct analogies for the European Mesolithic, and it is worth addressing briefly how apt these might be. As indicated above, there are two species present in North America, with some overlap in distribution. Kuhnlein & Turner (1991) in a review of use in Canada cite ethnographic reports indicating that both species were widely eaten, and that where their ranges overlapped both were used (Kuhnlein & Turner 1991), and the ethnographic data surveyed above found no recorded preference for the use of either species. Modern forager Samuel Thayer (2010, p. 197-205), however points out several differences between the species which might potentially have affected their use - including the presence of tiny irritating spines on the husks of beaked hazelnut, the often larger clusters of nuts of American hazelnut, the earlier ripening (by about a week or two) of beaked hazelnut, and its better flavour (to his taste). He suggests that American hazelnut is easier to harvest in quantity as it often dominates over large areas, while beaked hazelnut is more generally dispersed, though it may form small thickets. Thayer also notes that beaked hazel bears fewer nuts per bush, but that American hazelnut has a larger percentage of empty or wormy nuts, though all his comments relate specifically to his local area. Both are understory shrubs, though favouring different forest types, but they both grow most profusely in marginal or disturbed areas. While the ecology of the two species differ somewhat from *Corylus avellana* in present day Europe they probably make a rather good analogy for environments dominated by birch-willow-hazel scrub such as is, for example, suggested to have dominated the environment in the Late Mesolithic in the Aberdeen Bypass area, during pollen zone HM1 (Timpany 2016). One difference, though, which may have been significant is the height of the bushes - Talalay *et al*. (1984, p. 340) in their assessment of yields of a number of nut species in the Eastern Woodland noted that *C. americana* shrubs were rarely above head height so picking was easy, while hazel in Europe is a small shrub or tree of 6 to 12m (Stace 1997), and personal observation suggests that even young bushes which have just reached nut-producing stage often have branches which are higher than this picker can reach.

Secondly, ethnographic data from North America is often cited to suggest that hazelnuts are most likely to have been picked when under-ripe ("in the green" or "milk-ripe"), and the review above clearly supports this suggestion; but it is worth pointing out a differences between North American hazelnuts and *Corylus avellana* which may have implications for harvest at this stage. The harvesting characteristics of *C. americana* were outlined in detail by Talalay *et al*. (1984, p. 349) (and this study is one on which many European assessments of yield as well as processing efficiencies used are based), who conducted collecting experiments through the season to determine the optimal harvest time in terms of yields. Both American species of nuts are tightly enclosed in bracts; and thus are closer to the cultivated Kentish cobnut, (a hybrid of *C. avellana* with *C. maxima* which also has elongated bracts, less conducive to easy dehiscence), than they are to wild *C. avellana*, which has shorter and more open bracts. Bracts of the American species remain green for some time after ripening, and in *C. americana* are large and leaf-like, so that, though nuts were ripe by August, their visibility was poor, making harvest difficult, but by late September bracts were changing colour and leaves were falling, leading to increased harvests. By mid-late October almost all leaves had dropped but the nuts still remain on the shrubs, and this is thus the optimal period for harvest. Bracts do not begin to split until early November, shedding nuts to the ground where they are rapidly predated by animals. However, they also noted considerable variation from stand to stand in date and rate of dropping, with some bushes retaining a few nuts as late as January. These observations compare well with ethnographic summaries from across a wider area, e.g., Kuhnlein and Turner (1991) noted that "Hazelnuts were usually harvested from late August to October, and stored until completely ripe". As *C. avellana* nuts, once ripe, begin to drop readily from the bushes there may be much less opportunity for a prolonged harvest than with American species; on the other hand, practices such as shaking branches to encourage nuts to drop would be more effective with *C. avellana,* and might compensate for the difficulties of reaching nuts on taller bushes. The former might suggest a greater need for a more mobile as well as a more time-focussed harvesting strategy in the European Mesolithic than may have been possible in North America, as it might have been necessary to range more widely to find bushes or areas with nuts ripening at different times.

Parker (1910, p. 99) recorded an account of nut harvesting by the Iroquois, which is of some interest. He noted that gathering of nuts was often left to the young, and, together with the autumn harvests of berries of many kinds, it seems to have been regarded as a joyful activity, largely because of the communal nature of the harvest. However, Parker notes that the women "often went in companies, when serious business was meant, for with the failure of other crops, nuts formed an important food source".

2. Storage

Howes' (1948, p. 148-9) description of the storage of Kentish cobnuts is frequently cited in the archaeological literature. Nuts were "laid out to dry in airy sheds and turned over periodically to prevent mould", while "for home use" they could be stored, remaining "fresh and milky" until March, or even later provided they were first "thoroughly ripe and dry, to mitigate against mildew", and, to prevent shrivelling, kept in closed containers, perhaps covered with layers of sand, or salt and sand, in a cool place such as a cellar. Rowley-Conwy (1984 p. 307), for example, suggested that it was very unlikely that the necessary storage conditions suggested by Howes could have been achieved in the Mesolithic.

While ethnographic accounts detailed above clearly indicate that hazel, along with other, nuts can be stored, there is little detail specifically relating to them in terms of technology or storage period, contrasting in particular with the prolonged storage recorded for acorns. Ethnobotanical studies in the Primorye region (coastal Far Eastern Russia) cited by Sergusheva & Vostretsov (2009, p. 215), found that acorns were the major carbohydrate resource for indigenous peoples of the Russian Far East, and that these and Manchurian walnut were stored in large quantities, but that though the two species of hazel (*C. manchurica* and *C. heterophylla*) were very common "the nuts cannot be stored for long periods and are used before the beginning of winter".

Perhaps because of the lack of detail, and the frequent reference to heat-treatment of acorns, the suggestion that roasting of hazelnuts is required for storage has become prevalent in discussions of the Mesolithic, (and is frequently cited as one of the principal reasons for roasting supposedly demonstrated at a number of northwest European sites); and Ray Mears, in a repeat of the roasting method used by Score and Mithen discussed below commented that roasted hazelnuts were still edible and tasty and tasty three years later. However, other experimental studies have found the opposite, with roasted nuts surviving less well (e.g., Cunningham 2005; personal observation), and this is supported by studies of commercial hazelnut roasting (see Maness 2004; also Bishop 2013, p. 38).

Holst (2010) suggests that nuts in the Duvensee area were shelled to enable easier transport of hazelnuts; again, reports from the hazelnut industry indicate that shelling significantly reduces storage life, and that in controlled cool conditions dried nuts in their shells will keep for 12-24 months, with a maximum of 6 months for roasted nuts (PFAF database; Maness 2004). Bishop (2013, p. 39) suggests that drying nuts is likely to have enhanced their storability, as does much of the ethnographic evidence. Again, drying methods are not often detailed, but "parching" is frequently recorded for acorns in particular. Parching differs from roasting in that it involves brief contact with a heat source such as hot embers, usually with constant agitation, which simply surface-dries and destroys microorganisms on the parched items; but it does not cook the internal contents, though in some cases, such as recalcitrant seeds (in which the embryo is easily destroyed by drying) it might also prevent subsequent germination. Scarry (2003 p. 66, citing Petruso and Wickens 1984) points out that acorns require parching before storage to "destroy mold, prevent sprouting and destroy worm infestations"; and that this differs from methods needed for high fat nuts, but these are not specified, and parching is often cited as a stage in processing of (high fat) pine nuts in western North America***.***

3. Shelling

Specific methods for shelling hazelnuts are not detailed in the ethnographic record, but the ethnography of nut-shelling worldwide suggests a limited number of methods, primarily the "anvil and hammer" method (often with stones, usually for cracking nuts one at a time; or, eg., using wooden "paddles" most closely associated with the shelling of water chestnut (*Trapa* spp. - see e.g., Borojevic 2009), and the mortar and pestle method (in which could be included the use of a flat "anvil" to which a basketry "hopper" is attached) which is primarily suited to crushing whole nuts, often in numbers, with separation of more-or-less fragmentary shell and nut kernel undertaken subsequently); though methods such as the mass-processing of nuts by heating and then pouring cold water over the shells to crack them are also described (Howes 1948). The hammer and anvil method has been tested on hazelnuts by a number of experimental archaeologists (McComb & Simpson 1999; Score & Mithen 2000; Talalay *et al*. 1984; Lopez-Doriga 2013***;*** Roda Gilabert *et al*. 2012). Talalay et al. (1984, p. 351) for example noted that "as nuts were cracked a pit developed in the lower stone and deepened as additional nuts were cracked, making the process easier as nuts were held in the pit" (see also Goren-Inbar *et al*. 2002).

Zvelebil in 1994 (p. 56) pointed out that though pounding and grinding stones were widely reported from Mesolithic European sites they were rarely interpreted as potential plant processing tools, and to some extent this seems to still be the case; in contrast with North America, with much closer ethnographic analogies. Roda Gilabert *et al*. (2012) undertook experimental work and analysis of archaeological examples of pitted stones, concluding that nut shelling and processing may have been one of a number of uses of what were probably multifunctional tools; and there is an increasing acknowledgement of this as a possible role, particularly at perceived "hunter-gatherer" sites, and more especially in southern Europe, in some cases in conjunction with the use of studies of potential plant food residues (see e.g., Boric et al 2014, p. 18; Cristiani *et al*. 2016; Roda Gilabert *et al*. 2012; see also Goren-Inbar *et al*. 2002). This is especially so when they are found in close association with finds of hazelnuts (e.g., Mithen *et al*. 2001; Holst 2010). Pitted or cup-marked stones associated with the Neolithic and later periods are much more likely to be interpreted as "enigmatic" art or ritual objects, even when there are indications of nearby nut use, such as at Late Neolithic Beckton Farm (Pollard 1997). (A similar situation exists with large-scale versions of these known from across Europe and the Near East whose similarity to bedrock mortars is seemingly rarely acknowledged – Younker 1995; Wright 1994; see also http://oldeuropeanculture.blogspot.co.uk/search?q=bullaun).

Particularly in the case of hazelnuts nutshell is usually the only surviving part of the nut, and several studies have addressed its interpretation. Experimental cracking of hazelnuts has suggested that roasted hazelnut shells tend to break into fewer and smaller fragments than unroasted examples (Score & Mithen 2000; Lopez-Doriga 2013); or that nutshell fragments charred after cracking can potentially be distinguished from charred nutshell which has subsequently been fragmented, though attempts to apply this to an archaeological sample were equivocal, probably because the sample derived from a mixture of primary and secondary deposition (Lopez-Doriga 2013). Other potential problems in drawing comparisons between the results of charring experiments and actual charring of nutshell represented in the archaeological record is illustrated by one peculiar finding of Score & Mithen's (2000, p. 511) experiments. In experimental cracking of hazelnuts which had become fully charred, in addition to concluding that any kernels inside such nuts would be inedible, they found that these charred nutshells were very brittle and tended to easily crush when cracked, leaving a quantity of powdered shell, which, if it was generally the case, might suggest that survival of charred hazelnut shell should be much less common than it appears to be.

While other studies such as that of Berihuete Azorin & Antolin (2012) have used charring experiments of hazelnuts to provide a more systematic basis for estimates of minimum numbers of nuts represented in archaeological contexts, the reliability of the data to which these methods might be applied is variable. While taphonomic biases affecting the relative representation of nutshell in archaeological contexts has been long acknowledged (see Bishop 2009 for a summary; also Pearsall 2015 for a North American survey), problems of non-standardisation of recording may make these difficult to apply, as Bishop notes is the situation in Europe: "While some sites may have quantified all of the hazelnut shell regardless of how small the fragments were, on other sites only the larger fragments may have been counted. Generally, this information was not detailed in archaeobotanical reports, so the extent to which different quantification methods have been employed is unknown. Equally, on many sites hazelnut shell fragment frequencies were not quantified at all and simply recorded as a level of abundance or estimated rather than counted ... consequently, assessing the relative abundance of hazelnut shell between different sites is very difficult" (Bishop 2009, p. 81).

The results of charring experiments have been used in some studies making quantitative assessments of the role of hazelnuts in diet from charred remains in archaeological contexts, and these have involved often time-consuming or complex extrapolations and/or measurements of nutshell (e.g., Carruther's (2000) analyses used by Mithen et al. (2000); or the analysis of finds from sites in the Forth Estuary (Robertson *et al*. 2013). In North America, where nutshell finds in abundance have a long history of analysis a more pragmatic approach is widely applied, or at least advocated by leading archaeobotanists, recording both counts and weights in a systematised fashion and allowing measures of density (per sample volume) and ubiquity to be used which both attempt to compensate for taphonomic biases (see Pearsall 2015; or pages.wustl.edu/peblabguide/guide/sorting-flotation-samples for a detailed outline of laboratory practice), and to allow hypotheses relating to long-term changes in the abundance of different nuts on regional scales based on relatively comparable results to be derived (e.g., Carmody & Hollenbach 2013; Messner 2011; Scarry 2003). Other reasons for both counting and weighing nutshell have been advanced – e.g., in Fritz *et al*.'s (2001) study of ku-nu-che ball production discussed above they suggest that, for example, a low nutshell weight which might normally be interpreted as indicating the lack of importance of hickory nut at a site could, if combined with a high count, suggest the import of ku-nu-che balls to an area (resulting in numerous tiny fragments of nutshell); whereas smaller numbers but larger pieces and possibly a much larger weight of nutshell might indicate an initial processing site where the first part of the two-stage process of first carefully cracking nuts and removing bad and wormy specimens before mass pounding of good nuts to produce the balls had occurred. Also of interest in this study was the finding of a tool preference for the two stages of processing – flat stones for initial cracking, but mortars for finer pounding, and they suggest that mortars, often associated by archaeologists in the East with maize processing, may have been originally used in nut-pounding before becoming transferred to maize processing – a situation analogous to that which has been suggested in the Near East in relation to acorns and cereals (e.g., Wright 1994).

Potential taphonomic biases which have been suggested to be particularly relevant to the representation of hazelnut shell in European contexts include the likelihood that nut shell may have been used as a fuel. Thus, in Eastern North America, thick-shelled nuts, particularly of *Carya* and *Juglans* are often the most abundant archaeobotanical remains, in comparison not only with non-nut remains but with thinner shelled nuts including hazelnuts and acorns, but also beechnuts and chestnuts, and the "obvious" taphonomic reasons for this are widely acknowledged (see references cited above). It may be of particular interest that charred hickory and walnut dominate assemblages, as indications from the ethnographic record as discussed above do not suggest that either of these nuts are likely to have come into direct contact with fire as a direct consequence of the methods of processing commonly recorded for them. On the contrary, ethnographic accounts suggest that this is much more likely in the case of acorns, which are much less abundant as charred remains. Of particular interest is Fritz *et al*.'s (2001, p. 24) comment that modern day ku-nu-che makers consider hickory nutshell to be a good fuel, and some use it in their wood burners. They conclude that "frequent use of nutshell for fuel is likely to have increased the numbers of fragments in the archaeological record … even though many specimens would have burned to ash in the process. If hickory nutshell had not been routinely and purposefully burned as fuel, a far higher proportion would have rotted away over the years".

4. Cooking and eating

Though roasting of hazelnuts is a common feature of historic European cookery, the ethnographic record from North America outlined above gives very few indications of the cooking of hazelnuts in situations likely to be analogous with Mesolithic Europe, and in the majority of cases simply suggests they were "eaten", sometimes after drying and storing. Only one reference to nuts being roasted is made, with no further detail. Whether by roasting or not, the suggestion that cooking of nuts in some form is required has been made, and in particular the suggestion that phytates, particularly in raw nuts make their consumption in bulk problematic has been raised (Headland Report). Though phytates undoubtedly have an "antinutrient" role in reducing or preventing uptake of some minerals (particularly iron, zinc and calcium) some recent reviews consider the great range of phytochemicals including phytates present in nuts as beneficial to health (Bolling *et al*. 2011; Alasalvar & Bolling 2015). Some studies have emphasised the role of processing techniques, including roasting, boiling, drying, germination and malting, or mechanical processing (crushing or grinding), as well as long-term storage, in reducing phytate, while other studies have instead suggested that the effects of such post-harvest treatments of foods, including hazelnuts, are more equivocal, and are very dependent on specific circumstances. Positive benefits of "thermal processing" in particular on some deleterious constituents of raw plant foods may be balanced by reductions in bioavailability of others (Bolling *et al*. 2011, p. 261; Hotz & Gibson 2007). Bolling *et al*. (2011) emphasised that other nutritional benefits of nuts may outweigh any effects of anti-nutrients; as well as the need for more studies relating to specific components of nuts. A more recent article has reviewed the contradictory nature of studies of phytic acid as an antinutrient versus its possible beneficial effects and concluded that its effects on the human body are not yet sufficiently well understood (Silva & Bracarense 2016).

The commonest interpretation for the presence of charred remains of hazelnut shell in Mesolithic, and to some extent later, contexts, especially when found in some numbers, is that they derive from roasting of the nuts; though some have questioned this, as well as some of the reasons suggested for roasting and the archaeological features associated with the process, and alternatives are also suggested (Cunningham 2011b, p. 140; Mithen & Finlay 2000, p. 435; Bishop *et al*. 2013; Lopez-Doriga 2013).

Recent suggestions of large-scale Mesolithic hazelnut roasting rely heavily on two studies, at Staosnaig (Mithen & Finlay 2000; Mithen *et al*. 2001) and at sites in the Duvensee (Holst 2010, 2011). Analysis at Staosnaig centres around the c. 4.5m diameter feature F24, which contained a c. 30cm deep fill with large quantities of charred hazelnut shell. This was interpreted (Mithen & Finlay 2000, p. 441) as a hut, later turned into a dump for tool-making and plant-processing debris, which also spread to other nearby features, one stone-lined with an apparent flue (F41), and two others which are interpreted as possible roasting or steaming pits (Mithen *et al*. 2001, p. 228; Mithen & Finlay 2000, p.441). Some of the coarse stone artefacts found at Staosnaig were interpreted as possible anvils and hammerstones (including a number of elongated pebble tools which it is suggested would have made effective nutcrackers), as well as possible pounders (Mithen & Finlay 200, p.440; table 5.2.3). Three possible explanations for the abundance of charred hazelnut shell within F24 are suggested: accidental burning of nutshell waste from processing ("such large numbers would seem to preclude this possibility"); that fragments of nutshell were used as a fuel and deliberately burnt within F24 (which they suggest should result in greater quantities of wood charcoal and fire-cracked rock within the feature); or, the favoured explanation, that it represents the burnt residue from hazelnut roasting ovens. They conclude, *"*the roasting of hazelnuts may have been common practice during the Mesolithic as a means to prolong storage, or to facilitate processing, digestion and portability". It is suggested that nuts were roasted in two "ovens" (F43 and F49), by analogy with Mesolithic hearth pits from the Netherlands, interpreted as facilities for roasting hazelnuts (Groenendijk 1987), or root foods (Perry 1999) (Mithen *et al*. 2001, p. 228). These suggestions, however, seem to lack good ethnoarchaeological analogies, and these and other possible interpretations have been disputed by Crombe, who also suggests that many Mesolithic "hearth-pits" may instead be natural features produced by the burning of ant's nests in forest fires, and unrelated to domestic Mesolithic activity (Crombe et al. 2015).

Suggestions of hazelnut roasting on a large scale at Duvensee are centred on Holst's analysis of two sites (WP6 and WP8 excavated between 1975 and 1981) among a number excavated from peat at the edge of a former lake over a number of decades from the 1920s onwards which are still undergoing analysis, and have been interpreted as specialist hazelnut roasting hearths with short-term seasonal occupation over an extended period (of 2.4k years) in the early Mesolithic (Holst 2010, 2011). The Duvensee sites are characterised as open-air hearths (sand and hazelnut shell with some charcoal) surrounded by evidence of tool production and widespread layers of hazelnut shell. A detailed description of the hearth features at WP6 and WP8 is provided by Holst (2011, p. 196). Despite the exceptional preservation of organic materials (including wooden and bark artefacts), and the fact that reports suggest that features and lithic finds at excavations from the latter half of the twentieth century were meticulously recorded, hazel nutshells were neither “recorded or quantified”, and the only systematic analysis of botanical remains is that of a c. 50ml “hearth sample” from WP6 (Holst 2010, p. 2875-2876). Estimates of the numbers of hazelnuts (and from this the calorific input they may have made to the occupants' diet) represented on the sites is thus made from extrapolation of a count of nuts made during excavation in 1928 of a 5 litre (25x20c10cm) “turf” sample from the “nutshell layer” of another site, WP5. Holst states that the nutshell layer was estimated to be to 12m^2 with a depth of 10cm, but the location of this layer and its relationship to any or all of the WP sites is unclear. Diagrams of the features at WP6 and WP8 (e.g., Holst 2010, fig. 4) do not indicate the presence of this extensive nutshell layer, and instead show concentrations of hazelnuts; and, while profile drawings indicate both “burnt and unburnt” hazelnuts (Holst 2011, fig. 7) in the vicinity of the hearths, nowhere is there any discussion of the nature of preservation (charred or waterlogged) of the “layer”, nor of any implications which might be drawn from, for example, differences in distribution of charred and waterlogged nuts.

Lage (2011) has outlined the combination of experiment and ethnographic analogy used, initially by Klaus Bokelmann, the excavator of WP6 and 8, to suggest a number of hypotheses for hazelnut roasting at Duvensee related to the specific features characteristic of these sites (i.e., intermingled layers of sand and nuts) (see also Holst 2011, p.197). Bokelmann's first suggestion was of a pit dug into sand in which hazelnuts were placed, with an overlying layer of sand on which a fire was built. (In combination with descriptions and experimental investigations of so-called hearth-pits from the Netherlands (Groenendijk 1987; Perry 1999) this forms the model on which most ethnoarchaeological hazelnut roasting experiments are based (e.g., Score and Mithen 2000, p. 508; Bishop 2013; Lopez-Doriga 2013; Mears & Hillman 1987). Lage tested this method and found (as did Score & Mithen 2000 and Lopez-Doriga 2013) that this tended to result in some nuts being completely charred and inedible, while others remained unroasted. A number of alternatives were thus tested with a final favoured explanation being based on an ethnographic analogy with roasting of mongongo nuts by the !Kung, using a mixture of hot charcoal and sand (though Lage's description of this differs from Holst's) in which the nuts are placed, resulting in a process “without the nuts coming into direct contact with the fire, thus avoiding great losses of nuts due to burning” (Holst 2011, p. 197). Holst also notes that mongongo nut roasting hearths “differ from the Duvensee features in their remarkably smaller size and their utilization in a variety of daily tasks. Complex and specialised structures for roasting large amounts of hazelnuts, such as those recorded at Duvensee, seem to be a characteristic of the early Holocene” (Holst 2011, p. 197). The major focus of Holst's work is the analysis of the spatial distribution of lithics associated with the hearth features, which she suggests may enable the detection of similar roasting activities in areas where there is no preservation of organic remains (2011, p. 208). However, as she points out, alternative interpretations, as huts with bark floors and internal hearths, have been suggested for the features at Duvensee, as well as at a number of sites across Central and Northern Europe, and in particular Southern Scandinavia. A major problem in trying to assess the relevance of Holst's model to other finds of hazelnut, particularly charred remains, is the lack of detail about the nutshell itself in published reports. In particular it is unclear what proportion of nutshell finds at the Duvensee sites are charred, and how Holst's model suggests these became charred, if, as she suggests, the proposed roasting method resulted in few charred nuts. The interpretation of the sites is that each represents a single occupation of short duration (Holst 2011, p. 190) which have evidence for intensive and large-scale roasting of hazelnuts. It is suggested roasting “prolongs the 'shelf-life' of hazelnuts and is a prerequisite for storage” (p.195), and also “facilitates the cracking and processing of nuts … thus reducing the weight of this basic food source for transportation”. Thus, she implies the roasted shelled hazelnuts were removed elsewhere, probably by boat, leaving the nutshells and evidence of their processing behind. Ethnographic examples of nut use such as those described above provide few examples of nuts being shelled to facilitate transport or storage (except perhaps in specific circumstances such as the ku-nu-che ball process described above, which seems to have been particular to limited species of *Carya*) and that storage in shells is favoured, probably for the same reasons as suggested by studies in the commercial nut world. The validity of the use of the mongongo nut roasting analogy at Duvensee could be questioned (as Holst acknowledges), as the primary purpose of roasting mongongo nuts is to facilitate the cracking of their very thick-shells (see tspace.library.utoronto.ca/handle/1807/25206), something not needed for hazelnuts; and the mongongo nut is available year-round with roasting of small amounts on a daily basis. Not only is it not clear precisely how this method might have been upscaled to mass roasting at Duvensee (though the import of large quantities of sand to the sites is suggested to be involved), the reasons advocated for roasting hazelnuts must be questioned, and a more detailed understanding of the processes undertaken at Duvensee is required before its interpretation is accepted.

In conclusion, at both Staosnaig and Duvensee interpretation of features has concluded that they represent short-term occupations during which there was mass-roasting and shelling of hazelnuts. While at Staosnaig it is not suggested whether all the nuts were consumed on site during the time of occupation (though increased portability (after shelling) is emphasised here), at Duvensee it is implied that roasting and shelling enabled the transport of the nuts elsewhere. Both ethnographic data and studies of the storability of shelled and roasted nuts make these interpretations open to question.

Implications for the role of hazelnuts in subsistence and for the interpretation of archaeological features

As discussed above, while in North America the greater abundance of taxa of both nut and other potential plant food types has meant that methods for quantifying archaeobotanical remains which try to allow for the effect of taphonomic bias are reasonably widely applied (though perhaps less so to Archaic period sites than to those from later periods (see for example Emerson *et al*. 2009), such methods are only relatively recently being applied widely to the analysis of the role of wild plants in subsistence in Europe, and, as in North America, this is also more common in analyses of more recent sites, in particular the Neolithic, where often better preservation, or in some instances the involvement of archaeobotanists in designing systematic sampling and analytical strategies is becoming more common. Additionally, in some instances comparisons between charred and uncharred remains preserved in waterlogged sites have provided valuable insights, in particular into the unrepresentativeness of remains of some wild plants in charred plant assemblages, including in particular acorns (see e.g., Antolin & Jacomet 2015; Antolin et al. 2016b; Out 2012; see also Colledge & Connolly 2014; Sergusheva & Vostretsov 2009, p. 215 for the Russian Far East); and these studies have provided considerable support for the long-acknowledged likelihood of a taphonomic bias against recovery and recognition of acorns (see Mason *et al*. 2002; Mason 2005).

However, Bishop *et al*. (2015, p 65), while acknowledging possible biases have suggested that the absence of any evidence for Mesolithic acorns in Scotland could reflect the fact that they may not have been a significant resource here.
Support for this interpretation comes from suggestions from some that acorns have had a significant role in subsistence mostly where several species are present in one area, allowing buffering against periodic productivity of individual species (see e.g., Fiorentina & Primavera 2013 for a discussion).

To address the question of the impact taphonomic bias may have on the relative representation of acorn and hazelnut shell in the archaeological record two case studies from North America are briefly outlined below, as they are also very instructive in suggesting ways in which archaeological features relating to the use of nuts might be formed and/or interpreted.

Ashe Ferry in South Carolina is a site dating from the Late Woodland (Ashe Ferry phase c. A.D. 1000 – 1150) and early Middle Mississippian periods (Early Brown phase, ca. A.D. 1150-1350) where detailed archaeobotanical analysis was carried out of a site where archaeobotanical remains (all charred) were almost exclusively nuts, principally acorn and hickory, but with small numbers of a large range of largely uncultivated seeds and fruits (Peles & Scarry 2015; full report available online at www.rla.unc.edu/Publications/pdf/ResRep36/). Analysis, using a combination of weight and count data showed a clear differentiation of remains between fire-cracked-rock-filled features (which are interpreted as roasting ovens containing primary deposits mostly of acorn nutshell, which were located in a linear pattern along the river terrace near its crest), and deep pits, dominated by hickory nutshell, but including some acorn kernel, interpreted as secondary deposits formed after the original stored foods had been removed, located in finer-grained, probably less well-drained sediments further down the backslope. It is suggested that acorns were roasted or parched in or near hearth features and that bursting shell fragments became carbonised during this process, while unwanted acorn kernels, many of which had clear evidence of weevil damage, were discarded and later secondarily deposited in pits, which may have originally served as leaching pits for acorns, or alternatively have been storage pits. Hickory nutshell was present only as small fragments and concentrated in only two pits, and, given its greater survivability this is used to suggest that it was of only relatively minor importance, and perhaps represented the remnants of use of ke-nu-che balls brought to the site (see discussion above). Unusually, perhaps because of the relatively recent date of the site, and the likelihood that the acorn remains were recovered from primary undisturbed deposits, acorn remains were not only dominant overall, but large numbers of fragments were greater than 2mm in size (cf. pages.wustl.edu/peblabguide/articles/1177, which indicates that most acorn shell fragments recovered in North America are smaller than 2mm). It is possible to imagine that in similar circumstances, but less ideal conditions, survival or recovery of acorn shell may have been much less, and a site dominated by hickory nut shell would have resulted.

A second study which might provide some archaeological analogies for nut-related features is the Sunken Village waterlogged site in Oregon, also identified as an acorn storage or processing site, described by Mathews (2009/2011). She cites ethnographic evidence suggesting that pits for passive leaching of acorns in the Pacific northwest were often dug in areas with aquifers. Excavations in 2006 identified c. 100 possible leaching pits dating from the late eighteenth to late nineteenth century within a 125m long area along a river channel which would have been inundated from late autumn, after the acorn harvest, until spring; with one pit feature which provided particularly good preservation (including basketry, lithics, bone, wood and “botanical artefacts”) fully excavated. Charcoal in “large quantities” was found throughout the pit and is suggested as likely to be refuse from cooking or fires, or possibly due to the use of ashes in the leaching process. Circles of stakes and fire-cracked rock were associated with some of the pits, which were usually circular at the surface, and c. 70-80cm in diameter. Waterlogged whole and fragmented acorns of *Quercus garryana* dominated the archaeobotanical remains. Notably *Q. garryana* is the only major oak species likely to have been present in the area, with a relatively predictable 3-year cycle of a bumper crop, a moderate crop and a crop failure, which Mathews suggests may have meant the seasonal pattern of reliance indicated by the substantial finds were only possible in some years. Interestingly, Matthews comments that “Many acorns were whole (with the nut inside the shell) which means they were being left in these pits on the beach for later use instead of immediate consumption, unlike the numerous hazelnut fragments which appear to have been processed and possibly eaten at the site" (p. 128); but unfortunately there is no further discussion of the hazelnut remains in the report. A small portion of the acorns were fully charred, while most remains had mottled marks apparently the result of heat, though possibly due to the leaching process. As with Ashe Ferry it is possible to imagine a situation in which, with the passage of time and perhaps changes in hydrology, a similar archaeobotanical assemblage could become modified. If such a site was no longer waterlogged, all that might remain would be pits with fire-cracked rock, some wood charcoal, small numbers of charred acorns, and "numerous" hazelnut shell fragments (presuming the remains were originally charred).

Though both these examples are of sites interpreted as having a specialist role related to acorn use, it is not intended to suggest that this aspect of the sites necessarily provide a direct parallel with archaeological examples either known or yet to be investigated in Mesolithic Europe; but it is suggested that they might provide some alternative ways of thinking about some circumstances in which hazelnut shell may be recovered. It is even possible to suggest that there may be some parallels with features in the Aberdeen Bypass sites.

Conclusions

Some brief conclusions can be suggested about ways in which interpretations of the use of hazelnuts in the past might be enhanced by the admittedly sparse ethnographic record of their use and that of other nuts.

Ethnographic analogies chosen to support suggestions of hazelnut roasting may not be the only ones possible. In particular, roasting is most supported ethnographically as a stage in processing in the case of acorns and pine nuts; and a closer examination of these might be of value as analogies. The possibility that "roasting pits", if identified are ethnographically at least equally likely to relate to processing of root foods should also be borne in mind.

Hypotheses linking hazelnut roasting to intensive or large-scale use, or use which enhances storage, may be inappropriate, and in fact unnecessary, given, for example, the fact that in Eastern North America large quantities of charred nutshells are frequently recovered from archaeological sites from nuts (hickory and walnuts) which are not, as far as the ethnographic record suggests, subject to roasting as a stage in their processing, yet which (again from the ethnographic record) are known to have played a substantial role in diet.

The patchy nature of the archaeobotanical record and the vagaries of taphonomy mean that assumptions that large numbers of remains necessarily equals a major role in subsistence (and vice versa) may not be appropriate.

Taphonomic biases undoubtedly affect the recovery, and probably also the recognition, of acorn shell more than hazelnut shell. Even in North America, where many acorn species are relatively thick-shelled, fragments of charred acorn shell are most often smaller than 2mm, and the need to use particularly careful recovery techniques (for all types of fragile remains, including parenchymous tissues which may also be present) has been emphasised. White & Shelton (2014, p. 108) note that “such remains survive best in systems where the operator has the greatest control and can slow, stop, or start the [flotation] procedure according to the nature of observed materials” suggesting e.g., the use of hand-pumped flotation machines. Similarly, quantification which both weighs and counts archaeobotanical remains which are likely to be very fragmentary, such as nutshell, can help to address taphonomic biases; as can the use of ubiquity analyses rather than simple numbers of remains recovered from a site.

The ethnographic record is patchy and often poor in details, and the best examples relating to hazelnuts in particular come from North America, where, in comparison to northwest Europe, a much larger range of nut-bearing trees are present. The ethnographic record, and the archaeological record from many other parts of the world, seems to suggest that hazelnuts, though regularly eaten and much appreciated, were never the most significant nut, let alone plant food, in the diet, but it may be that Mesolithic Europe was an exception.

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Appendix-2.1.12 AMA09 Milltimber Archaeobotanical analysis - Angela Walker

Introduction

Forty-four bulk sediment samples, ranging in size from two to 40 litres, were recovered during archaeological work on the Aberdeen Western Peripheral Route. Following an initial assessment of the material recovered (Giorgi 2017) two samples were selected for full analysis on the basis of contextual importance and potential contribution to the overall site narrative. The samples derived from two Neolithic Pits [AMA09-2058] and [AMA09-2080] that were located to the west side of the land parcel. These features were the only ones that contained cereal remains.

Methodology

Bulk samples were subjected to flotation and wet sieving in a Siraf-style flotation machine. The floating debris (the flot) was collected in a 250 µm sieve and once dry, scanned using a binocular microscope. Any material remaining in the flotation tank (retent) was wet-sieved through a 1mm mesh and air-dried.

Samples were analysed using a stereomicroscope at magnifications of x10 and up to x100. Identifications, where provided, were confirmed using modern reference material and seed atlases including Cappers et al. (2006) and Zohary et al. (2012) nomenclature for wild taxa follows Stace (1997).

Results

The results of the analysis are presented in the environmental spreadsheet.

Pit [AMA09-2080]

Cereals

The small cereal assemblage was predominantly grains of barley (Hordeum sp.) with five grains identified as naked barley (Hordeum distichon/H. vulgare var. nudum). A very small number of the barley grains exhibited an angular profile in section, these 'angles' are a common characteristic of hulled barley. However, aside from the angular shape the grains did not exhibit any evidence of hulls. Wheat (Triticum sp.) grains, most likely glume wheat, were also present, including a single grain of emmer (Triticum dicoccum) wheat. Oat (Avena sp.) grains were also present though it was not possible to establish if these were from wild or cultivated species.

The preservation of the grains was very poor, with the majority of the grains exhibiting distortion, missing surfaces and fragmentation. This poor level of preservation resulted in a greater number of the grains being assigned to the cereal indeterminate category.

Wild taxa

The wild plant assemblage was very small (10 items) and comprised ruderal taxa such as corn spurrey (*Spergula arvensis)* and common nettle (*Urtica dioica*) as well taxa that derive from a range of habitat types, species identified included; milk-vetches (Astragalus sp.), hemp-nettles (*Galeopsis* sp.) mixed grasses (*Poaceae*) as well as an achene of the daisy family (*Asteraceae*).

Pit [AMA09-2058]

Cereals

Cereals present included grains of barley, with nine grains identified as the naked variety. Two oat grains were also recorded. The preservation of the grains was very poor, though it was possible to identify the majority of the grains to genus level.

Wild taxa

Only two wild plant 'seeds' were present in the assemblage from this feature; corn spurrey (Spergula arvensis) and a seed of the pea family (Fabaceae).

Other charred botanical remains

Both samples also contained a small quantity of material classified as charred indeterminate vesicular matter. This material was organic in origin and in some cases is more than likely to be cereal, but was so poorly preserved that all diagnostic features such as shape, surface and countable elements were missing.

Discussion

The charred plant assemblage from the two Neolithic pits suggests barley (likely naked barley) as the dominant crop type. Naked barley was also recovered from Neolithic Hearth [2D-1137] in the earlier excavations at Milltimber (Site SL/002) (Bailey & Holden 201*).

Barley has been recovered from other Neolithic sites in Scotland (Greig 1991, 300) and appears to have been an important crop at the time (McClaren 2000, 91), having previously been found at a number of sites in Aberdeenshire including Crathes, Warren Hill, where it was the main cereal along with emmer. Both naked barley and emmer were also found in Neolithic deposits from excavations at Garthdee Road and Balbridie (Fairweather & Ralston 1993).

The small number of 'weed' seeds recovered were those associated with disturbed ground, particularly corn spurrey. The vetches or wild peas may indicate the presence of hedgerows and fields and could potentially have been brought to the site with the crops.

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Appendix-2.1.13 AMA22 Wester Hatton Archaeobotanical Analysis - Angela Walker

Introduction

Ninety bulk sediment samples, ranging in size from three to 40 litres, were recovered during archaeological work on the Aberdeen Western Peripheral Route. Following an initial assessment of the samples (Giorgi 2017) four were selected for full analysis on the basis of contextual importance and potential contribution to the overall site narrative. Three of the samples derived features within structure Wester Hatton 2 and the fourth sample derived from post-hole [AMA22-6219]. All four of these features dated to the Early/Middle Bronze Age.

Methodology

Bulk samples were subjected to flotation and wet sieving in a Siraf-style flotation machine. The floating debris (the flot) was collected in a 250 µm sieve and once dry, scanned using a binocular microscope. Any material remaining in the flotation tank (retent) was wet-sieved through a 1mm mesh and air-dried.

Samples were analysed using a stereomicroscope at magnifications of x10 and up to x100. Identifications, where provided, were confirmed using modern reference material and seed atlases including Cappers et al. (2006) and Zohary et al. (2012) nomenclature for wild taxa follows Stace (1997). Number counts of items present were estimated.

Results

The results of the analysis are presented in the environmental spreadsheet.

Plant remains selected for analysis comprised three features; ring ditch [AMA22-6243], ring ditch [AMA22-6238] and pit [AMA22-6240] from Structure; Wester Hatton 2 as well as post-hole [AMA22-6219] associated with large Pit [AMA22-6188].

Abundant cereal remains were recovered from ring ditch [AMA22-6243], pit [AMA22-6240] and post-hole [AMA22-6219]. The assemblage was dominated by grains of barley (Hordeum sp.) including naked barley (Hordeum distichon /H. vulgare var. nudum) occurring in small numbers. The grains varied in size with a notable proportion of smaller grains, possibly 'tail end' grains. A small number of indeterminate wheat (Triticum sp.) and oat (Avena sp.) grains were also recorded. It was not possible to establish if the oats were from wild or cultivated species.

The preservation of the grains was very poor, with the majority exhibiting distortion, missing surfaces and fragmentation. This poor level of preservation resulted in the greater number of the grains being assigned to the barley indeterminate and cereal indeterminate categories.

Pit [AMA22-6240], ring ditch [AMA22-6243] and post-hole [AMA22-6219] also contained barley rachis (chaff) including the dense-eared form (Hordeum vulgare var. hexastichum).

Wild taxa

A number of charred 'weed seeds', (here used to include seeds, fruits, achene, caryopses etc) were recovered from all 4 features but in varying numbers. Ruderal taxa present included corn spurrey (*Spergula arvensis*) common chickweed (*Stellaria media*) ribwort plantain (*Plantago lanceolata*) bedstraws (*Galium* sp.) and knotgrasses (*Polygonum* sp.). Wetland taxa such as pale persicaria (*Persicaria lapathifolia*) and buttercups (*Ranunculus* sp.). Other species present included sheep's sorrel (*Rumex acetosella*), peas/vetches (*Lathyrus/Vicia*), clovers (*Trifolium* sp.) and eyebrights/bartsias (*Euphrasia sp./Odontites* sp.).

An abundance of large (>2mm) grass (Poaceae) 'seeds' including bromes (*Bromus* sp.) were recovered from pit [AMA22-6240] and ring ditch [AMA22-6243]. The grasses were of a similar size to the majority of the cereal grains interpreted as possible 'tail end' grains

Other charred botanical remains

Three samples also contained an abundance of material classified as charred indeterminate vesicular matter. This material was organic in origin and in some cases is more than likely to be cereal but was so poorly preserved that all diagnostic features such as shape, surface and countable elements were missing.

Discussion

The data from the initial environmental assessment (Giorgi 2017) and the archaeobotanical analysis suggests that during the Bronze Age occupation at Wester Hatton the dominant crop was naked 6-row barley with possible occasional hulled barley. The dominance of barley, particularly naked barley is common on Bronze Age sites in Scotland (Boyd 1988) but the presence of the hulled form is not. The site Bronze Age site at Oldmeldrum, Aberdeenshire (White & Richardson 2010) also demonstrated a similar pattern of a dominance of naked barley grains with occasional hulled barley but the assemblage from this site dated to the Late Bronze Age and not the Early/Middle Bronze Age like Wester Hatton.

The three largest concentrations of grain recovered from Wester Hatton 2 were from ring ditch [AMA22-6243], ring ditch [AMA22-6238] and pit [AMA22-6240], the grains were very poorly preserved and it is difficult to determine how they became incorporated in these features. Whether it was though the accumulation of waste material generated in and around the building during use or via a final conflagration event when the building was abandoned.

The wild plant assemblage was similar in composition to other Scottish Bronze Age sites with common agricultural weeds such as corn spurrey and chickweed possibly being brought in with the barley crop during harvest. This may also be the case for the abundant mixed grasses and bromes from Pit [AMA22-6240] and ring ditch [AMA22-6243].

The presence of abundant grasses alongside the barley grains suggests that crop processing was undertaken at the site, this is further alluded to via the presence of the barley chaff and smaller weed seed present. However, as the plant remains do not directly relate to the original function of the features it is difficult to determine the location that the processing took place.

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Appendix-2.1.14 SL/004A Gairnhill Timber Trough Lining Report - Anne Crone with species analysis by Laura Bailey

Materials and Construction

The dimensions and construction of the trough lining has been fully described elsewhere. The wooden lining was only found on the base and three sides, at the southern end was a stone upright. As the basal planks ran underneath the stone upright it was assumed at some point the trough was larger. When the stone upright was inserted the west plank was shortened, redressed and butted against the stone. The original cut measured 2.20m x 1.23m x0.49m but the later addition of southern stone created a trough area measuring 1.80m x 0.42m x 1.00m.

The base was lined with three alder timbers placed parallel to each other, while each of the long sides were lined with a single alder timber set on edge. The northern end was lined by two vertically-set oak planks. The timbers were all in much degraded condition, bacterial decay having made the alder timbers in particular very soft. See Table 1 for full descriptions.

Table 1: trough lining summary

Timber #	Location	Species	in situ measurement (mm)	Description
S1017	East	alder	1600 x 160 x 170	half-log, with no other evidence of working other than it has been cleft in half
S1018	West	alder	1230 x 160 x 180	half-log. The outer face is very decayed but the edges may have been squared and it may have been plank-like in cross-section.
S1023	Base, east	alder	1170 x 80 x 20	thin, flattened length of radially-cleft wood. This form of conversion is unlike anything else used in the construction and it is possible that this was a splinter off S1024 which has moved after abandonment.
S1024	Base, centre	alder	1730 x 280 x 60	large plank formed from a half-log, the outer chord of which has been removed to form a roughly rectangular cross-section. It is too decayed to determine whether the plank had been fully squared but bark survives in small strips along one edge suggesting that it was not.
S1025	Base, west	alder	1170 x 140 x 50	plank formed from a half-log, the outer chord of which has been removed to form a roughly rectangular cross-section. The edges appeared to have been dressed square.
S1026/1 & S1026/2	North	oak	Thickness 110	two chords which may have been cleft off the same trunk. The oak was very slow-grown, with between 16 and 20 growth rings per cm. The bark survives on the back of S1026/2 but it is very irregular and displays no curvature suggesting that the original tree was massive. Both chords have been positioned so that the outer surface of the tree lies against the back of the cut. The base has been chopped to a flattish cross-section; on S1026/1 the

				tool marks have survived well and blade jambs up to 40 mm wide are visible. The upper ends are very decayed, the ribbed decay pattern consistent with the timbers having stood upright. The inner surface of S1026/2 has been charred.

Discussion

The planks forming the base and sides of the trough have been fashioned by cleaving logs in half and then cleaving the outer chord off the half-log leaving a roughly rectangular cross-section. There is evidence on some but not all planks, that the edges have also been dressed square. This is a plank conversion known as an inner tangential, whereas the oak chords forming the N end of the trough appears to be an outer tangential, on which the curved outer surface of the original log has not been removed. This manner of converting logs into planks was in use from the Neolithic through to the Iron Age (ie O'Sullivan 1996, 304, 327 & Figure 427) and has been observed on wetland sites of Iron Age date in Scotland (Crone forthcoming). This method of conversion appears to have been used on many of the examples of wood-lined troughs discussed below. O'Sullivan observed a correlation between the width of the plank produced and the type of conversion used, the half-split and tangential conversions producing the widest plank possible, while the radially-split planks were amongst the narrowest. This is in keeping with Taylor's observations that it is easier and less wasteful to radially-split timbers of 0.4 m diameter or less but larger trees are relatively easily split tangentially (Taylor 2010, 91).

There are very few other wood-lined troughs from Scotland. Two examples from SW Scotland had been lined with large tangentially-split oak planks. These are Dervaid, Glenluce where the trough was lined with a plank some 2.25 m long and 0.75 m wide (Russell-White 1990, 74), and Cleuchbrae Linn, Johnstonebridge where the trough was lined with a plank, 3 m long and 0.8 m wide (Duncan & Halliday 1997). At Beechwood Farm, near Inverness the base of the trough had been lined with a hollowed-out oak trunk, while the sides and ends had been lined with oak planks (Cressey & Strachan 2003, 195); the oak trunk produced a radiocarbon date of 2110 – 1751 cal BC, closely comparable to that from ABSL 004a.

There are many more examples of burnt mound troughs with their wood linings surviving in situ in England and Ireland, and what these mainly show is the variety of construction employed. In Ireland the most recent overviews list wickerwork, brushwood, planks, hollowed-out tree trunks and dug-out canoes as linings used in Late Neolithic and Bronze Age troughs (Dennehy 2008,10; Hawkes 2013, 19), often with corner posts or stakes to reinforce the structure. In England there are no recent overviews of Bronze Age burnt mound structures but published examples show a similar range of constructions, ie a rectangular trough with base and sides lined with small logs at Willington, Derbyshire (Beamish 2009), oak planks at Burlescombe, Devon (Best & Gent 2007) and Nant Farm, Lynn Peninsula, Gwnedd (forthcoming). These examples are all MBA or LBA in date. Perhaps the closest example to ABSL 004a in terms of date and construction is that from Garlands Hospital, Carlisle, where a tangentially converted alder plank in the base of a pit under a burnt mound produced a date of 2300-1985 cal BC (GU-8007; Neighbour & Johnson 2005).

Appendiz-2.1.15 SL/004D The carbonised wood assemblage from Gairnhill 4 - Anne Crone (with species analysis by Laura Bailey)

The carbonised wood examined derived from Gairnhill 4, a Late Bronze Age ring-ditch roundhouse. The wood was recovered from inner ring-ditch segments [4D-0240] and [4D-0074]. The assemblage consisted primarily of hazel (*Corylus avellana*) (52%), *Maloideae* (a botanical family that encompasses fruit trees, hawthorn and rowan) (22%), alder (*Alnus glutinosa*) (15%), oak (*Quercus* sp.) (8%), and birch (*Betula* sp.) (3%).

Results

The charcoal is described by context, those which appear to represent the same structure are grouped together.

Context (4D-0314)

This context contained the carbonised remains of a wickerwork panel. The two surviving stakes or verticals were alder and oak (Sample <4D-0243>). The stakes/verticals measured 34 mm in diameter, while the withies, or horizontals consisted entirely of hazel rods some 15 mm in diameter on average. One withy displayed a chopmark on one face.

Context (4D-0358)

This context produced of six lengths of carbonised wood, one of which was alder and the other five oak. These lengths were recovered from the base of the ring-ditch. There is no evidence that they were shaped beyond the round, but they were highly fragmented. The fragments associated with these lengths were slightly larger in diameter in comparison to the majority of the other wood pieces in the assemblage. Some of the fragments had estimated minimum diameters of 84 and 90 mm, while (4D-0358B) in particular may have measured up to 300 mm minimum in diameter. Although only small fragments of (4D-0358D) survive the curvature of the growth-rings suggest it was a log of similar size to (4D-0358B).

Contexts (4D-0484/0487/0488)

Each of these contexts represented a cluster of roundwood lengths that were mainly a mixture of alder and hazel, although a single piece of birch and oak is present. The lengths range in diameter from 16 mm to 77 mm and did not exhibit any evidence of working.

Contexts (4D-0491 & 4D-0492)

These two contexts should be treated as one; in plan they appeared to represent a bundle of roundwood overlain by two lengths of roundwood; (4D-0492E) and (4D-0491J), which lay at right angles to the alignment of those below. All the Maloideae in the assemblage came from these contexts, and there were also small number of lengths of alder, hazel and one of birch. The Maloideae roundwood had an average diameter of 32 mm, and eight had been shaped. The roundwood displayed evidence of being pared along their lengths, and many displayed knife or axe facets around the entire circumference. The best-preserved example is (4D-491L) which displays nine thin facets reducing the diameter of the rod from 35 mm to 12 mm, so that it resembles a peg.

Discussion

There was no evidence to suggest that any of the carbonised wood that survived the burning event had been shaped beyond the round, i.e. it is all invariably roundwood. The only clear evidence for modification is that of the Maloideae in (4D-0491/0492). The assemblage can be characterised as comprising small (10 – 30 mm) to medium (30 – 50 mm) diameter roundwood, most suitable for wickerwork panels and stakes (see Crone 2008, 273). Apart from the larger oak roundwood in (4D-0358) there was nothing present that represented more substantial structural timbers.

The carbonised wood was found spread out along the ring-ditch. The wickerwork panel (4D-0314) survives best along the back of the ring-ditch where it is most suggestive of a collapsed wall screen. Carbonised wickerwork panelling in the same position have been found in the Middle Iron Age roundhouse RH23 at Kintore (Crone 2008, 281-3), where it could represent the outer wall of the house. The inner face of the bank in the Bronze Age hut circle 10/1 on Tormore, Arran was also lined with withies (Barber 1997 11, 15). However, at both these sites the wickerwork panelling would have formed the lining of the outer wall, whereas at Gairnhill the wickerwork panel lies within an internal ring-ditch. Evidence for internal concentric wickerwork screens have been found on the Iron Age wetland site of Black Loch of Myrton (Crone & Cavers 2015). Wickerwork panels have also been found used as sub-floors at that site, so it is equally possible that (4D-0314) could be the remains of flooring, though it remains unclear as to whether there was wood lying over or under (4D-0314).

It is difficult to determine the function of the rest of the carbonised wood given that most of the material was mixed, so it is impossible to say whether the wood represents internal structural elements, walling or roofing. The experimental burning of an admittedly, rectangular house at Lejre, Denmark showed that the roof collapsed first, the walls falling in afterwards so that stratigraphically, the roof timbers would have been found under the wall components (Rasmussen 2007, 77). However, in Gairnhill 4 the ring-ditch lies some 2 m – 2.5 m inside the ring-groove which would have housed the wall timbers, so it seems unlikely that any of the surviving wood in the ring-ditch came from the walling. It is more likely therefore to represent either internal fittings or roof timbers.

The homogeneity of some of the clusters of wood suggests that they might represent a discrete structural element, for example, all but two of the oaks in the assemblage occur in (4D-0358) and all the Maloideae in (4D-0492/0492). The degree of shaping displayed by some of the roundwood in (4D-0492/0492) would not have been necessary in most structural elements, such as a wickerwork panel, roofing or flooring and suggests that some care has been taken in the construction of whatever it is. The selection of species is also unusual; Maloideae most often occurs as a relatively small component of fuel debris (cf. Table 31 – Crone 2008, 283); the fruit species in particular are good fuel woods. Interestingly, the only concentration of Maloideae in the roundhouses at Kintore was in the ring-ditch of RH09, where it was identified as cf. rowan (ibid 277).

If we exclude the hazel used in (4D-0314) and the clusters of oak and Maloideae described above, as examples of deliberate selection for a particular function then hazel and alder, with a small amount of birch and oak were used for general construction in Gairnhill 4. Only one posthole yielded charcoal and that was a piece of birch (4D- 0385).

The site that invites the closest parallels with Gairnhill 4 is Kintore, where several of the Late Bronze Age and Middle Iron Age roundhouses had burnt down and rich assemblages of charcoal had been preserved. Like Gairnhill very little (ie 2%) of the assemblage was greater than 50 mm in diameter prompting the suggestion that the larger structural elements might have been removed pre-conflagration (Crone 2008, 286). The species used in construction throughout the Bronze Age at Kintore varied very little (ibid, Table 30 & Figure 190); there it was primarily a mixture of birch, hazel and oak, with smaller amounts of alder and willow. Unlike Gairnhill, evidence for the modification of timbers had survived in the form of squared willow and alders (ibid, 277). At Birnie, where several Iron Age roundhouses had burnt down, oak overwhelmingly dominates, comprising between 70% and 92.5% of the assemblages from the roundhouses; there was evidence for some radially split oaks but like Gairnhill the assemblage was primarily unconverted roundwood (Crone & Cressey 2014).

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Appendix-2.1.16 SL/003B Analysis of the cremated bone from Nether Beanshill - David Henderson

The assemblage

Burnt bone was recovered from 10 contexts, both by hand excavation and from sieved soil samples, which were processed by washing and sieving at standard mesh sizes of 10mm, 5mm and 2 mm. Bone was recovered from the residue by hand sorting.

Contexts (3B-0004), (3B-0007) and (3B-0023) represent fills of pit [3B-0003], containing Vessel 03-V01. Contexts (3B-0016/0017), (3B-0044) and (3B-0046) were fills of small ring ditches, and represent samples taken from slots dug across these features. Contexts (3B-0022), (3B-0101) and (3B-0105) were the fills of small pits and context (3B-0303) was the fill of Vessel 03-V03, excavated under laboratory conditions. All recovered bone was completely calcined, i.e. burnt to a white colour indicating that it had been subject to prolonged exposure to temperatures of over ~600°C (McKinley 2000, 406).

Results

The samples taken from the ring-ditch fills yielded very little bone (less than a gram in any single context), none was positively identifiable as human. Of the small pit fills, (3B-0022) yielded 16g of human bone, including skull fragments, (3B-0105) was charcoal rich, but essentially bone free, so unlikely to be a cremation or pyre-clearing deposit.

Pit [3B-0003], containing Vessel 03-V01, had a small quantity (<50g) of human bone from context (3B-0004), the top fill, but essentially none (<1g) from fills (3B-0007) or (3B-0023) surrounding and beneath the vessel. The material in (3B-0004) was identified as being from an adult, with fragments of jaw, skull and vertebral joints, but no further age- or sex-determining features were noted.

A full catalogue of the material present in contexts (3B-0101) and (3B-0303) is lodged in the site archive.
Pit fill (3B-0101) produced slightly more bone than the other pits, but at 41g, still less than about 3% of the weight expected from a complete adult cremation (McKinley 2000, 407). There was 26g of fragments of limb-bone, one skull fragment and 15 g of non-identifiable fragments. No age or sex characteristics were observed.

The fill of Vessel 03-V03 provided a more substantial quantity of bone, 191g, although the vessel was heavily truncated. Of this, 160g was non-identifiable material, including general limb bone fragments; the identifiable material was all from the skull and dentition, except one rib fragment. No sexual characteristics were recorded. The presence of only unfused cranial sutures and of unworn enamels from the premolar teeth, combined with the observation that all the molar root tips seen were fully developed, suggests a young individual, probably in their twenties.

Although human cranial bone is inherently more easily identifiable than the rest of the skeleton, due to its unique form, the absence of almost any other identifiable fragment may indicate that the remains were gathered from the pyre from the head end and placed directly into the vessel. This must remain speculative, as so much of the upper part of the deposit has been lost to truncation.

Reference

McKinley J, 'The analysis of cremated bone' in M Cox & S Mays (Eds), *Human Osteology in Archaeology and Forensic Science*. Cambridge, 2000.

Appendix-2.1.17 SL/004D Gairnhill Faunal Remains Analysis - David Henderson

Introduction

The Gairnhill site produced a small quantity of faunal bone, all of it burnt. This implies a very poor preservation environment for osteological material, where only bone reduced solely to its mineral component by heating survives. In total 55 contexts yielded 125g of bone. Most of these contexts produced one or two grams of material, usually in the form of tiny, unidentifiable fragments. Of the 584 fragments of bone recovered, 24 were fully or partially identified. Two fragments were identified as possibly human. A full catalogue of the assemblage is lodged in the site archive.

Species Present

Two possible fragments of human bone were recorded, both cremated. A possible humerus shaft fragment was recovered from (4D-0098); a fragment possibly from the upper shaft of a right femur came from (4D-0066), a spread of redeposited material which also contained artefacts possibly associated with earlier funerary rituals.

Context (4D-0066) also produced a fragment of probable cetacean bone (from a large dolphin or small whale species).

Other non-domestic animals represented are frog (one tibia-fibula) and small rodent/shrew (11 bones) from (4D-0015) and (4D-0016) respectively. As these are burnt, it may be that they represent remains of the regurgitated pellet of a bird of prey, accidentally added with fuel into a fire.

The common domestic animals are present in small numbers, two fragments of cattle, two of pig, six of sheep/goat (limb bones and remains of ‘chops’) and a single dog bone.

Such scant material cannot support any inferences about the economy or husbandry practices at the site.

Scottish Universities Environmental Research Centre

Appendix-2.1.18 Using OSL to reconstruct the historic landscape of the River Dee at Milltimber

April 2017

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Summary

This study supports an investigation into the landscape history of the north bank of the River Dee at Milltimber, excavated by Headland Archaeology, in advance of the construction of the southern leg of the Aberdeen Western Peripheral Route (Balmedie-Tipperty). The optically stimulated luminescence (OSL) investigation is commissioned through Headland Archaeology, on behalf of Jacobs, representing Transport Scotland and the Aberdeen City and Aberdeenshire Councils. The area investigated has been subject to intensive cultural activity at a number of periods over the last 10,000 years, with evidence of late Upper Palaeolithic and Mesolithic settlement and lithic production, Neolithic and Chalcolithic activity, and Roman military presence. Reconstructing the evolution of the River Dee is important in understanding how the landscape contributed to this activity.

The report will summarise the background to the OSL investigations, sampling and initial luminescence profiling using portable OSL equipment, the preliminary interpretations, and the subsequent laboratory analyses, first, by exploratory luminescence screening measurements, then the progression to quantitative quartz single aliquot regenerative dose (SAR) OSL dating.

The work progressed successfully from the initial stages of these investigations through to the final programme of OSL dating.

First, the preliminary findings from 'field' profiling were informative, producing a complete, relative temporal sequence for the late Holocene landscape history of River Dee at Milltimber, from the formation of the Camphill Terrace, through the incision and lateral migration of the proto-River Dee, to the formation of the Floodplain Terrace.

Second, laboratory profiling confirmed the consistency of the data sets within the sections targeted for dating (those associated with Channel 1 of the Floodplain Terrace), suggesting lateral migration of Channel 1 in the last 5 ka. Moreover, these profiles also imply a significant temporal break, in excess of 1,250 years, between final migration of Channel 1 and the later period of historic floods.

Third, the temporal framework for the late Holocene modification of the Floodplain Terrace is provided by 9 quartz SAR OSL ages, constraining a.) The late fluvial history of Channel 1 from c. 5 ka (3080 ± 380 BC: SUTL2731) to c. 4.5 ka (2500 ±500 BC; SUTL2728). The incision of the River Dee from the Camphill Terrace surface to the level of the Floodplain Terrace was complete by the middle of the Neolithic. b.) The Roman activity at Milltimber to the 1st - 2nd centuries AD (AD 180 ± 90; SUTL2733). c.) The historic record of post-Roman floods, from the onset of the Little Ice Age (AD 1450 ± 40; SUTL2734) through to its waning stages (AD 1740 ± 40; SUTL2729).

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1. Introduction

This report contributes to archaeological investigations by Headland Archaeology at Milltimber, specifically on the floodplain of the River Dee, commissioned by Jacobs Ltd on behalf of Transport Scotland and the Aberdeen City and Aberdeenshire Councils, in advance of the construction of the southern leg of the Aberdeen A9 Western Peripheral Route (Balmedie-Tipperty). The report will summarise the background to the optical stimulated luminescence (OSL) investigations, sampling and initial luminescence profiling using portable OSL equipment, preliminary interpretations, and subsequent laboratory analyses, first with calibrated luminescence characterisation and second by quantitative quartz single aliquot regenerative dose (SAR) OSL dating.

1.1. Background

The site of the excavations was located approximately 0.5 km S of the village of Milltimber, and 1.5 km ESE of Peterculter, on the north bank of the River Dee.

It encompasses two river terraces, which form a stepped topographic profile from the river northwards upslope to the village. The topographically higher of the terraces is the Camphill Terrace, dated by the presence of Late Upper Palaeolithic traits in the lithic assemblage (Ballin pers comm) to deglaciation at some time in the Late Devensian. It is gravel/clast-dominated, and so likely to represent deposition from high-energy flows. This terrace is called the Camphill Terrace (Tipping pers comm). The surface of this terrace is characterised by a number of shallow (<0.5m), channel-like embayments or troughs, which are infilled partly with basal conglomerate lags, overlain by a fine-grained sandy fill. Also documented on this terrace surface are a number of cut negative features, in the forms of pits and troughs, which are attributed to Mesolithic occupations in the area (a number of the pits contain structural features i.e. post grooves). A shallow <0.5m thick unit of fine-grained sand, possibly overbank (flood) sediment from Holocene events is patchily preserved on the Camphill Terrace surface. These deposits may be part of the terrace stratigraphy or could equally be attributed to a late post-Roman catastrophic flood (see below).

The lower terrace (separated topgraphically by around 3m) is the site of the investigations reported here, as this area contains evidence for temporary Roman occupation in the form of a number of ovens cut into the terrace deposits. This terrace is henceforth referred to as the Floodplain Terrace. The floodplain of this terrace has relief, with at least two palaeo-channels preserved in proximity to the archaeological excavations (Channels 1 and 2). The Roman ovens are cut into the banks of these palaeo-channels and into the base of the slope forming the upper erosional surface of the Camphill Terrace.

1.2. Aims and objectives

The main objectives of the OSL investigations were to: 1.) assess the suitability of the material for OSL dating, and 2.) establish a chronology by which to interpret the landscape history of the site,

(a) prior to and leading up to the Roman occupation in the area,

(b) reconstructing the former position(s) of the River Dee, and

(c) post-Roman site formation processes (including the chronological sequence to flood events in the area).

2. OSL Sampling

Tim Kinnaird, of SUERC, visited the Milltimber site on the 5th November 2014 to examine the sediment stratigraphies exposed there in further detail, characterise the luminescence properties of this sediment, and collect samples for OSL dating. In-situ gamma dose measurements were taken for each of the full dating samples. A list of the samples collected for OSL dating and profiling is tabulated below.

Luminescence profiling samples were taken by first excavating the sections back to remove material which had been light exposed. Small tubes recovering 1-5g samples were inserted in the profiling sample positions, under temporary dark cover, and recovered, together with a 10g sample of the surrounding material which was placed in a numbered petri dish for use with the portable OSL reader. Both profiling tubes and the petri dish subsamples were sealed in labelled zip-seal bags and then placed in an opaque bag to protect them from further light exposure. Subsamples from these profiling samples were measured on immediate return to the SUERC luminescence laboratories under subdued lighting conditions using a SUERC portable OSL reader (Sanderson and Murphy 2010) to provide initial observations of the luminescence signals across the stratigraphic sequences. Full luminescence dating samples were taken from the cleaned sections using stainless steel tubes. Bulk material was collected from the surrounding units for dosimetric measurements and water content analysis. Field gamma spectrometry measurements were recorded in situ in close association to the dating samples.

52 profiling samples were collected. The samples were taken from 6 profiles. Sample details are provided overleaf. 28 laboratory profiling samples and 10 dating samples were collected through profiles 1 - 3. The profiles encompass:

1. sediment associated with the lower of the two terrace deposits (the Floodplain Terrace, profiles 1, 2 and 3; figs 2-1 to 2-5),
2. sediments infilling the Roman oven [F17, cut feature 2B-2036, inset 12B on illus 10] (profile 2; figs 2-1, 2-2 and 2-4),
3. the sedimentary fill of Channel 1 (profile 3; fig. 2-5)
4. sediment infilling the shallow 'embayments' on the lower surface of the Camphill Terrace (profile 4);
5. sediment infilling the 'Mesolithic' pits, cut into the Camphill Terrace (profile 5); and
6. sediment laying on the top of the Camphill Terrace (profile 6), either part of the terrace stratigraphy, or deposited during a late, post-Roman flood.

Profile 1 examines the natural sediment stratigraphy that forms (and comprises) the eroded western bank of Channel 1 of the Floodplain Terrace. The significance of these samples (8 profiling and 2 dating samples) is that they relate, firstly, to the fluvial incision or downcutting from the higher and older Camphill Terrace: they are TAQ dates on incision. Second, they help date the formation of the Floodplain Terrace. A series of ovens were cut back into these terrace deposits. Profile 2 examines the fill of one of these ovens (oven F17 [cut-feature 2B-2036]) and its immediate substrate, which was excavated into the western bank of Channel 1. This profile encompasses the substrate (P2/8), the charcoal-rich layer immediately above the cut (P2/7; [2B-2036]), the reddened or heated materials above this (P2/6), and the overlying, infilling brown loamy sands and silts (P2/2-P2/5; contexts 2B-2041 into 2B-2042). Interestingly, the fill of the cut feature - context 2041 - does not extend over the adjacent context 2B-2044, which makes it more likely to be a deliberate backfill. The upper unit in profiles 1 and 2, characterised by brown loamy sands and silts (context 2B-2045), covers all the underlying units (P2/1), and has been attributed to a final flooding of this terrace.

The fill (2B-2043) of [2B-2036] has a radiocarbon date on charcoal of *Alnus glutinosa* of 21-208 calAD (SUERC-58504; GU36515).

The third profile encompasses the fill of Channel 1, sampled from the standing baulk several metres S and SW of profiles 1 and 2. The significance of these samples (13 profiling and 3 dating samples) is that they should provide temporal information on the final siltation and abandonment of Channel 1, prior to the migration or avulsion of the River Dee away from this channel. In detail, profiles 1 and 3, encompasses several lithological units, from the base up, coarse-grained and gritty sands which comprise the substrate (P1/8, P2/8 and P3/13), overlain by dark-grey silts (P1/4-7 and P3/11-13; context 2B-2043) and dark-brown loamy sands (P1/4 and P3/9-10; contexts 2B-2043 and 2B-2044), and then brown loamy sands and silts (P1/1-3 and P3/1-10; context 2B-2042).

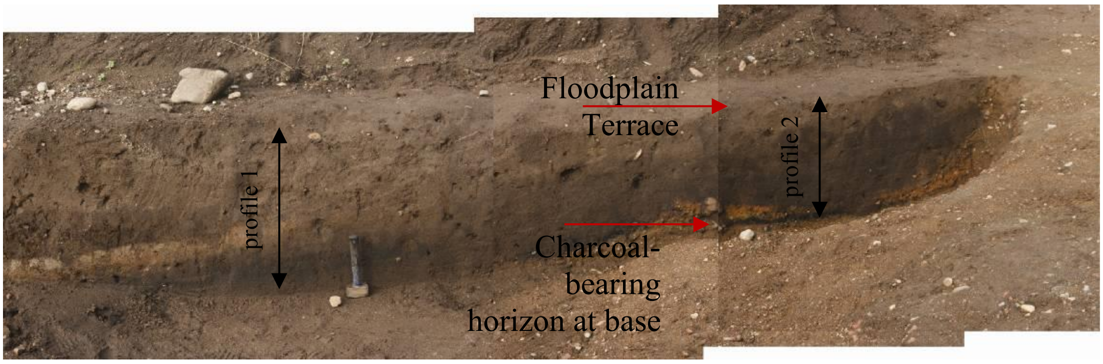

Figure 2-1: Photograph of the Roman oven [2036] cut into the Floodplain Terrace, showing the relative positions of profiles 1 and 2 (see figs 2-2 and 2-3)

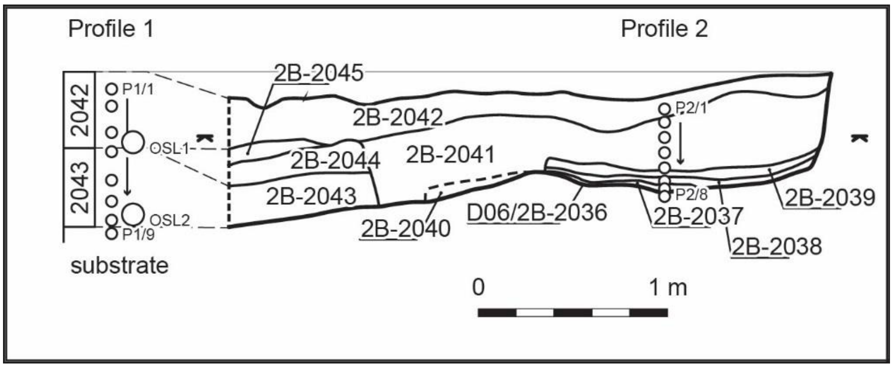

Figure 2-2: Section drawing for oven F17, and profile 1 examined along strike

Ten OSL dating samples were collected. Eight of the samples provide temporal constraints to interpret the landscape history of the site (details provided in the table overleaf; figs 2-2 to 2-4). Two of the samples augment the existing radiocarbon chronologies for the Roman occupation at Milltimber, through providing constraints on the age and degree of firing within the oven. Roman activity at Milltimber is tied to the late 1st century AD (although only one of these was taken through to dating). Following this, there is limited evidence that the Romans returned to this camp and reused it in the campaigns of the mid-2nd century (although possible) or the 3rd century.

Sample ID	Depth / cm	Altitude / m AOD	Context no.	Sediment description	*Significance?*
Profile 1; Natural succession, immediately W of cut feature [2036]					
P1/1	9	12.08	2042	brown fine-grained silt loam	final flooding of terrace, post-Roman occupation of the area
P1/2	18	11.99	2042		
P1/3	32	11.85	2042		
P1/4	42	11.75	2044	dark brown-grey silt loam	natural succession into which Roman ovens are cut; means to reconstruct fluvial history up to Roman occupation
P1/5	57	11.60	2043	fine-grained dark silts	
P1/6	68	11.49	2043		
P1/7	78	11.39	2043		
P1/8	85	11.32	substrate	waterlogged at base	
Profile 2; Fill of cut feature [2036], the Roman Oven					
P2/1	7	12.11	2042		
P2/2	14	12.04	2042	brown fine-grained silted loam	final flooding of terrace, post-Roman occupation of the area
P2/3	22	11.96	2042		
P2/4	30	11.88	2041	brown fine-grained silted loam	
P2/5	38	11.80	2041		
P2/6	45	11.73	2038	red-brown 'fired/burnt' loam	Roman occupation
P2/7	49	11.69	2037	dark-grey, charcoal-rich horizon/ burnt substrate?	
P2/8	53	11.65	substrate	waterlogged at base	
Profile 3; Natural succession, downslope/riverward of profiles 1 and 2					
P3/1	16	c.12.59	2042	brown loamy silts	final flooding of terrace, post-Roman occupation of the area
P3/2	25	c.12.50	2042		
P3/3	33	c.12.42	2042		
P3/4	40	c.12.35	2042		
P3/5	49	c.12.26	2042		
P3/6	57	c.12.18	2042		
P3/7	68	c.12.07	2042		
P3/8	76	c.11.99	2042		
P3/9	85	c.11.90	2043	brown to brown-grey loamy silts	natural succession into which Roman ovens are cut; means to reconstruct fluvial history up to Roman occupation
P3/10	91	c.11.84	2043		
P3/11	99	c.11.76	2043	brown loamy silts	
P3/12	105	c.11.70	?substrate		
P3/13	112	c.11.63	substrate	waterlogged at base	
Profile 4: Shallow channel-like 'embayment', N of, and topographically above profiles 1 and 2					
P4/1	5		-	dark brown silty sand	
P4/2	11		-		
P4/3	18		-		
P4/4	26		-	orange sand	
P4/5	33		-		
P4/6	45		-	stoney sand	
P4/7	55		-		
P4/8	65		-		
Profile 5: Fill of Mesolithic pit					
P5/1	4		-	orange brown sand	

P5/2	9		-	(slightly darker) orange brown sand	
P5/3	17		-	dark sand	
P5/4	24		-	coarse tan sand	
P5/5	37		-	light brown sand	
P5/6	45		-		
P5/7	54		-	coarse, clean(er) sand	
P5/8	65		-		
P5/9	78		-		
Profile 6: Sandy materials, deposited above profiles and 2					
P6/1	5		-	orange brown sand	
P6/2	10		-		
P6/3	20		-		
P6/4	27		-		
P6/5	33		-		
P6/6	40		-	grey, more compact stoney sand	
P6/7	48		-		

Table 2-1: Sample descriptions, contexts and archaeological significance of the profiling samples used for initial screening and laboratory characterisation [a] relative to site datum

Associated with profile	Field no.	SUTL no.	Depth /cm	Context	Archaeological significance
1	OSL1	2727	37	observed base of [2042]	constrain history of flooding events post-Roman occupation
	OSL2	2728	76	observed base of [2043]	reconstruct fluvial history of Channel 1
2	OSL3	2729	12	top of [2042]	constrain history of flooding events post-Roman occupation
	OSL4	2730	38	base of [2042]	
	OSL5	2731	55	substrate; equivalent to [2043]	reconstruct fluvial history of Channel 1
	OSL6	2732	42	[2038] charcoal-bearing horizon	constrain age of oven [F17]
	OSL7	2733	45	[2038] burnt substrate	
3	OSL8	2734	80	base of [2042]/[2041]	constrain history of flooding events post-Roman occupation
	OSL9	2735	95	equivalent to [2043]	reconstruct late fluvial history of Channel 1
	OSL10	2736	112	substrate; observed base of [2043]	

Table 2-2: Sample descriptions, contexts and archaeological significance of dating samples

Field gamma spectrometry (FGS) measurements were made using a Health Physics Instruments Rainbow MCA with a 2”x 2” NaI probe. Field spectra were each measured for 300s in holes cut around the luminescence sampling positions using a trowel and calibrated to the 1457 keV peak from 40K before calculation of dose rates. Prior to fieldwork, measurements were made using this system on the doped concrete reference pads at SUERC in order to provide cross-reference to dose-rate conversion factors established by Sanderson (1987), based on comparisons with TL dosimetry in doped blocks then at the Oxford and Risø luminescence laboratories.

The spectra were calibrated to the 1457 keV peak from 40K, then dose rates were determined from integral counts >450 keV, >1350 keV, and the energy integral (sum of counts times energy) across all the recorded spectrum. Using this approach yielded dose rates from the pads that were within errors of expected values.

Table 2-3 shows the gamma dose rates recorded in-situ for the dating samples. Interestingly, the in situ gamma dose rates vary by section (profiles 1 and 2, mean, 0.91 ± 0.01 mGy a-1; profile 3, mean, 1.16 ± 0.01 mGy a-1), rather than lithological control. This has some bearing on the subsequent interpretation of the luminescence proxy information: it implies that within single sediment stratigraphies dosimetric variations are not contributing (significantly) to the observed range in signal intensities (more on this below).

SUTL no.	FGS			
	mGy a^{-1}	% err	geometric correction	mGy a^{-1}
OSL1	0.75 ± 0.02	3.0	0.8	0.90 ± 0.02
OSL2	0.72 ± 0.02	3.0	0.8	0.86 ± 0.02
OSL3	0.77 ± 0.02	3.0	0.8	0.92 ± 0.02
OSL4	0.80 ± 0.02	2.9	0.8	0.96 ± 0.02
OSL5	0.95 ± 0.03	3.0	0.9	1.04 ± 0.03
OSL8	1.03 ± 0.03	2.9	0.8	1.24 ± 0.02
OSL9	0.97 ± 0.03	2.9	0.8	1.16 ± 0.02
OSL10	0.91 ± 0.03	2.9	0.8	1.09 ± 0.02

Table 2-3: In situ gamma dose rate measurements made using a Health Physics Instruments Rainbow MCA with a 2” × 2” NaI probe

Figure 2-3: Photograph of profile 1, showing the positions of the laboratory profiling and dating samples

Figure 2-4: Photographs of profile 2, showing the positions of the laboratory profiling and dating samples

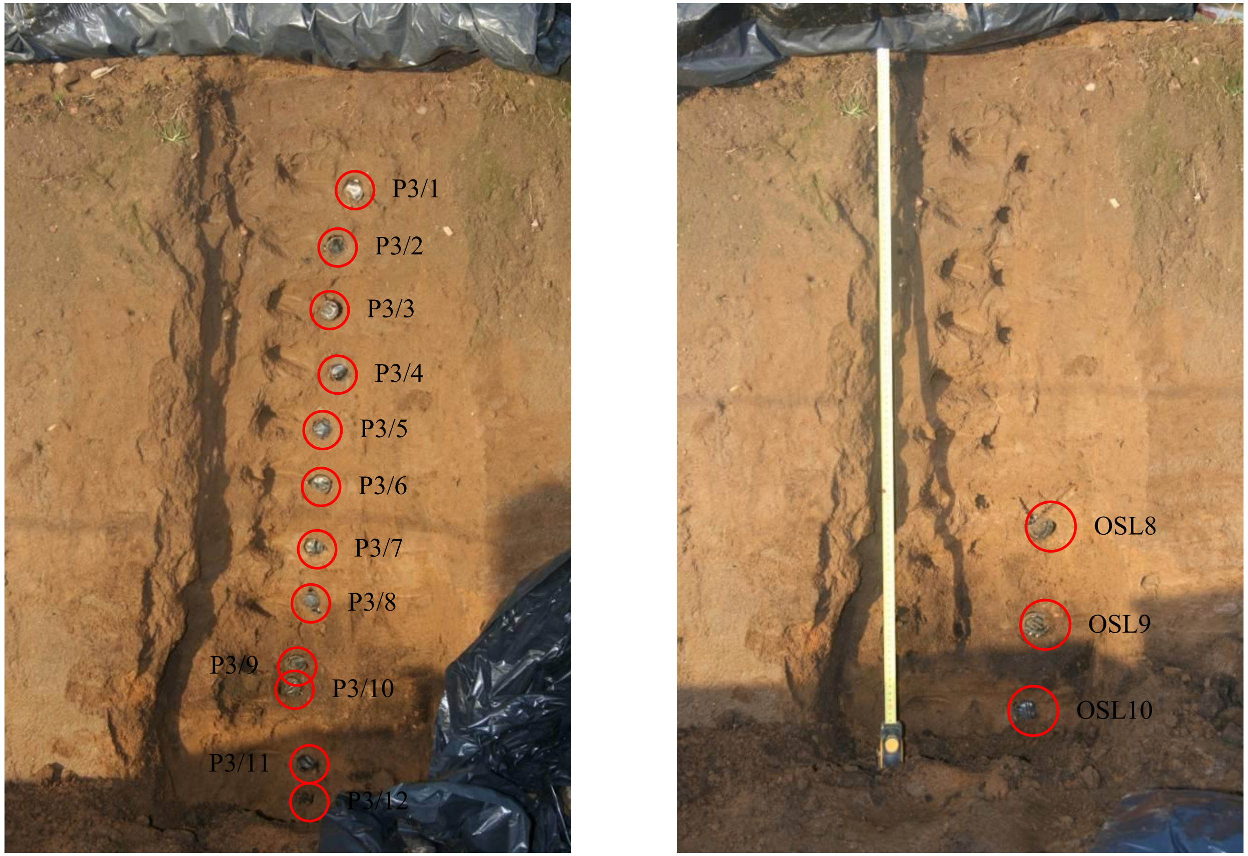

Figure 2-5: Photographs of profile 3, showing the positions of the laboratory profiling and dating samples

3. Preliminary luminescence stratigraphies

All samples were first appraised using the SUERC portable OSL reader, following an interleaved sequence of system dark count (background), infra-red stimulated luminescence (IRSL) and OSL, similar to that described by Sanderson and Murphy (2010). This method allows for the calculation of IRSL and OSL net signal intensities, depletion indices and IRSL:OSL ratios (as in Kinnaird et al., 2015), which are then used to generate luminescence-depth profiles. The interpretation of the net signal intensities, their depletion indices and the IRSL/OSL ratio have been discussed in Sanderson & Murphy (2010). Where minerals and the sediments have common sensitivities and dose rates the IRSL and OSL intensities may act as age proxies for well bleached sedimentary units, in which case inversions or discontinuities would reflect changes in initial residuality or in depositional circumstances. If sensitivity, colour or mineralogical origins change through the section, then intensities might also reflect those changes. The depletion index, which represents the proportion of signal released in the first half of the stimulation cycle relative to the second half, is an indicator of sample transparency coupled to information about whether the samples contained an inherited or single cycle signal. Higher depletion indices would indicate better bleached material. The IRSL/OSL ratio is potentially sensitive to mineralogical input changes, potentially reflecting quartz/feldspar relative contents and hence the weathering history of the sediment.

The IRSL and OSL net signal intensities are plotted against depth for the six sediment stratigraphies in figures 3-1 and 3-2. The profiles are informative, showing consistency within units from profile to profile, conveying information on unit correlations between sections, and suggesting relative temporal chronologies.

Profiles 1 - 3: fluvial terrace deposits, the cut feature [2036] and its anthropogenic and natural fills

A number of units, defined on their luminescence characteristics, are common to all three profiles: (i) the substrate (grading into the dark-grey silts) is characterised by moderately large signal intensities - 2.7 to 9.3 $\times 10^5$ photon counts in IRSL, and 1.5 to 3.5 $\times 10^6$ photon counts in OSL; (ii) the uppermost silts, reflecting final flooding/silting of the cut feature [2036] are characterised by low signal intensities - 1.6 to 2.4 $\times 10^4$ photon counts in IRSL, and 1.0 to 1.7 $\times 10^4$ photon counts in OSL (the range in signal intensities obtained for the equivalent units in profile 3 spans from 4.8 $\times 10^3$ to 7.0 $\times 10^4$ photon counts in IRSL and 3.9 $\times 10^4$ to 3.8 $\times 10^4$ photon counts in OSL, implying a slightly more continuous environmental record); (iii) the middle unit of tan, brown to grey-brown silts and loamy sands, is characterised by intermediate IRSL and OSL net signal intensities (4.4 to 8.1 $\times 10^4$ photon counts and 2.0 to 4.7 $\times 10^5$ photon counts, respectively). The progression in luminescence signals with depth, suggestive of in situ luminescence growth and normal age-depth progressions, is a promising behaviour for luminescence dating.

The anthropogenic fills of the cut feature [2036] are readily distinguishable from the natural sediment accumulations. The basal unit, encompassing the burnt substrate, is characterised by large signal intensities (more similar to the substrate than the overlying fills. It is interesting to speculate why this may be so. Most probable is that the sensitivity of the quartz grains in the anthropogenic layers was modified by heating, but poor bleaching at deposition, or an additional input of sediment at this time, are also possible. Subsequent laboratory characterisation provide the means to test this. Continuing up section, the profile shows a step decrease in signal intensities, progressing into the finer fill, consistent with a prominent temporal break. Further characterisation of the luminescence properties of both units using laboratory screening methods can tell if there is an age discontinuity between the two. Notably, some of the highest depletion ratios are observed within the brown silts which infill the oven, indicating that the OSL signals may have been well-bleached prior to deposition.

Profile 4: the fill of the shallow depression preserved on the Camphill Terrace
The luminescence-depth plot for profile 4 shows a straight-forward progression in luminescence signals with depth, from top to base, 7.9×10^4 to 2.8×10^6 IRSL photon counts and 2.9×10^5 to 1.2×10^7 OSL photon counts, which is consistent with the in-situ growth of luminescence, and a normal age-depth progression. (A single maxima in signal intensity at a depth of 45 cm in the sequence - 3.4×10^6 and 2.1×10^7 photon counts, IRSL and OSL respectively, and notably the lowest depletion indices within this profile - coincides with the first of the gravel horizons in the profile). The higher signal intensities most probably reflect residual luminescence carried by poorly zeroed grains within this unit.

Profile 5: the fill of the negative feature (Mesolithic?) cut into the Camphill Terrace
The sediments sampled in profile 5 are characterised by a more complex luminescence stratigraphy, implying a more complex depositional history, with the large spread in signal intensities with depth reflecting variable zeroing at deposition, and/or sensitivity variations, controlled by grain size fluctuations, mineralogical variations etc. Notwithstanding this, the profile does show a slight increase in signal intensities with depth from 10^5 to 10^6 photon counts in IRSL, and 10^6 to 10^7 photon counts in OSL. In detail, throughout the profile, maxima in signal intensities are followed by a tail to lower intensities, potentially indicating deposition from high-energy events (natural or anthropogenically induced), interleaved with periods of slower sedimentation (natural), and potentially better luminescence resetting.

Profile 6: 'overbank' sands 'resting' on Camphill Terrace - post-Roman catastrophic flooding, or stratified sands of the Camphill Terrace?
A more straight-forward progression in luminescence signals with depth is noted for profile 6, from top to base, 4.6×10^5 to 1.2×10^6 IRSL photon counts and 1.6×10^6 to 5.4×10^6 OSL photon counts. The substrate is characterised by slightly higher IRSL and OSL signal intensities than those observed in profiles 1 to 3 - 1.2×10^6 photon counts, in IRSL to 5.6×10^6 photon counts, in OSL; further up the profile, within the orange 'overbank' sands, the IRSL and OSL signal intensities range between 7.0×10^6 and 4.6×10^5 photon counts and 3.2×10^6 and 1.6×10^6 photon counts, respectively. The data then imply a temporal discontinuity between deposition of the lower and upper units.

Discussion. In each profile, a number of discrete units were identified based on their luminescence properties, which provided the means to correlate between adjacent and/or stratigraphically related units. Moreover, the stratigraphic trends in the profiling data indicate the sections in which there are large temporal discontinuities i.e. between the substrate and the overlying accumulations of silts (P1-3). This would imply that sensitivity variations within the majority of these bulk materials are not the controlling variable in determining net luminescence intensities.

The dynamic range in IRSL and OSL net signal intensities between the known-age materials - cultural materials associated with the Roman encampment - and the fill of the 'Mesolithic pit' is consistent with the hypothesized age relationship (assuming similar environmental dose rates). Interestingly, as the fill of the 'shallow embayments' on the Camphill Terrace are characterised by similar signal intensities, then it can be postulated that these are of a similar age.

The data imply a refinement to the suggested landscape history: 1.) Late Devensian materials are represented in the lowest parts of the profiles in the Camphill Terrace deposits; 2.) the sands lying on, and comprising the upper units of the Camphill Terrace represent sediment deposited at a late stage in aggradation of this terrace and are not products of very much later flood-stage sediments; 3.) the 'shallow embayments' on top of the Camphill Terrace, were cut prior to, and subsequently in-filled contemporaneously with the Mesolithic occupations; 4.) the field profiles are consistent with the interpretation that the Romans cut back into the natural accumulations forming the bank of the Floodplain Terrace; 5.) post-Roman flooding deposited silts across the floodplain of the Floodplain Terrace; and 6.) final silting of Channel 1 on the Floodplain Terrace occurred continuously, but episodically, over the subsequent 2000 years.

Having established that the sediment stratigraphies sampled here have promising luminescence behaviour, and are amenable to OSL dating, the work then progressed to the subsequent stage of laboratory analyses, firstly to assess luminescence sensitivities and stored dose values by laboratory profiling, and secondly to undertake full OSL dating, and therefore generate the chronologies to interpret the site formation processes.

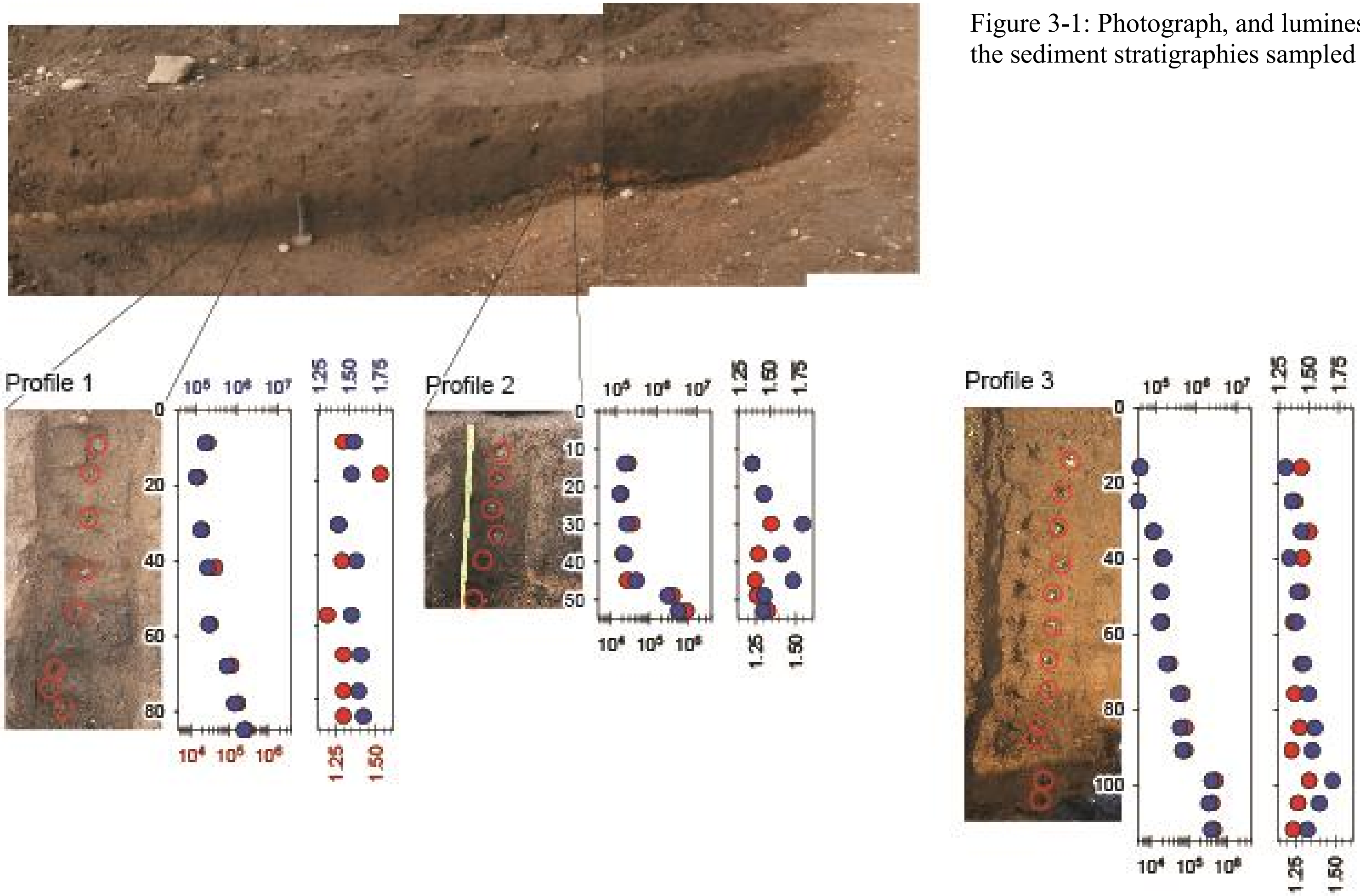

Figure 3-1: Photograph, and luminescence -depth profile, for the sediment stratigraphies sampled in profiles 1-3

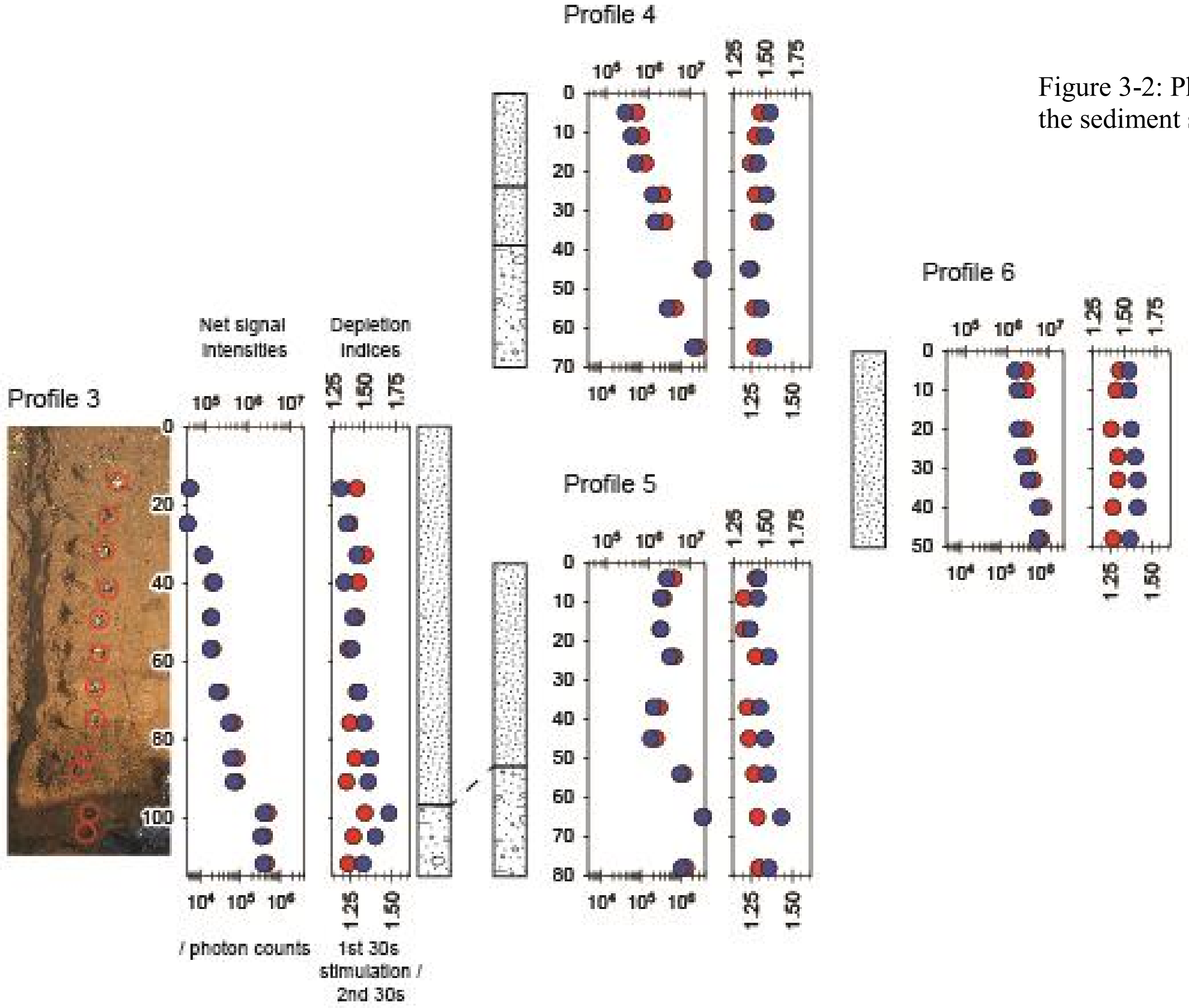

Figure 3-2: Photograph, and luminescence -depth profile, for the sediment stratigraphies sampled in profiles 1-3

Sample no.	Depth	IRSL net signal intensities	IRSL depletion ratio	OSL net signal intensities	OSL depletion ratio	IRSL : OSL ratio
P1/1	9	27900 ± 170	1.3 ± 0.02	171050 ± 420	1.54 ± 0.01	0.1631 ± 0.0011
P1/2	18	16050 ± 130	1.53 ± 0.03	103670 ± 330	1.52 ± 0.01	0.1549 ± 0.0014
P1/3	32	19800 ± 150	1.27 ± 0.02	131190 ± 370	1.41 ± 0.01	0.1509 ± 0.0012
P1/4	42	44390 ± 220	1.29 ± 0.01	198430 ± 450	1.56 ± 0.01	0.2237 ± 0.0012
P1/5	57	32230 ± 190	1.20 ± 0.01	209710 ± 460	1.52 ± 0.01	0.1537 ± 0.0010
P1/6	68	113580 ± 340	1.30 ± 0.01	591410 ± 770	1.60 ± 0.01	0.1920 ± 0.0006
P1/7	78	167350 ± 410	1.30 ± 0.01	904550 ± 960	1.58 ± 0.01	0.1850 ± 0.0005
P1/8	85	273120 ± 530	1.30 ± 0.01	1532370 ± 1240	1.62 ± 0.01	0.1782 ± 0.0004
P2/2	14	29270 ± 180	1.23 ± 0.01	169870 ± 420	1.36 ± 0.01	0.1723 ± 0.0011
P2/3	22	18720 ± 150	1.30 ± 0.02	125880 ± 360	1.46 ± 0.01	0.1487 ± 0.0012
P2/4	30	36440 ± 200	1.35 ± 0.01	190840 ± 440	1.78 ± 0.01	0.1909 ± 0.0011
P2/5	38	20900 ± 150	1.27 ± 0.02	163540 ± 410	1.61 ± 0.01	0.1278 ± 0.0010
P2/6	45	27230 ± 170	1.25 ± 0.02	317780 ± 570	1.70 ± 0.01	0.0857 ± 0.0006
P2/7	49	416230 ± 650	1.26 ± 0.01	1954920 ± 1400	1.46 ± 0.01	0.2129 ± 0.0004
P2/8	53	931230 ± 970	1.33 ± 0.01	3536160 ± 1890	1.45 ± 0.01	0.2633 ± 0.0003
P3/1	16	5410 ± 90	1.29 ± 0.04	43990 ± 220	1.31 ± 0.01	0.1231 ± 0.0021
P3/2	25	4850 ± 90	1.25 ± 0.04	38580 ± 200	1.36 ± 0.01	0.1258 ± 0.0023
P3/3	33	11730 ± 120	1.34 ± 0.03	94910 ± 320	1.44 ± 0.01	0.1235 ± 0.0014
P3/4	40	19740 ± 150	1.30 ± 0.02	165570 ± 410	1.34 ± 0.01	0.1192 ± 0.0010
P3/5	49	18180 ± 150	1.29 ± 0.02	143770 ± 380	1.41 ± 0.01	0.1265 ± 0.0011
P3/6	57	21000 ± 160	1.24 ± 0.02	130150 ± 370	1.40 ± 0.01	0.1614 ± 0.0013
P3/7	68	31920 ± 190	1.29 ± 0.01	194590 ± 450	1.46 ± 0.01	0.1641 ± 0.0010
P3/8	76	69730 ± 270	1.25 ± 0.01	380650 ± 620	1.50 ± 0.01	0.1832 ± 0.0008
P3/9	85	82120 ± 290	1.28 ± 0.01	415900 ± 650	1.55 ± 0.01	0.1974 ± 0.0008
P3/10	91	81370 ± 290	1.23 ± 0.01	472830 ± 690	1.53 ± 0.01	0.1721 ± 0.0007
P3/11	99	506900 ± 720	1.34 ± 0.01	2437570 ± 1570	1.70 ± 0.01	0.2080 ± 0.0003
P3/12	105	411500 ± 650	1.27 ± 0.01	2120850 ± 1460	1.59 ± 0.01	0.1940 ± 0.0003
P3/13	112	462370 ± 680	1.24 ± 0.01	2383570 ± 1550	1.49 ± 0.01	0.1940 ± 0.0003
P4/1	5	79270 ± 290	1.31 ± 0.01	288840 ± 540	1.54 ± 0.01	0.2744 ± 0.0011
P4/2	11	107500 ± 330	1.28 ± 0.01	406990 ± 640	1.50 ± 0.01	0.2641 ± 0.0009

P4/3	18	130350 ± 370	1.25 ± 0.01	500980 ± 710	1.44 ± 0.01	0.2602 ± 0.0008
P4/4	26	356280 ± 600	1.28 ± 0.01	1297930 ± 1150	1.51 ± 0.01	0.2745 ± 0.0005
P4/5	33	413200 ± 650	1.30 ± 0.01	1474420 ± 1220	1.50 ± 0.01	0.2802 ± 0.0005
P4/6	45	3389130 ± 1850	1.25 ± 0.01	21015290 ± 4600	1.37 ± 0.01	0.1613 ± 0.0001
P4/7	55	737660 ± 860	1.27 ± 0.01	2930820 ± 1720	1.47 ± 0.01	0.2517 ± 0.0003
P4/8	65	2746030 ± 1660	1.28 ± 0.01	11896610 ± 3460	1.49 ± 0.01	0.2308 ± 0.0002
P5/1	4	692300 ± 840	1.28 ± 0.01	2761540 ± 1670	1.45 ± 0.01	0.2507 ± 0.0003
P5/2	9	374140 ± 620	1.21 ± 0.01	1977880 ± 1410	1.44 ± 0.01	0.1892 ± 0.0003
P5/3	17	307680 ± 560	1.21 ± 0.01	2002600 ± 1420	1.38 ± 0.01	0.1536 ± 0.0003
P5/4	24	707260 ± 850	1.28 ± 0.01	3340850 ± 1840	1.53 ± 0.01	0.2117 ± 0.0003
P5/5	37	292790 ± 550	1.23 ± 0.01	1351700 ± 1170	1.46 ± 0.01	0.2166 ± 0.0004
P5/6	45	245850 ± 500	1.24 ± 0.01	1148860 ± 1080	1.50 ± 0.01	0.2140 ± 0.0005
P5/7	54	1203340 ± 1100	1.27 ± 0.01	5832290 ± 2430	1.52 ± 0.01	0.2063 ± 0.0002
P5/8	65	3800070 ± 1960	1.29 ± 0.01	19297140 ± 4410	1.63 ± 0.01	0.1969 ± 0.0001
P5/9	78	1380320 ± 1180	1.30 ± 0.01	6264110 ± 2510	1.53 ± 0.01	0.2204 ± 0.0002
P6/1	5	462460 ± 680	1.31 ± 0.01	1591250 ± 1270	1.54 ± 0.01	0.2906 ± 0.0005
P6/2	10	466670 ± 690	1.29 ± 0.01	1786250 ± 1340	1.54 ± 0.01	0.2613 ± 0.0004
P6/3	20	432050 ± 660	1.26 ± 0.01	1838210 ± 1360	1.56 ± 0.01	0.2350 ± 0.0004
P6/4	27	531350 ± 730	1.30 ± 0.01	2371650 ± 1550	1.59 ± 0.01	0.2240 ± 0.0003
P6/5	33	703460 ± 840	1.30 ± 0.01	3207680 ± 1800	1.61 ± 0.01	0.2193 ± 0.0003
P6/6	40	1233750 ± 1120	1.27 ± 0.01	5758170 ± 2410	1.61 ± 0.01	0.2143 ± 0.0002
P6/7	48	1102510 ± 1060	1.27 ± 0.01	5424740 ± 2340	1.55 ± 0.01	0.2032 ± 0.0002

Table 3-1: Field profiling data, as obtained using portable OSL equipment, for the sediment stratigraphies examined at Headland Archaeology's excavations at Milltimber

4. Laboratory calibrated screening measurements

It has already been shown that: 1.) there are measureable stratigraphic trends in the luminescence-depth profiles; 2.) it is possible to correlate between units on the basis of their luminescence behaviour, in addition to their sedimentological characteristics and archaeological contexts, providing temporal markers to interpret the site formation processes/later landscape history of the Floodplain Terrace. It remains to be determined whether the observed signal intensities and progressions are controlled or influenced by sensitivity variations.

Laboratory profiling provides one means to assess luminescence sensitivity distributions, and the first preliminary assessment of apparent doses, and therefore the magnitude and range of apparent sediment ages.

These measurements were restricted to profiles 1 to 3, those concerned with the Floodplain Terrace, and the sediments enclosing the evidence for Roman activity at the site.

4.1. Methodology

All profiling samples were wet sieved at 90 and 250µm. The 90-250 µm fractions were then subjected to acid treatments of 1M HCl for 10 mins, 15% HF for 15mins and 1M HCl for 10mins. The samples were split into two fractions, one for polymineral analysis and one for quartz analysis.

Luminescence sensitivities (Photon Counts per Gy) and stored doses (Gy) were evaluated from paired aliquots of the polymineral and HF-etched quartz fractions, using Risø DA-15 automatic readers (following procedures establised in Burbidge et al., 2007; Sanderson et al., 2001; Sanderson et al., 2003). The readout cycles comprised a natural readout, followed by readout cycles for a nominal 1Gy test dose, a 5Gy regenerative dose, and a further 1Gy test dose. For the polymineral samples, a 260˚C preheat was followed by 60s OSL measurements using the IR LEDs at 50˚C, the IR LEDs at 225˚C (the post-IR IRSL signal), the blue LEDs at 125˚C, and a TL measurement to 500˚C. For the quartz samples, a 240˚C preheat was used with 60s OSL measurements using the blue LEDs.

4.2. Results

The data are tabulated below (tables 4-1 to 4-4), and presented graphically in figures 4-1 to 4-4. The laboratory profiling data reproduces the maxima and trends in the field profiling dataset.

For profile 1, the section adjacent to the Roman oven and its fill, laboratory profiling reveals a relatively straight-forward progression in OSL stored dose estimates with depth, from 0.8 to c. 7.7 Gy (substrate returns values in excess of 10 Gy). The only apparent complexity to the luminescence stratigraphy is the presence of a re-worked, and partly zeroed horizon at a depth of c. 42 cm, which coincides with the transition/boundary between the substrate and the overlying sequence of post-Roman flood deposits. The temporal break between the flood deposits and substrate, indicated by a step-change in OSL store dose values, is on the order of 4 Gy, which assuming an environmental dose rate of c. 3 mGy a^{-1} corresponds to a hiatus in excess of 1,250 years.

Similarly, a progression in OSL stored dose estimates with depth, from sub-Gy to c. 7.5 Gy (the substrate is represented by values in excess of 12 Gy; P3/11 to P3/13), is noted for profile 3, which examines the infill of Channel 1 on the Floodplain Terrace (the oven F17 is cut into the bank of Channel 1). In contrast to profile 1, the range in OSL (and IRSL) stored dose values across this profile is expanded, representing a more complete and continuous environmental record. Re-deposited, and poorly to partly zeroed, horizons are present at depths of 33 and 85 cm; the latter corresponds to the transition between the lower substrate and overlying sequence of post-Roman flood deposits.

Profile 2 which examines the substrate (deposits forming the bank of Channel 1 of the Floodplain Terrace), then the fill of the Roman oven, completes the later Holocene landscape history. The substrate (and substrate-derived materials) are characterised by stored dose values in excess of 10 Gy, which assuming an environmental dose rate of 3.2 $mGya^{-1}$ corresponds to depositional ages in excess of 3 ka. The lower, anthropogenic fill of the cut feature, is represented by OSL stored dose values in the range 6 to 5 Gy, which is consistent with the Roman age. Interestingly, these materials are characterised by the largest OSL sensitivities, an order of magnitude larger than those observed elsewhere in the profile. The sampled materials include charcoal, and reddened sediments, confirmation that these horizons were heated and the quartz was sensitized during this process. In contrast, the overlying natural fills, which must represent the final siltation of this feature, are characterised by stored dose values in the range 4 to 0.5 Gy. Luminescence sensitivities return to values more comparable with the substrate. This suggests that after the Roman occupation of this area, this oven was left open, and that the subsequent history of floods in the region, led to the gradual siltation of this negative feature.

SUTL no.	Depth / cm	Stored dose / Gy		Sensitivity / photon counts Gy^{-1}		/ Gy	/ photon counts Gy^{-1}
		Aliquot 1	Aliquot 2	Aliquot 1	Aliquot 2	Mean	
Profile 1							
2724A	9	0.80 ± 0.02	1.44 ± 0.03	9932 ± 100	9479 ± 97	1.12 ± 0.32	9706 ± 226
2724B	18	0.84 ± 0.02	0.60 ± 0.01	10897 ± 104	20745 ± 144	0.72 ± 0.12	15821 ± 4924
2724C	32	1.52 ± 0.05	1.63 ± 0.09	2994 ± 55	1387 ± 37	1.57 ± 0.05	2191 ± 804
2724D	42	8.23 ± 0.31	8.08 ± 0.32	1945 ± 44	1718 ± 41	8.15 ± 0.07	1832 ± 114
2724E	57	6.82 ± 0.34	3.97 ± 0.11	955 ± 31	3470 ± 59	5.39 ± 1.43	2213 ± 1258
2724F	68	12.92 ± 0.24	7.71 ± 0.16	7213 ± 85	6261 ± 79	10.32 ± 2.61	6737 ± 476
2724G	78	11.42 ± 0.38	6.36 ± 0.12	2161 ± 46	7320 ± 86	8.89 ± 2.53	4741 ± 2580
Profile 2							
2725A	7	0.59 ± 0.01	0.79 ± 0.02	16125 ± 127	4791 ± 69	0.69 ± 0.10	10458 ± 5667
2725B	14	2.72 ± 0.05	1.37 ± 0.03	7005 ± 84	6376 ± 80	2.04 ± 0.67	6690 ± 315
2725C	22	6.46 ± 0.15	3.37 ± 0.06	5204 ± 72	7974 ± 89	4.91 ± 1.54	6589 ± 1385
2725D	30	5.25 ± 0.17	3.66 ± 0.09	2580 ± 51	4543 ± 67	4.45 ± 0.80	3561 ± 982
2725E	38	5.63 ± 0.07	3.63 ± 0.07	17070 ± 131	7765 ± 88	4.63 ± 1.00	12418 ± 4652
2725F	45	5.88 ± 0.04	5.53 ± 0.06	62999 ± 251	22657 ± 151	5.70 ± 0.18	42828 ± 20171
2725G	49	11.04 ± 0.06	17.12 ± 0.17	69511 ± 264	24019 ± 155	14.08 ± 3.04	46765 ± 22746
2725H	53	10.65 ± 0.38	10.84 ± 0.31	1885 ± 43	2434 ± 49	10.74 ± 0.09	2160 ± 275
Profile 3							
2726b	25	0.60 ± 0.02	0.44 ± 0.01	5157 ± 72	16755 ± 129	0.52 ± 0.08	10956 ± 5799
2726c	33	23.42 ± 0.14	1.09 ± 0.01	52466 ± 229	37453 ± 194	12.3 ± 11.2	44959 ± 7506
2726d	40	1.13 ± 0.01	4.43 ± 0.03	48500 ± 220	48541 ± 220	2.78 ± 1.65	48520 ± 21
2726e	49	1.30 ± 0.02	1.15 ± 0.02	11490 ± 107	19392 ± 139	1.23 ± 0.08	15441 ± 3951
2726f	57	3.53 ± 0.06	1.96 ± 0.03	9631 ± 98	12811 ± 113	2.74 ± 0.79	11221 ± 1590
2726g	68	3.16 ± 0.02	3.12 ± 0.02	46133 ± 215	93059 ± 305	3.14 ± 0.02	69596 ± 23463
2726h	76	4.65 ± 0.03	6.35 ± 0.22	56809 ± 238	2239 ± 47	5.5 ± 0.85	29524 ± 27285
2726i	85	11.11 ± 0.3	10.02 ± 0.15	3465 ± 59	10805 ± 104	10.56 ± 0.54	7135 ± 3670
2726j	91	6.83 ± 0.06	8.16 ± 0.08	33611 ± 183	22432 ± 150	7.49 ± 0.67	28021 ± 5590
2726k	99	11.67 ± 0.77	14.13 ± 0.76	472 ± 22	741 ± 27	12.9 ± 1.23	607 ± 134
2726l	105	12.86 ± 0.38	14.35 ± 0.36	2496 ± 50	3280 ± 57	13.61 ± 0.74	2888 ± 392
2726m	112	12.95 ± 0.84	7.71 ± 0.25	517 ± 23	2516 ± 50	11.65 ± 6.59	1709 ± 1999

Table 4-1: OSL screening measurements on paired aliquots of 90-250µm 40% HF-etched 'quartz'

Table 4-2: IRSL screening measurements on paired aliquots of 90-250µm 15% HF-etched 'polymineral'

SUTL no.	Depth / cm	Stored dose / Gy		Sensitivity / photon counts Gy^{-1}		/ Gy	/ photon counts Gy^{-1}
		Aliquot 1	Aliquot 2	Aliquot 1	Aliquot 2	Mean	
Profile 1							
2724A	9	5.48 ± 0.13	3.56 ± 0.07	380 ± 19	510 ± 23	4.52 ± 0.96	445 ± 65
2724B	18	12.65 ± 0.56	1.62 ± 0.05	120 ± 11	306 ± 17	7.13 ± 5.51	213 ± 93
2724C	32	4.75 ± 0.08	2.73 ± 0.05	728 ± 27	808 ± 28	3.74 ± 1.01	768 ± 40
2724D	42	32.51 ± 0.5	22.45 ± 0.45	828 ± 29	547 ± 23	27.48 ± 5.03	688 ± 141
2724E	57	30.76 ± 0.59	22.24 ± 0.41	551 ± 23	587 ± 24	26.5 ± 4.26	569 ± 18
2724F	68	50.42 ± 0.83	44.15 ± 0.71	716 ± 27	772 ± 28	47.28 ± 3.13	744 ± 28
2724G	78	28.96 ± 0.35	29.99 ± 0.42	1282 ± 36	969 ± 31	29.48 ± 0.52	1126 ± 157
Profile 2							
2725A		1.87 ± 0.04	2.73 ± 0.06	538 ± 23	442 ± 21	2.3 ± 0.43	490 ± 48
2725B	14	1.98 ± 0.05	2.07 ± 0.04	443 ± 21	721 ± 27	2.03 ± 0.04	582 ± 139
2725C	22	3.96 ± 0.1	6.32 ± 0.1	353 ± 19	877 ± 30	5.14 ± 1.18	615 ± 262
2725D	30	5.85 ± 0.15	7.3 ± 0.22	334 ± 18	265 ± 16	6.58 ± 0.73	300 ± 34
2725E	38	11.37 ± 0.22	7.27 ± 0.19	567 ± 24	322 ± 18	9.32 ± 2.05	444 ± 123
2725F	45	6.43 ± 0.18	43.07 ± 0.79	287 ± 17	588 ± 24	25 ± 18	437 ± 151
2725G	49	53.84 ± 0.93	97.43 ± 2.28	673 ± 26	373 ± 19	76 ± 22	523 ± 150
2725H	53	166.6 ± 3.5	192.3 ± 2.8	472 ± 22	914 ± 30	155 ± 129	597 ± 678
Profile 3							
2726b	25	0.46 ± 0.01	0.59 ± 0.02	739 ± 27	535 ± 23	0.52 ± 0.07	637 ± 102
2726c	33	2.02 ± 0.07	1.36 ± 0.04	228 ± 15	344 ± 19	1.69 ± 0.33	286 ± 58
2726d	40	9.68 ± 0.21	5.89 ± 0.15	424 ± 21	351 ± 19	7.79 ± 1.9	387 ± 37
2726e	49	1.24 ± 0.03	1.44 ± 0.02	413 ± 20	914 ± 30	1.34 ± 0.1	664 ± 250
2726f	57	6.52 ± 0.11	3.09 ± 0.06	653 ± 26	664 ± 26	4.81 ± 1.71	658 ± 5
2726g	68	8.78 ± 0.22	5.24 ± 0.17	351 ± 19	231 ± 15	7.01 ± 1.77	291 ± 60
2726h	76	12.85 ± 0.22	13.25 ± 0.26	713 ± 27	530 ± 23	13.05 ± 0.2	622 ± 92
2726i	85	13.77 ± 0.22	15.37 ± 0.25	741 ± 27	761 ± 28	14.6 ± 0.8	751 ± 10
2726j	91	22 ± 1	18 ± 1	323 ± 18	850 ± 29	20 ± 2	586 ± 264
2726k	99	51 ± 1	62 ± 1	1107 ± 33	999 ± 32	57 ± 5	1053 ± 54
2726l	105	59 ± 1	65 ± 1	1117 ± 33	922 ± 30	62 ± 3	1019 ± 97
2726m	112	60 ± 2	82 ± 2	456 ± 21	1042 ± 32	72 ± 22	742 ± 585

SUTL no.	Depth / cm	Stored dose / Gy		Sensitivity / photon counts Gy^{-1}		/ Gy	/ photon counts Gy^{-1}
		Aliquot 1	Aliquot 2	Aliquot 1	Aliquot 2	Mean	
Profile 1							
2724A	9	6.89 ± 0.3	15.85 ± 0.61	1646 ± 41	2282 ± 48	11.37 ± 4.48	1964 ± 318
2724B	18	9.21 ± 0.45	2.19 ± 0.14	1250 ± 35	1162 ± 34	5.7 ± 3.51	1206 ± 44
2724C	32	6.31 ± 0.25	4.63 ± 0.17	2275 ± 48	2535 ± 50	5.47 ± 0.84	2405 ± 130
2724D	42	38 ± 2	16.02 ± 0.46	2099 ± 46	3640 ± 60	27 ± 11	2870 ± 771
2724E	57	22 ± 1	21 ± 1	2766 ± 53	2333 ± 48	22 ± 1	2550 ± 216
2724F	68	39 ± 1	41 ± 2	3363 ± 58	2323 ± 48	40 ± 1	2843 ± 520
2724G	78	34 ± 1	28 ± 1	4326 ± 66	4577 ± 68	31 ± 3	4451 ± 125
Profile 2							
2725A		2.77 ± 0.16	3.59 ± 0.15	1322 ± 36	2037 ± 45	3.18 ± 0.41	1680 ± 357
2725B	14	2.60 ± 0.11	2.17 ± 0.08	2206 ± 47	3107 ± 56	2.38 ± 0.21	2656 ± 450
2725C	22	2.51 ± 0.06	7.08 ± 0.24	5055 ± 71	2930 ± 54	4.80 ± 2.29	3993 ± 1063
2725D	30	7.22 ± 0.26	6.95 ± 0.24	2227 ± 47	2529 ± 50	7.09 ± 0.14	2378 ± 151
2725E	38	8.88 ± 0.26	4.93 ± 0.17	3484 ± 59	2782 ± 53	6.90 ± 1.98	3133 ± 351
2725F	45	7.25 ± 0.14	14.97 ± 0.23	6995 ± 84	9957 ± 100	11.11 ± 3.86	8476 ± 1481
2725G	49	39 ± 2	95 ± 6	2035 ± 45	1184 ± 34	67 ± 28	1610 ± 425
2725H	53	199 ± 12	220 ± 9	1031 ± 32	1997 ± 45	180 ± 151	1387 ± 1481
Profile 3							
2726b	25	0.13 ± 0.01	3.95 ± 0.22	21395 ± 146	1373 ± 37	2.04 ± 1.91	11384 ± 10011
2726c	33	1.99 ± 0.09	2.08 ± 0.14	2047 ± 45	1049 ± 32	2.03 ± 0.04	1548 ± 499
2726d	40	118 ± 6	118 ± 6	1477 ± 38	1210 ± 35	118 ± 2	1344 ± 133
2726e	49	2.06 ± 0.12	2.06 ± 0.08	1344 ± 37	2641 ± 51	2.06 ± 0.01	1993 ± 649
2726f	57	8.10 ± 0.27	5.65 ± 0.15	2939 ± 54	4367 ± 66	6.88 ± 1.23	3653 ± 714
2726g	68	19 ± 1	4.36 ± 0.19	1576 ± 40	1745 ± 42	12 ± 7	1661 ± 84
2726h	76	12.95 ± 0.61	19 ± 1	1758 ± 42	1122 ± 33	15.74 ± 2.79	1440 ± 318
2726i	85	12.71 ± 0.41	13.29 ± 0.43	3147 ± 56	3176 ± 56	13.00 ± 0.29	3162 ± 14
2726j	91	23 ± 1	15.62 ± 0.45	1576 ± 40	3814 ± 62	19 ± 4	2695 ± 1119
2726k	99	62 ± 2	63 ± 2	2944 ± 54	2805 ± 53	62 ± 1	2874 ± 69
2726l	105	69 ± 2	74 ± 3	2725 ± 52	2417 ± 49	71 ± 3	2571 ± 154
2726m	112	99 ± 4	99 ± 4	1647 ± 41	2429 ± 49	99 ± 10	2184 ± 828

Table 4-3: post-IRSL OSL screening measurements on paired aliquots of 90-250μm 15% HF-etched ‘polymineral’

Table 4-4: post-IRSL TL screening measurements on paired aliquots of 90-250μm 15% HF-etched ‘polymineral’

SUTL no.	Depth / cm	Stored dose / Gy		Sensitivity / photon counts Gy^{-1}		/ Gy	/ photon counts Gy^{-1}
		Aliquot 1	Aliquot 2	Aliquot 1	Aliquot 2	Mean	
Profile 1							
2724A	9	24 ± 1	107 ± 3	2436 ± 24	2852 ± 26	65 ± 42	2644 ± 208
2724B	18	84 ± 4	244 ± 1	976 ± 15	2772 ± 25	54 ± 30	1874 ± 898
2724C	32	25 ± 1	22 ± 1	4365 ± 31	5163 ± 34	24 ± 2	4764 ± 399
2724D	42	50 ± 1	44 ± 19	5553 ± 36	3631 ± 28	47 ± 3	4592 ± 961
2724E	57	46 ± 1	52 ± 1	3301 ± 28	4058 ± 31	49 ± 3	3680 ± 378
2724F	68	83 ± 2	107 ± 2	4988 ± 34	4785 ± 33	95 ± 12	4886 ± 101
2724G	78	51 ± 1	62 ± 1	8629 ± 45	5945 ± 37	57 ± 6	7287 ± 1342
Profile 2							
2725A		17 ± 1	22 ± 1	4827 ± 33	2674 ± 24	19 ± 3	3751 ± 1077
2725B	14	23 ± 1	15 ± 1	3646 ± 29	4005 ± 30	19 ± 4	3825 ± 179
2725C	22	20 ± 1	36 ± 1	3010 ± 26	5924 ± 36	28 ± 8	4467 ± 1457
2725D	30	23 ± 1	17 ± 1	2438 ± 23	2256 ± 22	20 ± 3	2347 ± 91
2725E	38	19 ± 1	22 ± 1	4289 ± 32	1978 ± 22	20 ± 2	3134 ± 1156
2725F	45	8.85 ± 0.24	19 ± 1	3182 ± 28	4363 ± 31	14 ± 5	3773 ± 591
2725G	49	56 ± 2	129 ± 3	4353 ± 32	3483 ± 27	92 ± 36	3918 ± 435
2725H	53	224 ± 7	207 ± 4	2508 ± 23	6961 ± 40	193 ± 146	3651 ± 5760
Profile 3							
2726b	25	20 ± 1	24 ± 1	6071 ± 37	3888 ± 30	22 ± 2	4980 ± 1091
2726c	33	21 ± 1	21 ± 1	3042 ± 25	2299 ± 24	21 ± 1	2670 ± 371
2726d	40	129 ± 3	159 ± 5	3124 ± 27	2379 ± 23	144 ± 15	2751 ± 372
2726e	49	21 ± 1	17 ± 1	2945 ± 27	5517 ± 34	19 ± 2	4231 ± 1286
2726f	57	38 ± 1	35 ± 1	5055 ± 34	6427 ± 37	36 ± 2	5741 ± 686
2726g	68	63 ± 2	33 ± 1	2672 ± 26	1930 ± 20	48 ± 15	2301 ± 371
2726h	76	32 ± 1	44 ± 1	3922 ± 30	3725 ± 30	38 ± 6	3823 ± 98
2726i	85	20 ± 1	29 ± 1	4553 ± 35	4699 ± 32	25 ± 4	4626 ± 73
2726j	91	37 ± 1	31 ± 1	5220 ± 35	5412 ± 35	34 ± 3	5316 ± 96
2726k	99	58 ± 1	54 ± 1	6643 ± 37	6644 ± 39	56 ± 2	6643 ± 1
2726l	105	58 ± 1	82 ± 2	5800 ± 37	4480 ± 32	70 ± 12	5140 ± 660
2726m	112	190 ± 5	135 ± 3	3315 ± 27	4669 ± 32	139 ± 98	3954 ± 1354

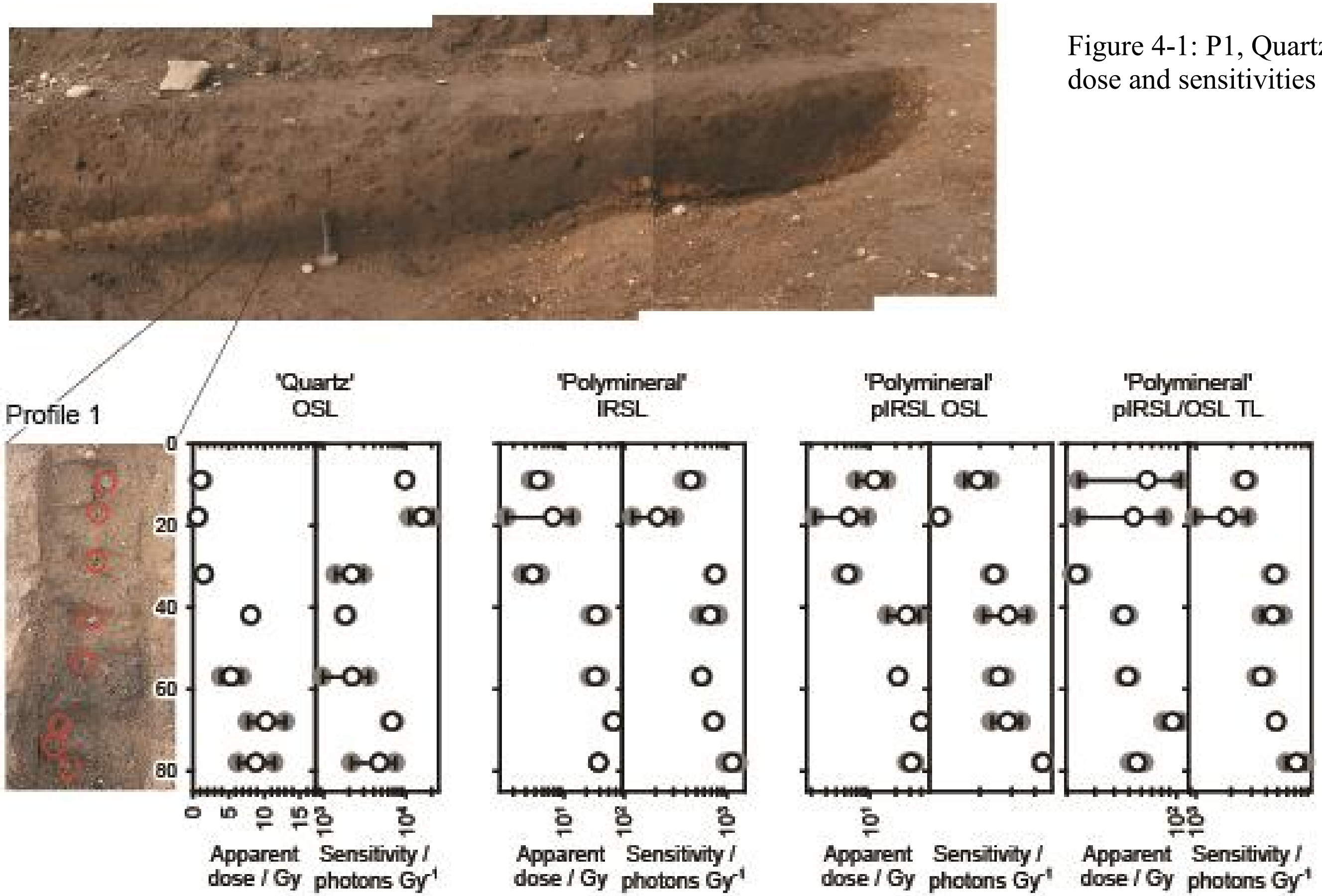

Figure 4-1: P1, Quartz OSL and polymineral IRSL stored dose and sensitivities plotted vs depth

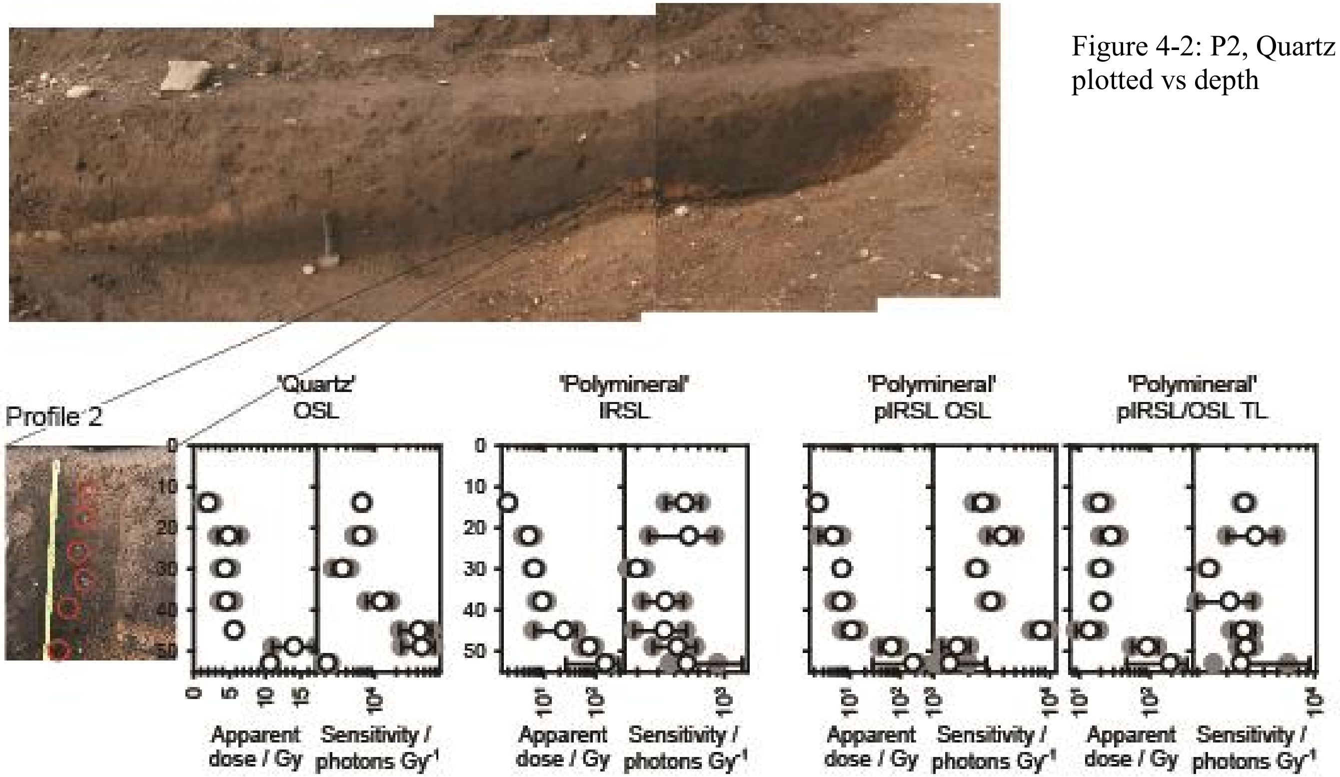

Figure 4-2: P2, Quartz OSL stored dose and sensitivities plotted vs depth

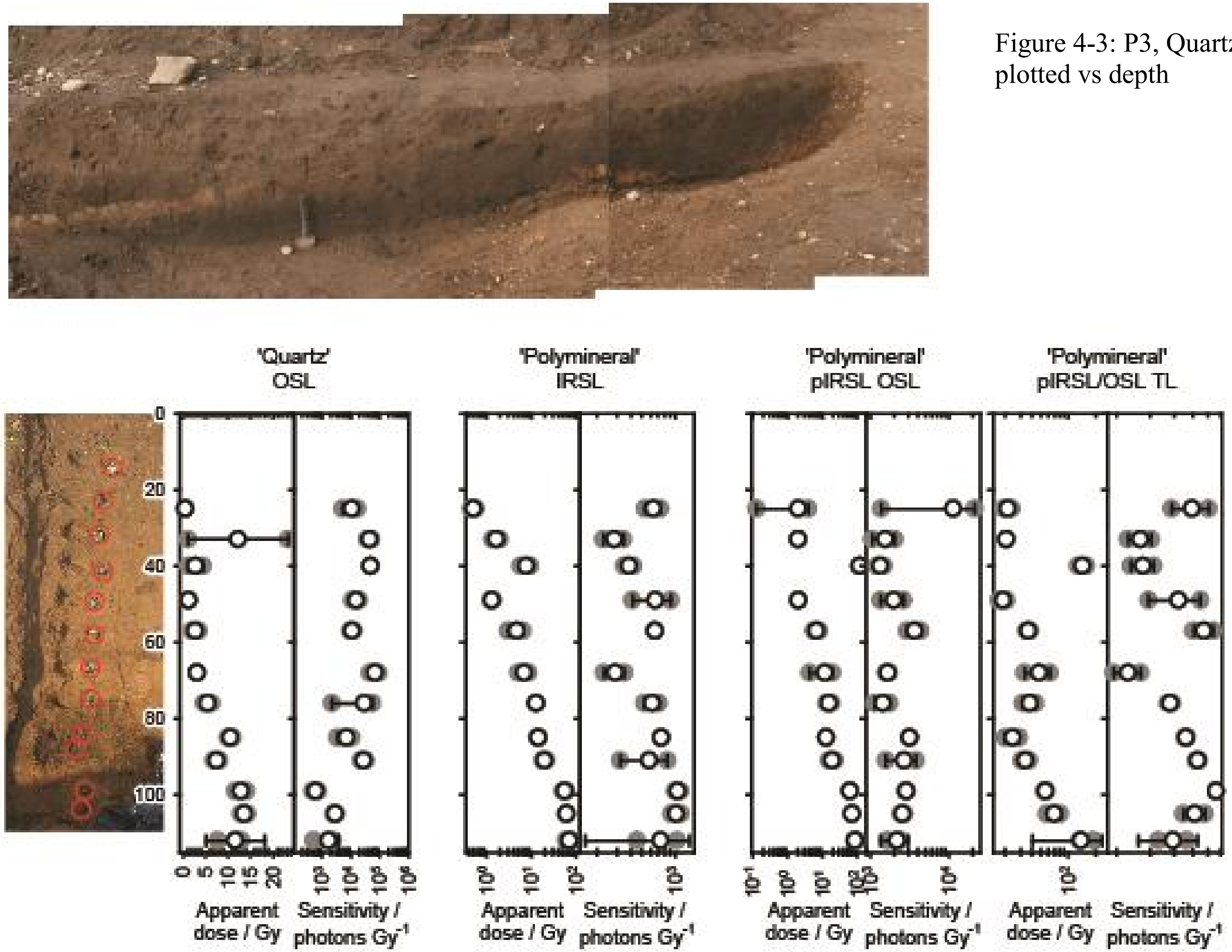

Figure 4-3: P3, Quartz OSL stored dose and sensitivities plotted vs depth

5. Quartz OSL SAR measurements

The preceding sections have highlighted: 1.) the relative temporal sequence for the late Holocene landscape history of the River Dee at Milltimber; 2.) specifically, the relatively late modifications of the Camphill and Floodplain terraces, together with a proxy record of post-Roman historic floods.

The following sections outline the protocols employed to obtain the first quantitative quartz OSL SAR ages for sediments associated with the Floodplain Terrace, and its later proxy record for historic floods.

5.1. Sample preparation

5.1.1. Water contents

Dating materials and bulk sediment samples were weighed, saturated with water and re-weighed. Following oven drying at 50 °C to constant weight, the actual and saturated water contents were determined as fractions of dry weight. These data were used, together with information on field conditions to determine water contents and an associated water content uncertainty for use in dose rate determination.

5.1.2. HRGS and TSBC Sample Preparation

Bulk quantities of material, weighing c. 50g, were removed from each full dating and bulk sediment sample for environmental dose rate determinations. These dried materials were transfer to high-density-polyethylene (HDPE) pots and sealed with epoxy resin for high-resolution gamma spectrometry (HRGS). Each pot was stored for 3 weeks prior to measurement to allow equilibration of ^{222}Rn daughters. A further 20 g of the dried material was used in thick source beta counting (TSBC; Sanderson, 1988).

5.1.3. Quartz mineral preparation

Approximately 20g of material was removed for each tube and processed to obtain sand-sized quartz grains for luminescence measurements. Each sample was wet sieved to obtain the 90-150 and 150-250 µm fractions. Both fractions were treated with 1 M hydrochloric acid (HCl) for 10 minutes, 15% hydrofluoric acid (HF) for 15 minutes, and 1 M HCl for a further 10 minutes. The HF-etched sub-samples were then centrifuged in sodium polytungstate solutions of ~2.51, 2.58, 2.62, and 2.74 gcm^{-3}, to obtain concentrates of potassium-rich feldspars (2.51-2.58 gcm^{-3}), sodium feldspars (2.58-2.62 gcm^{-3}) and quartz plus plagioclase (2.62-2.74 gcm^{-3}). The selected quartz fraction was then subjected to further HF and HCl washes (40% HF for 10mins, followed by 1M HCl for 10 mins).

All materials were dried at 50°C and transferred to Eppendorf tubes. The 40% HF-etched, 2.62-2.74 gcm^{-3} 'quartz' fractions were dispensed to 10mm stainless steel discs for measurement, the purity of which were checked using a Hitachi S-3400N scanning electron microscope (SEM) coupled with an Oxfords Instruments INCA EDX system, to determine approximate elemental concentrations for each sample. 32 aliquots were dispensed for each sample.

5.2. Measurements and determinations

5.2.1. Dose rate determinations

Dose rates were measured in the laboratory using HRGS and TSBC. Full sets of laboratory dose rate determinations were made for all samples.

HRGS measurements were performed using a 50% relative efficiency "n" type hyper-pure Ge detector (EG&G Ortec Gamma-X) operated in a low background lead shield with a copper liner. Gamma ray spectra were recorded over the 30 keV to 3 MeV range from each sample, interleaved with background measurements and measurements from a SUERC Shap Granite standard in the same geometries. Sample counts were for 80ks. The spectra were analysed to determine count rates from the major line emissions from ^{40}K (1461 keV), from selected nuclides in the U decay series (^{234}Th, $^{226}Ra + ^{235}U$, ^{214}Pb, ^{214}Bi and ^{210}Pb) and the Th decay series (^{228}Ac, ^{212}Pb, ^{208}Tl) and their statistical counting uncertainties. Net rates and activity concentrations for each of these nuclides were determined relative to Shap Granite by weighted combination of the individual lines for each nuclide. The internal consistency of nuclide specific estimates for U and Th decay series nuclides was assessed relative to measurement precision, and weighted combinations used to estimate mean activity concentrations (Bq kg^{-1}) and elemental concentrations (% K and ppm U, Th) for the parent activity. These data were used to determine infinite matrix dose rates for alpha, beta and gamma radiation.

Beta dose rates were also measured directly using the SUERC TSBC system (Sanderson, 1988). Count rates were determined with six replicate 600 s counts on each sample, bracketed by background measurements and sensitivity determinations using the Shap Granite secondary reference material. Infinite-matrix dose rates were calculated by scaling the net count rates of samples and reference material to the working beta dose rate of the Shap Granite (6.25 ± 0.03 mGy a^{-1}). The estimated errors combine counting statistics, observed variance and the uncertainty on the reference value.

The dose rate measurements were used in combination with the assumed burial water contents, to determine the overall effective dose rates for age estimation. Cosmic dose rates were evaluated by combining latitude and altitude specific dose rates (0.17 ± 0.01 mGy a^{-1}) for the site with corrections for estimated depth of overburden using the method of Prescott and Hutton (1994).

5.2.2. Quartz SAR luminescence measurements

All measurements were conducted using a Risø DA-15 automatic reader equipped with a $^{90}Sr/^{90}Y$ β-source for irradiation, blue LEDs emitting around 470 nm and infrared (laser) diodes emitting around 830 nm for optical stimulation, and a U340 detection filter pack to detect in the region 270-380 nm, while cutting out stimulating light (Bøtter-Jensen et al., 2000).

Initially, equivalent dose determinations were made on sets of 32 aliquots per sample, using a single aliquot regeneration (SAR) sequence (cf Murray and Wintle, 2000). Using this procedure, the OSL signal levels from each individual disc were calibrated to provide an absorbed dose estimate (the equivalent dose) using an interpolated dose-response curve, constructed by regenerating OSL signals by beta irradiation in the laboratory. Sensitivity changes which may occur as a result of readout, irradiation and preheating (to remove unstable radiation-induced signals) were monitored using small test doses after each regenerative dose. Each measurement was standardised to the test dose response determined immediately after its readout, to compensate for observed changes in sensitivity during the laboratory measurement sequence.

The regenerative doses were chosen to encompass the likely value of the equivalent (natural) dose. A repeat dose point was included to check the ability of the SAR procedure to correct for laboratory-induced sensitivity changes (the 'recycling test'), a zero dose point is included late in the sequence to check for thermally induced charge transfer during the irradiation and preheating cycle (the 'zero cycle'), and an IR response check included to assess the magnitude of non-quartz signals. Regenerative dose response curves were constructed using doses of 0.5, 1, 2.5, 10 and 2.5 Gy, with test doses of 1.5 Gy. The 32 aliquot sets were sub-divided into eight subsets, such that eight preheating regimes were explored - 200°C to 270°C, in 10°C increments.

5.3. Results

5.3.1. Dose rates

HRGS results are shown in Table 5-1, both as activity concentrations (i.e. disintegrations per second per kilogram) and as equivalent parent element concentrations (in % and ppm), based in the case of U and Th on combining nuclide specific data assuming decay series equilibrium.

K concentrations ranged between 2.3 and 3.0 % (with a mean of 2.5 ± 0.2% (stdev)), U concentrations between 2.2 and 4.6 ppm (mean, 2.9 ± 0.8 ppm) and Th concentrations between 7.9 and 12.1 (mean, 10.6 ± 1.6 ppm). By section, the range in concentrations was less variable: for profile 1, the mean values were K- 2.5 ± 0.1 %, U- 2.7 ± 0.4 ppm and Th- 9.2 ± 0.8 ppm; profile 2, K- 2.6 ± 0.3 %, U- 2.7 ± 0.5 ppm and Th- 9.4 ± 1.2 ppm; and profile 3, K- 2.4 ± 0.1 %, U- 3.5 ± 1.2 ppm and Th- 12.0 ± 0.3 ppm.

SUTL no.	Activity Concentration[a] / Bq kg^{-1}			Equivalent Concentration[b]		
	K	U	Th	K / %	U / ppm	Th / ppm
Profile 1						
2727	747 ± 5	29.9 ±13.1	39.5 ± 3.7	2.42 ± 0.02	2.42 ± 1.06	9.74 ± 0.91
2728	777 ± 4	36.2 ± 1.2	34.8 ± 0.8	2.51 ± 0.01	2.93 ± 0.10	8.57 ± 0.19
Profile 2						
2729	753 ± 55	38.6 ± 1.9	37.3 ± 5.7	2.44 ± 0.18	3.13 ± 0.15	9.20 ± 1.40
2730	751 ± 44	37.4 ± 2.2	38.8 ± 2.1	2.43 ± 0.14	3.03 ± 0.17	9.57 ± 0.51
2731	917 ± 29	29.1 ± 2.9	44.2 ± 4.2	2.96 ± 0.09	2.36 ± 0.23	10.90 ± 1.04
2733	822 ± 28	27.4 ± 2.5	32.1 ± 3.6	2.66 ± 0.09	2.22 ± 0.21	7.91 ± 0.88
Profile 3						
2734	714 ± 47	56.7 ± 0.6	49.2 ± 2.7	2.31 ± 0.15	4.59 ± 0.05	12.13 ± 0.66
2735	745 ± 20	44.8 ± 3.8	49.3 ± 4.7	2.41 ± 0.06	3.62 ± 0.31	12.14 ± 1.16
2736	768 ± 20	27.0 ± 2.7	47.1 ± 4.4	2.48 ± 0.06	2.19 ± 0.22	11.61 ± 1.08

Table 5-1: Activity and equivalent concentrations of K, U and Th determined by HRGS

[a]Shap granite reference, working values determined by David Sanderson in 1986, based on HRGS relative to CANMET and NBL standards.

[b]Activity and equivalent concentrations for U, Th and K determined by HRGS (Conversion factors based on NEA (2000) decay constants): 40K: 309.3 Bq kg^{-1} %K^{-1}, 238U: 12.35 Bq kg^{-1} ppmU^{-1}, 232Th: 4.057 Bq kg^{-1} ppm Th^{-1}

Infinite matrix alpha, beta and gamma dose rates from HRGS are listed for all samples in Table 5-2, together with infinite matrix beta dose rates from TSBC and field gamma dose rates from FGS. Beta dose rates from HRGS ranged between 2.6 and 3.1 mGy a^{-}

^{1} (with mean values of 2.8 ± 0.1 mGy a^{-1}). The beta dose rates measured by TSBC ranged between 2.5 and 3.2 mGy a^{-1}, with a mean of 2.8 ± 0.2 mGy a^{-1}. Gamma dose rates from HRGS ranged from 1.3 and 1.7 mGy a^{-1} (with a mean value of 1.5 ± 0.1 mGy a^{-1}). Wet gamma dose rates were measured in situ by FGS for each of the dating positions, with values ranging between 1.1 and 1.5 mGy a^{-1}, with a mean of 1.3 ± 0.2 mGy a^{-1}.

SUTL no.	HRGS, dry[a] / mGy a^{-1}			TSBC, dry / mGy a^{-1}	FGS, wet / mGy a^{-1}
	Alpha	Beta	Gamma		
Profile 1					
2727	13.92 ± 0.44	2.64 ± 0.02	1.36 ± 0.01.	2.85 ± 0.22	1.13 ± 0.02
2728	14.48 ± 3.02	2.76 ± 0.01	1.38 ± 0.01	2.83 ± 0.22	1.08 ± 0.02
Profile 2					
2729	15.49 ± 3.43	2.74 ± 0.02	1.42 ± 0.01	2.68 ± 0.21	1.15 ± 0.02
2730	15.48 ± 0.61	2.73 ± 0.12	1.42 ± 0.05	2.78 ± 0.22	1.20 ± 0.02
2731	14.60 ± 1.00	3.12 ± 0.09	1.55 ± 0.06	3.13 ± 0.13	1.42 ± 0.02
2733	12.00 ± 0.87	2.76 ± 0.08	1.30 ± 0.06	2.50 ± 0.20	-
Profile 3					
2734	21.73 ± 0.51	2.93 ± 0.13	1.71 ± 0.05	3.19 ± 0.25	1.54 ± 0.01
2735	19.05 ± 1.21	2.88 ± 0.08	1.62 ± 0.07	3.00 ± 0.24	1.46 ± 0.02
2736	14.66 ± 1.00	2.71 ± 0.07	1.45 ± 0.06	2.82 ± 0.22	1.36 ± 0.02

Table 5-2: Infinite matrix dose rates determined by HRGS and TSBC
[a]based on dose rate conversion factors in Aikten (1983) and Sanderson (1987)

The water content measurements are given in Table 5-3, together with the assumed values for the average water content during burial. Field (ranging from 8 to 25 % of dry weight) and saturated (12 to 30 % of dry weight) water contents were determined from all samples in the laboratory, with working values between 12 and 21 % adopted for effective dose rate evaluation. Effective dose rates to the HF-etched 200[b] µm quartz grains are given in table 4-3 (the mean of the TSBC and HRGS data, accounting for water content and grain size), together with the estimate of the gamma dose rate (the mean of the FGS and HRGS data, accounting for water content). Effective beta dose rates ranged between 1.9 and 2.4 mGy a^{-1}, and the effective gamma dose rates between 1.1 and 1.5 mGy a^{-1}. Total effective dose rates to quartz ranged between 3.2 and 4.0 mGy a^{-1}.

SUTL no.	Water contents / %			Effective Dose Rate[a] / mGy a^{-1}		
	Field	Sat	Assumed	Beta[b]	Gamma	Total[b,d]
Profile 1						
2727	19.6	24.0	21 ± 3	1.95 ± 0.2	1.11 ± 0.07	3.20 ± 0.21
2728	24.5	26.8	21 ± 5	2.00 ± 0.14	1.11 ± 0.11	3.23 ± 0.17
Profile 2						
2729	7.7	12.1	10 ± 4	2.19 ± 0.24	1.23 ± 0.11	3.59 ± 0.26
2730	9.2	16.0	12 ± 5	2.16 ± 0.23	1.23 ± 0.08	3.53 ± 0.24
2731	9.9	14.8	13 ± 3	2.44 ± 0.1	1.39 ± 0.07	3.96 ± 0.12
2733	21.5	27.1	12 ± 5	1.89 ± 0.12	1.06 ± 0.07	3.09 ± 0.14
Profile 3						
2734	24.3	28.1	12 ± 5	2.17 ± 0.15	1.45 ± 0.12	3.74 ± 0.19
2735	25.3	31.8	12 ± 5	2.12 ± 0.14	1.39 ± 0.09	3.63 ± 0.16
2736	20.3	24.7	12 ± 5	2.00 ± 0.13	1.27 ± 0.08	3.40 ± 0.15

Table 5-3: Effective beta and gamma dose rates following water correction.

[a] Effective beta dose rate combining water content corrections with inverse grain size attenuation factors obtained by weighting the 200[b] µm attenuation factors of Mejdahl (1979) for K, U, and Th by the relative beta dose contributions for each source determined by Gamma Spectrometry;
[d] includes a cosmic dose contribution

5.3.2. Quartz single aliquot equivalent dose determinations

For equivalent dose determination, data from single aliquot regenerative dose measurements were analysed using the Risø TL/OSL Viewer programme to export integrated summary files that were analysed in MS Excel and SigmaPlot. Composite dose response curves were constructed from selected discs and when possible, for each of the eight preheating groups from each sample, and used to estimate equivalent dose values for each individual disc and their combined sets.

Dose response curves for each of the eight preheating temperature groups and the combined data were determined using either a fit to exponential function or a linear (Appendix B). There was no evidence of significant differences in normalised OSL ratios (both in natural and regenerated dose points) between subsets of discs pre-heated at temperatures from 200°C to 270°C). Accordingly composite dose response curves from selected discs for each sample were constructed and used to estimate equivalent dose values for each individual discs and their combined sets.

Equivalent dose distributions were appraised on a sample-by-sample basis, and across stratified samples, using conventional statistics and kernel density probability and Abanico plotting methods (see Table 5-4; appendix B). Eight of the nine samples were characterised by heterogeneous equivalent dose distributions, with moderately to broad central tendencies (with more complex distributions more prevalent in the older terrace deposits). Comments on the individual equivalent dose distributions are provided in table 5-4, together with the weighted and robust mean combinations, with the respective standard deviations and standard errors listed. As indicated in the table, and in section 6, the weighted estimates of equivalent dose were used in age estimation. The rationale for this includes the evidence, also seen in distributional plots in appendix B, that the few aliquots tailing to high dose carried larger uncertainties than the central well-measured aliquots, and consideration of stratigraphy and profiling.

SUTL no.	n[a]	Comments on equivalent dose distributions / individual samples	Comments on equivalent dose distributions / associated samples	Weighted Mean[b]	Robust Mean[b]
2727 (OSL1)	18/26	heterogeneous, multi-modal distribution; dominant population centred at c. 10 Gy; with both low- and high- dose outliers (c. 2-3 Gy and >20 Gy, respectively); low-dose population correlates with those aliquots which return high IRSL responses	**SUTL2727** < (overlies) 2728	**9.33 ± 0.62 (0.23)**	10. 7 ± 3.0 (0.7)
2728	14/22	broad central distribution at c. 15 Gy; with both low- and high- dose outliers (c. 2-3 Gy and >20 Gy, respectively)	**SUTL2728** > (underlies) 2727	**14.6 ± 1.5 (0.3)**	16.2 ± 4.1 (1.0)
2729	25/32	heterogeneous, multi-modal distribution; dominant population centred at c. 1 Gy; with individual aliquots which tail to higher dose populations (2-5 Gy)	**SUTL2729** < (overlies) 2730 < 2731	**1.00 ± 0.12 (0.02)**	1.55 ± 0.79 (0.15)
2730	18/32	broad central distribution at 4-5 Gy, with individual aliquots which tail to higher dose populations (>5 Gy)	SUTL2729 < **2730** < 2731	**4.26 ± 0.27 (0.07)**	4.35 ± 1.29 (0.29)
2731	27/30	complex multi-modal distribution; broad central distribution at 20-24 Gy; with both low-dose populations at 6 and 13 Gy, and aliquots which tail to higher dose populations (>30 Gy)	SUTL2729 < 2730 < **2731**	**20.2 ± 1.4 (0.4)**	27.6 ± 8.8 (1.6)
2733	30/40	tight distribution centered at 5-6 Gy	SUTL2731 > **2733** > 2730 > 2729	**5.66 ± 0.05 (0.07)**	5.90 ± 0.28 (0.05)
2734	22/40	broad distribution at 3-4Gy; with some aliquots which tail to higher dose populations at 10-11 Gy and >30 Gy	**SUTL2734** < (overlies) 2735 < 2736 (and < 2728 and 2731)	**2.11 ± 0.25 (0.06)**	3.17 ± 1.5 (0.31)
2735	19/28	extremely, broad distribution with multiple components at 10-12 Gy, 16-17 Gy and >20 Gy	SUTL2734 < **2735** < 2736 (and < 2728 and 2731)	**12.1 ± 1.2 (0.4)**	15.5 ± 6.0 (1.3)
2836 (OSL10)	14/23	extremely, broad distribution with multiple components at 10-12 Gy, 16-17 Gy and >20 Gy	SUTL2734 < 2735 < **2736** (and < 2728 and 2731)	**11.9 ± 1.5 (0.5)**	15.0 ± 5.1 (1.3)

Table 5-4: Comments on apparent age distributions of SUTL2727 to SUTL2736

[a] no.of accepted aliquots/no. of aliquots measured; [b] preferred estimates in bold

5.3.1. **Age determinations**

The total dose rate is determined from the sum of the equivalent beta and gamma dose rates, and the cosmic dose rate. Age estimates are determined by dividing the equivalent stored dose by the dose rate. Uncertainty on the age estimates is given by combination of the uncertainty on the dose rates and stored doses, with an additional 5% external error.

6. Discussion and conclusions

In this report, luminescence profiling has been used to produce a complete, relative temporal sequence for the late Holocene landscape history of River Dee at Milltimber, and relate these to the evidence of Mesolithic and Roman activities. Moreover, the post-5 ka environmental history of the Floodplain Terrace is further constrained by 27 laboratory analyses and 9 quartz SAR OSL sediment ages. The work progressed successfully from the initial 'field' profiling, through laboratory profiling towards the final programme of OSL dating. The key findings from each of these stages are briefly re-iterated here, prior to a discussion on the dating results and conclusions.

1.) The interpretation of the preliminary findings from 'field' profiling, led to the following preliminary temporal sequence: a.) Late Devensian materials are represented in the lowest parts of the profiles examining the negative features on the Camphill Terrace. b.) The overbank sands lying on, and comprising the upper units of the Camphill Terrace, are part of this feature. c.) The 'shallow embayments' on the floodplain of the Camphill Terrace, were cut prior to, and subsequently in-filled contemporaneously with the Mesolithic occupations. d.) The field profiles are consistent with the interpretation that the Romans cut back into the natural accumulations forming the bank of the Floodplain Terrace. e.) Post-Roman flooding deposited silts across the floodplain of the Floodplain Terrace. f.) Final silting of Channel 1 on the Floodplain Terrace occurred continuously, but episodically, over the subsequent 2000 years.
2.) The laboratory profiles confirmed the consistency of the data sets within the sections targeted for dating (those associated with Channel 1 on the Floodplain Terrace). Significantly, the stored dose estimates from the terrace deposits of Channel 1 are on the order of c. 15 Gy, which assuming an environmental dose rate of c. 3 mGy a^{-1}, corresponds to lateral migration of Channel 1 in the last 5 thousand years. Moreover, these profiles also imply a significant temporal break, in excess of 1,250 years, between final migration of Channel 1 and the later period of historic floods. The progression in stored dose values through the fill of Channel 1 is consistent with these deposits containing a proxy record of historic floods over the last 2 ka.
3.) The temporal framework to interpret the late Holocene history of the River Dee at Milltimber is provided by 9 quartz SAR OSL sediment ages. These samples encompass: the late modification of the Floodplain Terrace, and the means to reconstruct the late fluvial history of Channel 1 (SUTL2727-28, 2731, 2735-36); the Roman activity at Milltimber (SUTL2732); and the historic record of post-Roman floods (SUTL2729-30, 2734).

   It is well recognised that fluvial sediments have potential for including mixed-age sediments, and indeed the dose distributions obtained from the 8 dating samples from the terrace deposits of Channel 1 show some aliquots which tail towards higher apparent ages. Moreover, the stratigraphically lowest samples - those associated with the earlier history of Channel 1 - are characterised by the more complex, heterogeneous distributions of equivalent dose. Nevertheless, the use of weighted statistics yielded dating results which are internally coherent, and provide robust constraints on the last 5 ka of fluvial history.

The combination of these approaches led to the following preliminary conclusions (Table 6-1):

1.) The sand substrate to the Roman oven (as sampled in profile 2) is dated to approximately 5 ka (3080 ± 380 BC: SUTL2731). The sample lies at 10.93m AOD, c. 20cm above the base of Channel 1, so it does not date the earliest sediments at the valley-side, but it allows the suggestion that incision of the River Dee from the Camphill Terrace surface was complete by the middle of the Neolithic.
2.) In the sediment stratigraphy adjacent to the oven (sampled in profile 1), the base of the overlying context (2B-2043) was dated to c. 4.5 ka (2500 ±500 BC; SUTL2732). Within profile 3, equivalent units correlated with this context were dated to c. 3.3 to 3.5 ka (1310 ±360 BC, SUTL2735 and 1480 ±460 BC, SUTL2736). These dates suggest a very slow sediment accumulation rate for unit 2B-2043 of around 0.1cm/yr, in proximity to the channel. The difference in the three sediment ages, may be best explained by thinking that none of the samples need have been at the base of this unit, only at the uneven base of the section. Even withstanding this, these data must imply that sediment accumulation was not continuous, at least at the northern edge of the Floodplain Terrace
3.) Sediment accumulating after the use of Oven DO6 filled Channel 1. The sediments are flood-derived, incremental overbank sediments and not those of an active channel. These sediments have been assigned to contexts 2B-2041 and 2B-2042. In profile 2, the base of context 2B-2042 is dated to AD 810 ± 90 (SUTL2730); with sedimentation through till at least AD 1740 ± 40 (SUTL2729); note, that this is a minimum constraint as 'soil' stripped before excavation may have included overbank sediment. The mean sediment accumulation rate in Profile 2 in the last *c.* 2000 years was *c.* 0.02cm/yr. This is surprisingly slow, and may indicate that sediment loss was greater than sediment accumulation on the floodplain (consistent with the erosional boundary between contexts 2B-2041 and 2B-2042; Fig. 2-2). In profile 3, the base of the equivalent unit - 2B-2041/2B-2041 - is dated to AD 1450 ± 40 (SUTL2734).

SUTL no.	Archaeological context	Dose rate / mGy a^{-1}	Stored dose / Gy	Years / ka	Calendar yrs
2727	base of [2042]	3.20 ± 0.21	9.3 ± 0.6 (0.2)	2.91 ± 0.20	900 ±200 BC
2728	observed base of [2043]	3.23 ± 0.17	14.6 ± 1.5 (0.3)	4.52 ± 0.26	2500 ±500 BC
2729	top of [2042]	3.59 ± 0.26	1.0 ± 0.1 (0.02)	0.28 ± 0.02	AD 1740 ± 40

2730	base of [2042]	3.53 ± 0.24	4.3 ± 0.3 (0.07)	1.20 ± 0.08	AD 810 ± 90
2731	substrate; equivalent to [2043]	3.96 ± 0.12	20.2 ± 1.4 (0.4)	5.10 ± 0.19	3080 ±380 BC
2733	[2038] burnt substrate	3.09 ± 0.14	5.9 ± 0.1 (0.07)	1.83 ± 0.08	AD 180 ± 90
2734	base of [2042]/[2041]	3.74 ± 0.19	2.1 ± 0.3 (0.06)	0.57 ± 0.03	AD 1450 ± 40
2735	equivalent to [2043]	3.63 ± 0.16	12.1 ± 1.2 (0.4)	3.33 ± 0.19	1310 ±360 BC
2736	substrate; observed base of [2043]	3.40 ± 0.15	11.9 ± 1.5 (0.5)	3.49 ± 0.22	1480 ±460 BC

Figure 6-1: Quartz OSL sediment ages

7. References

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Appendix A: Dose Response Plots

Quartz Composite OSL Dose Response Curves

Figure A-1: Composite dose response curves for SUTL2727

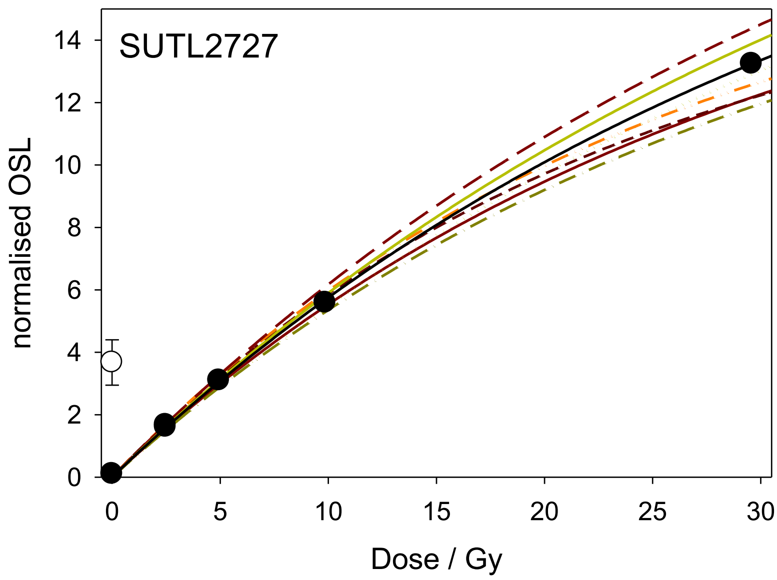


Figure A-2: Composite dose response curves for SUTL2729

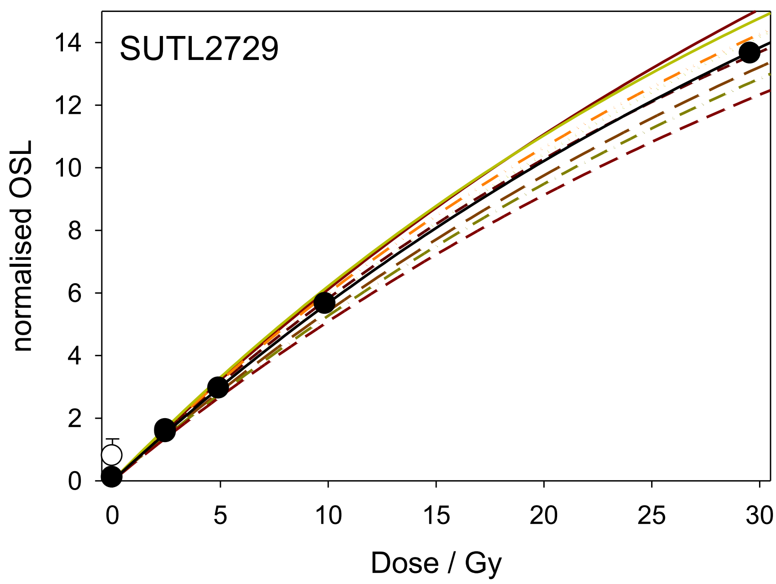


Figure A-3: Composite dose response curves for SUTL2730

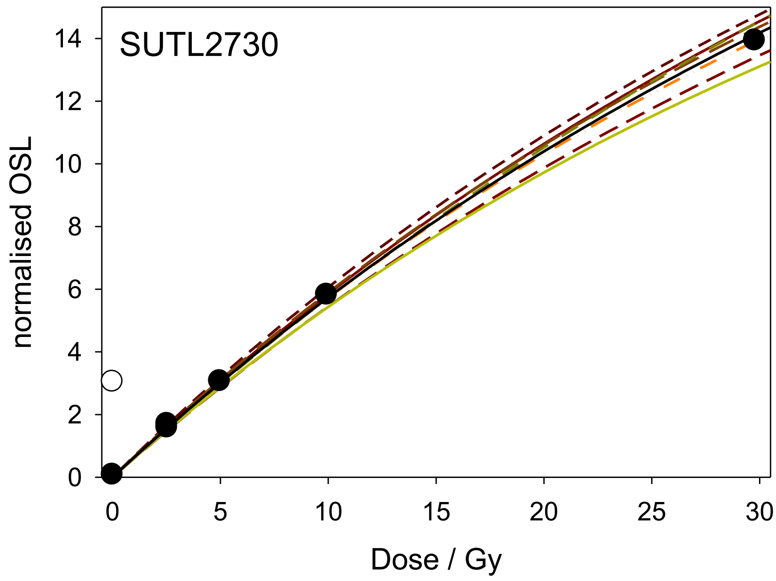


Figure A-4: Composite dose response curves for SUTL2731

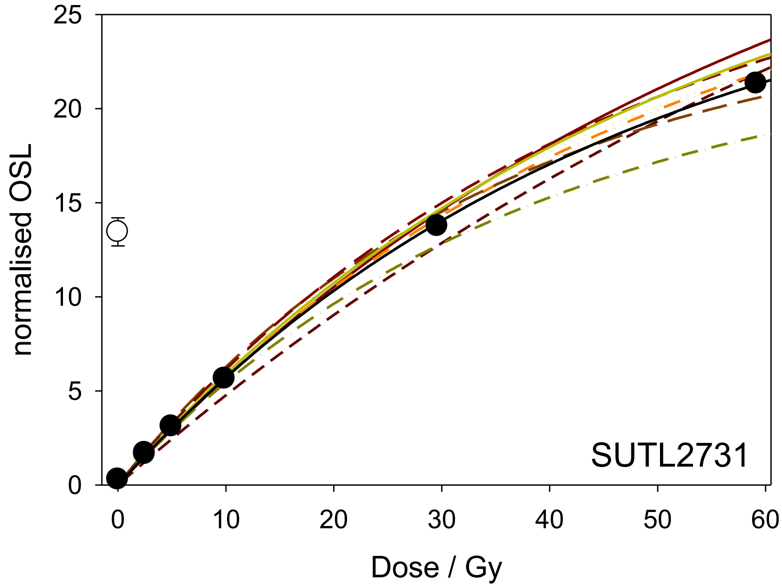


Figure A-5: Composite dose response curves for SUTL2733; a.) 1.5 Gy Td; b.) 0.75 Gy

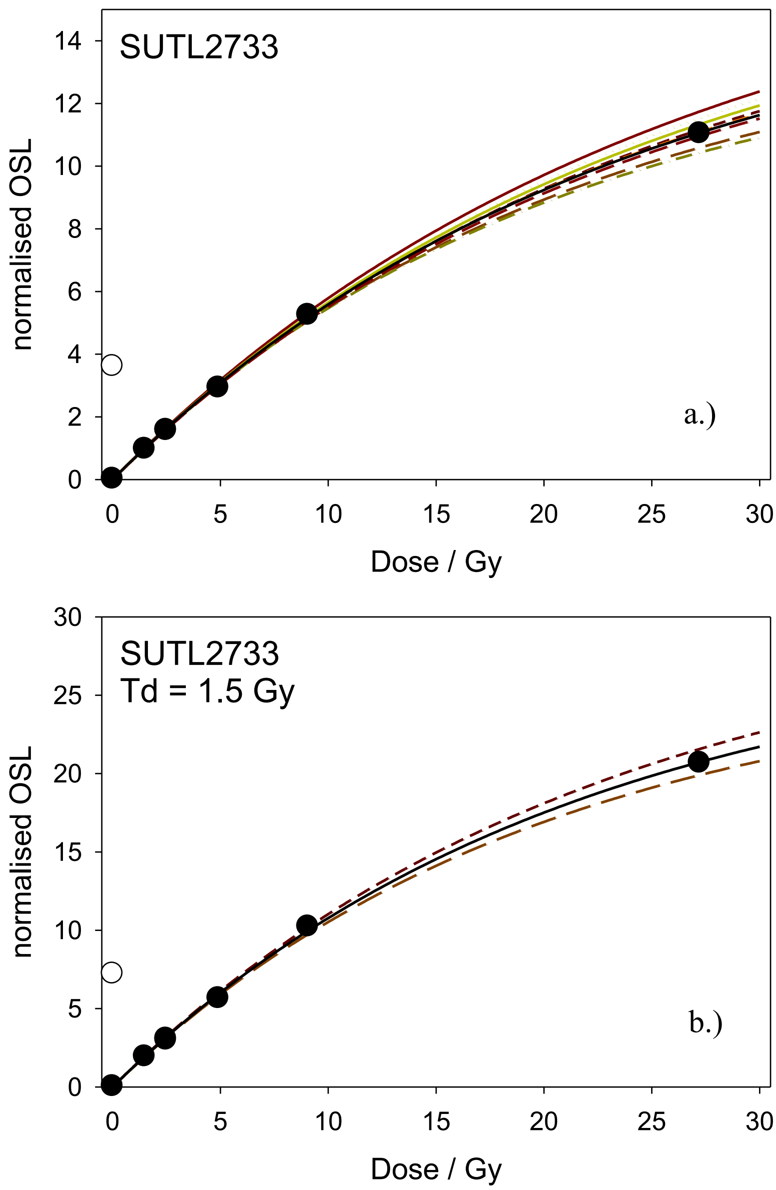


Figure A-6: Composite dose response curves for SUTL2734

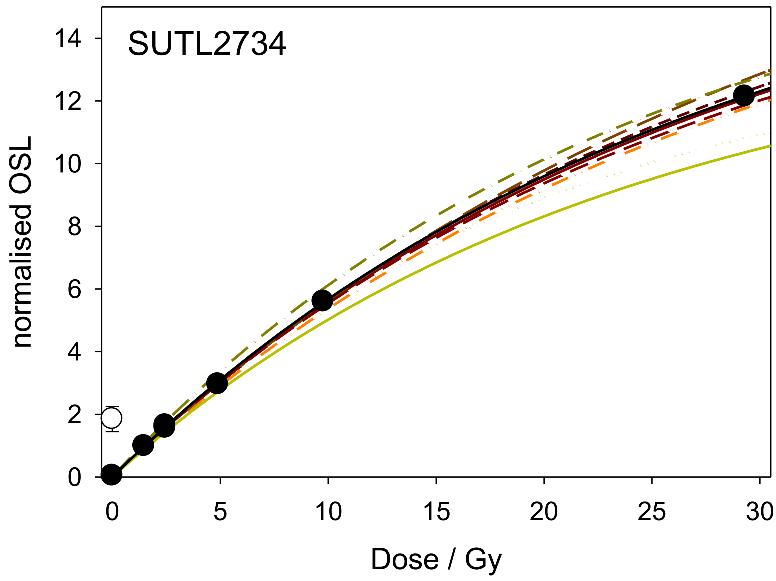


Figure A-7: Composite dose response curves for SUTL2735

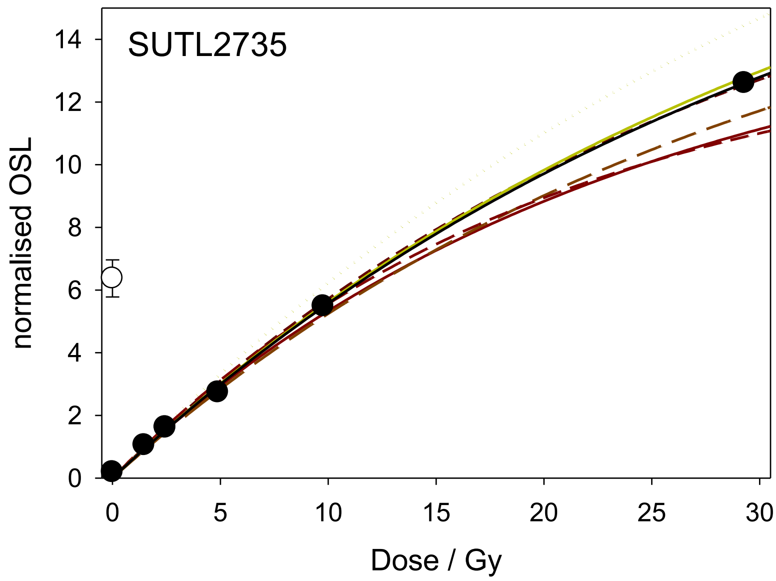
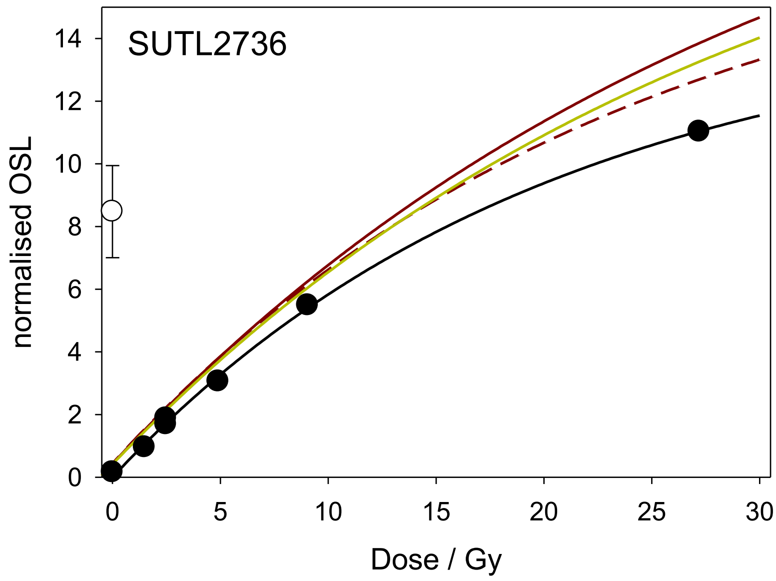
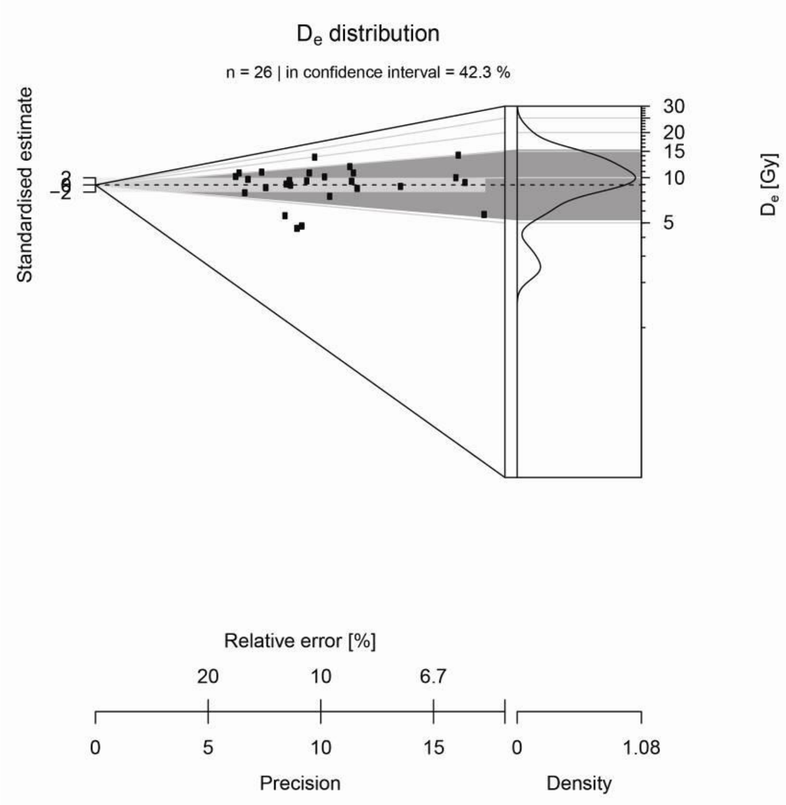


Figure A-8: Composite dose response curves for SUTL2736



Appendix B: De distributions

Figure B-1: Equivalent dose distributions for SUTL2727 (after Dietze et al., 2013), as (a) Abanico Plot, and (b) KDPE plot



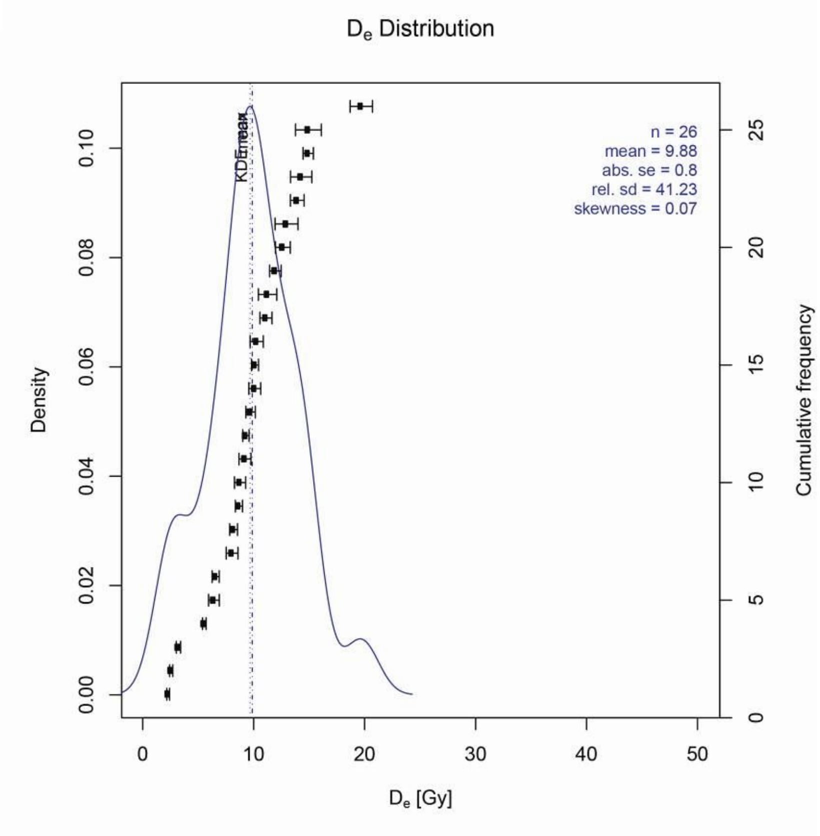


Figure C-2: Equivalent dose distributions for SUTL2728 (after Dietze et al., 2013), as (a) Abanico Plot, and (b) KDPE plot

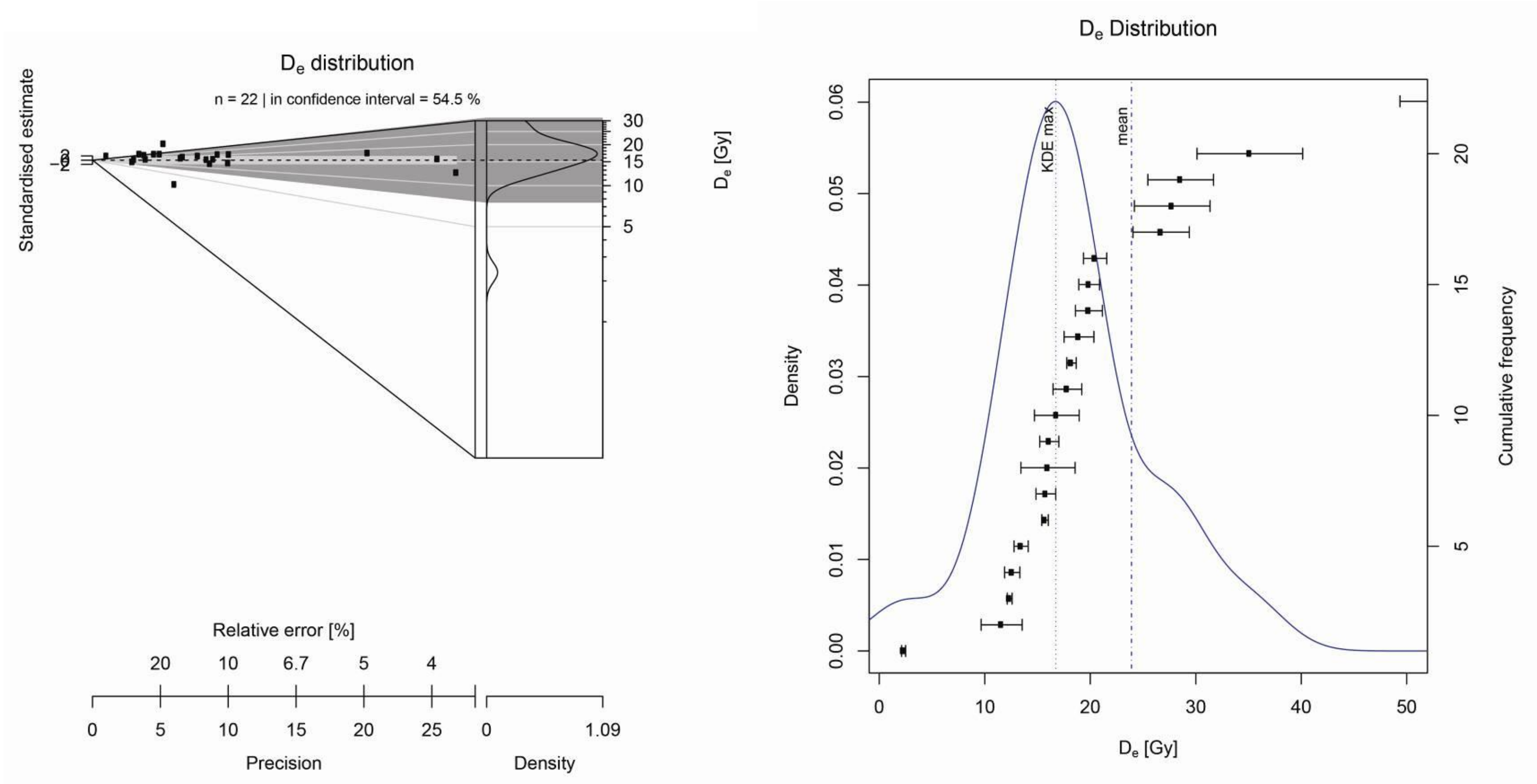
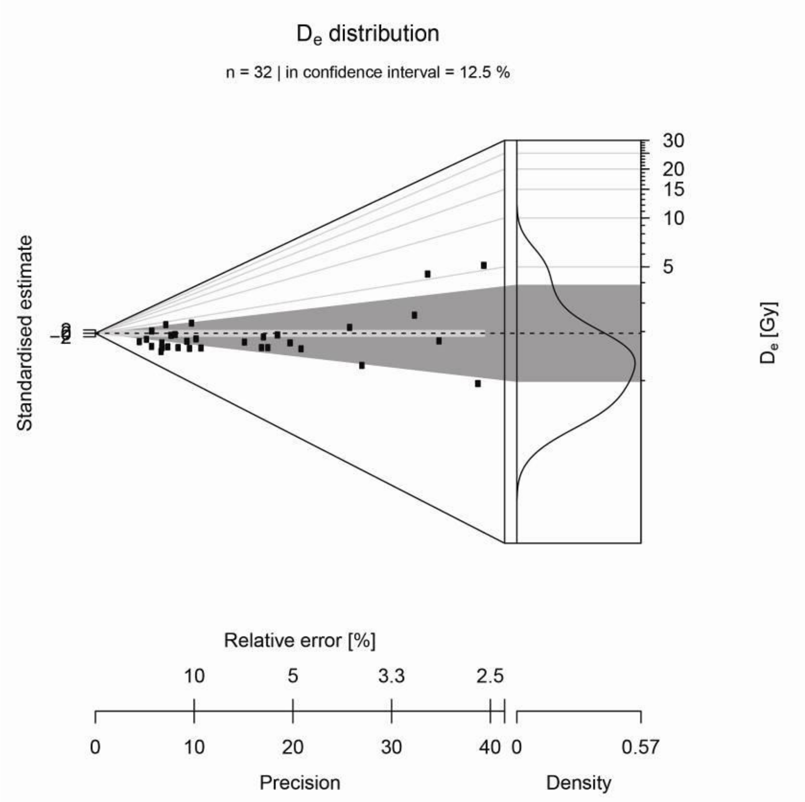


Figure C-3: Equivalent dose distributions for SUTL2729 (after Dietze et al., 2013), as (a) Abanico Plot, and (b) KDPE plot



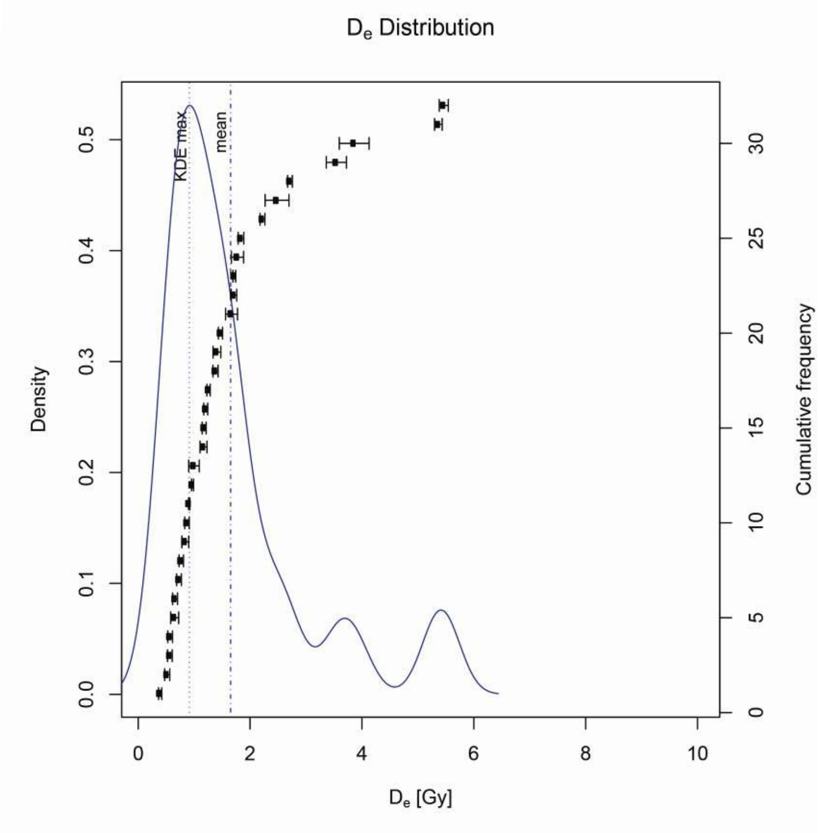


Figure C-4: Equivalent dose distributions for SUTL2730 (after Dietze et al., 2013), as (a) Abanico Plot, and (b) KDPE plot

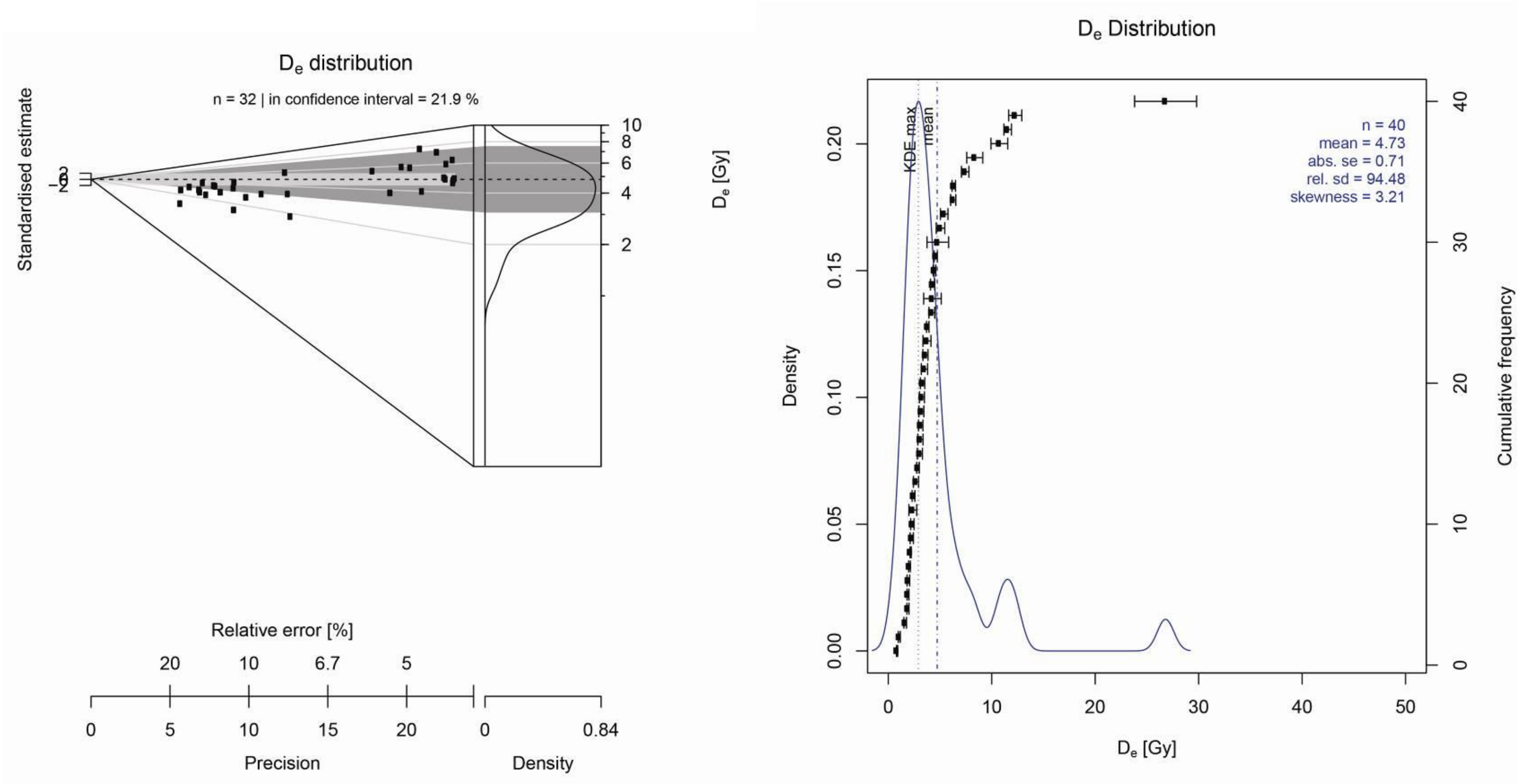


Figure C-5: Equivalent dose distributions for SUTL2731 (after Dietze et al., 2013), as (a) Abanico Plot, and (b) KDPE plot

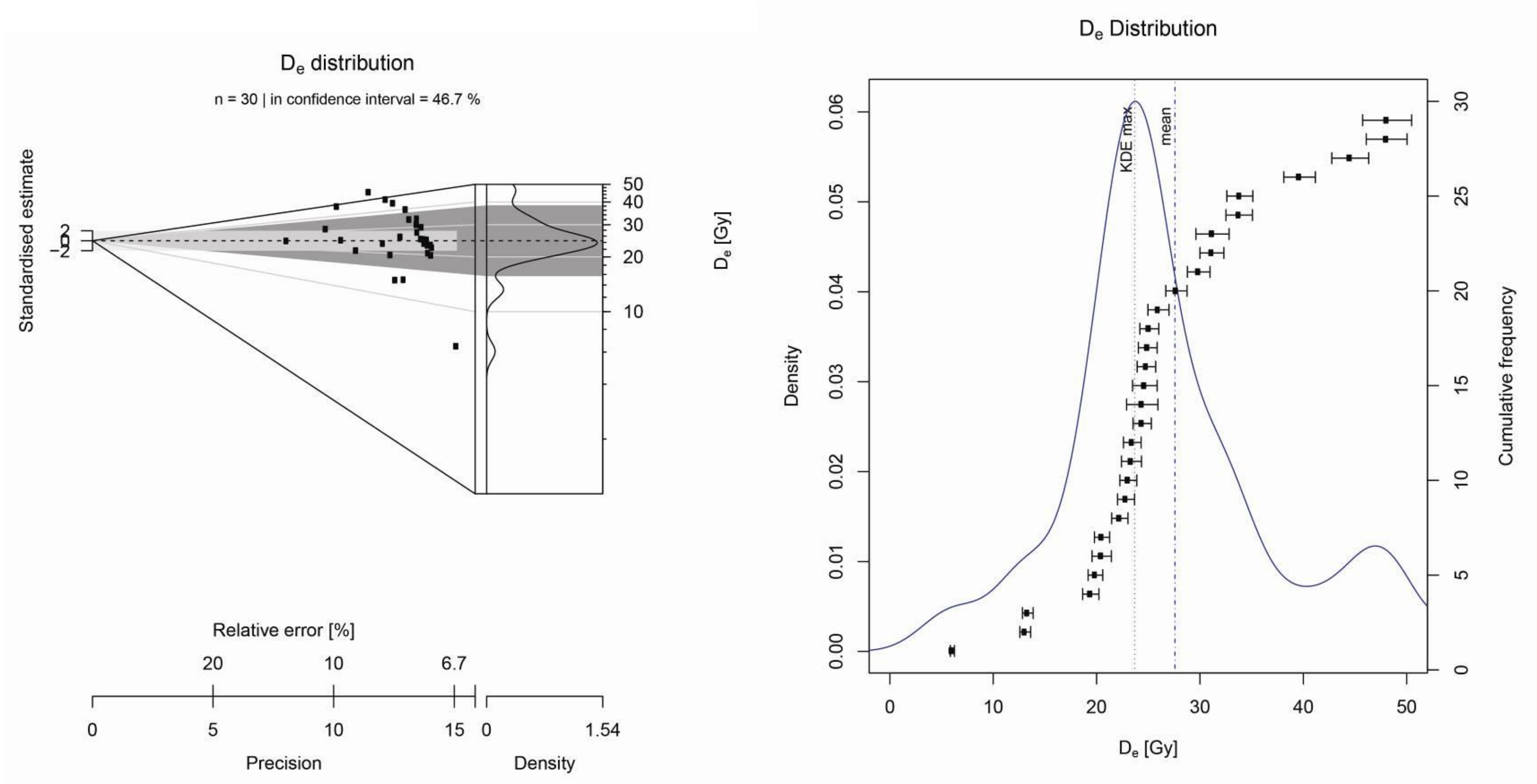


Figure C-6: Equivalent dose distributions for SUTL2733 (after Dietze et al., 2013), as (a) Abanico Plot, and (b) KDPE plot

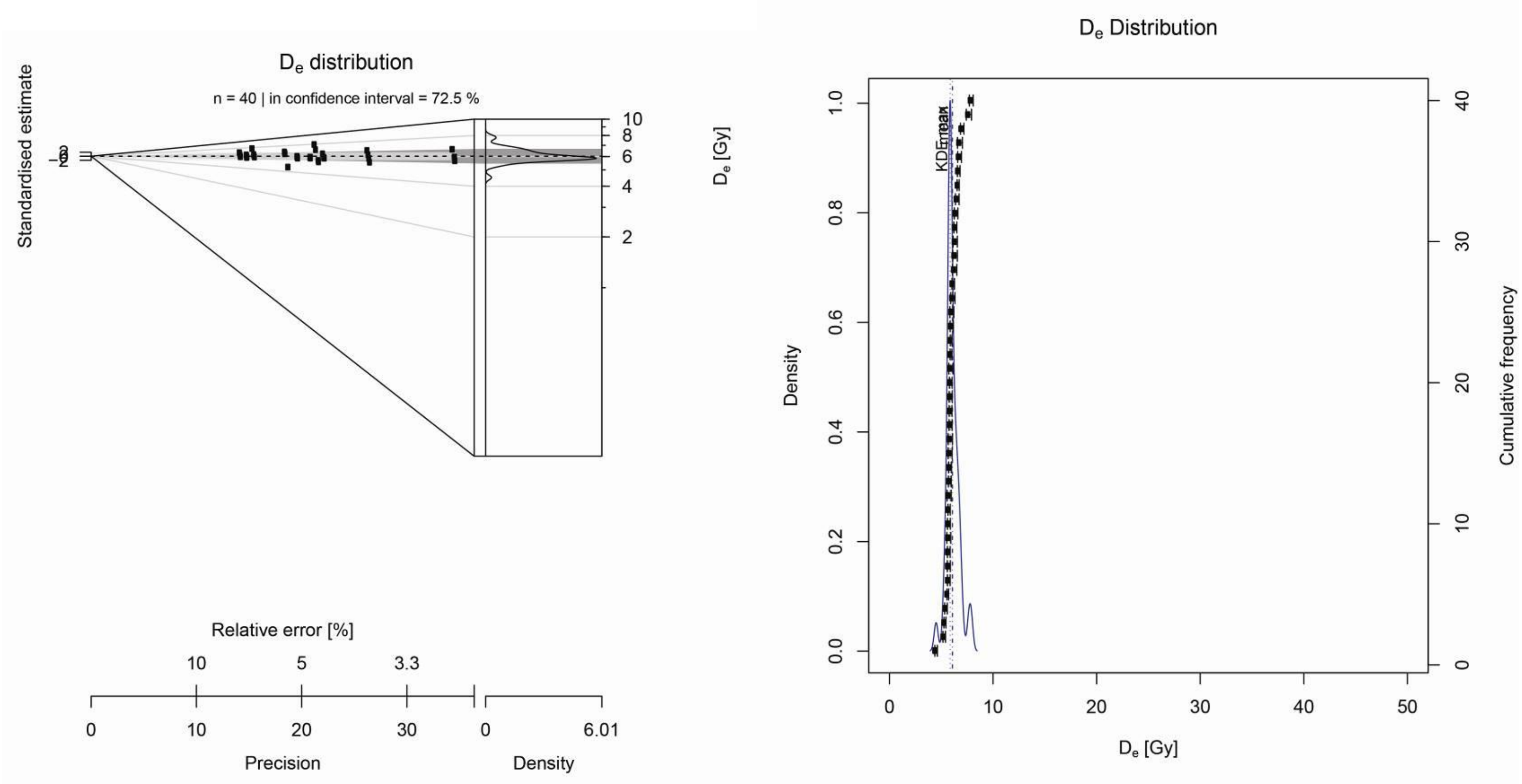
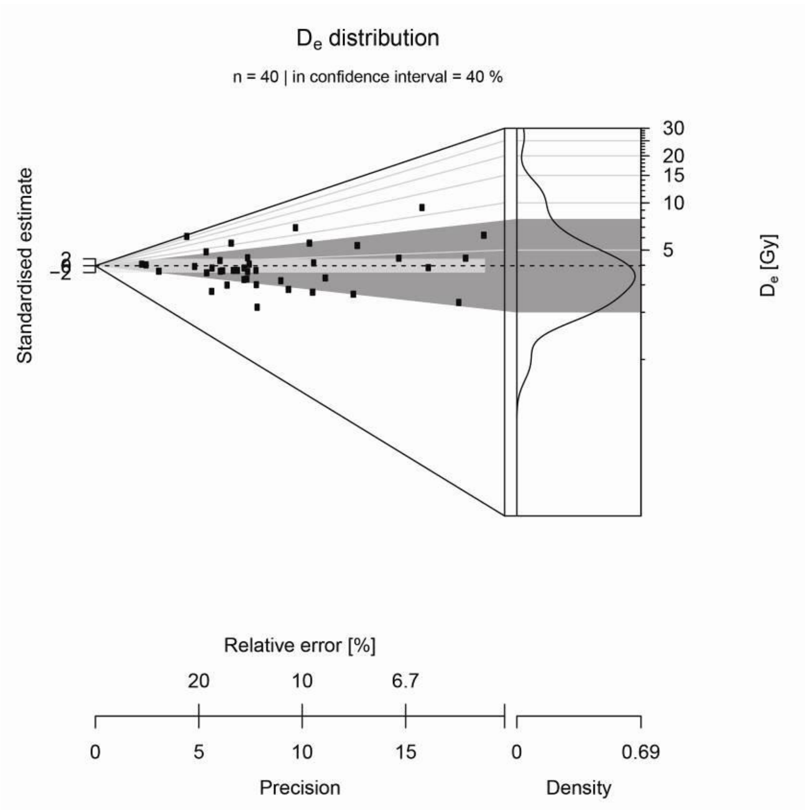


Figure C-7: Equivalent dose distributions for SUTL2734 (after Dietze et al., 2013), as (a) Abanico Plot, and (b) KDPE plot



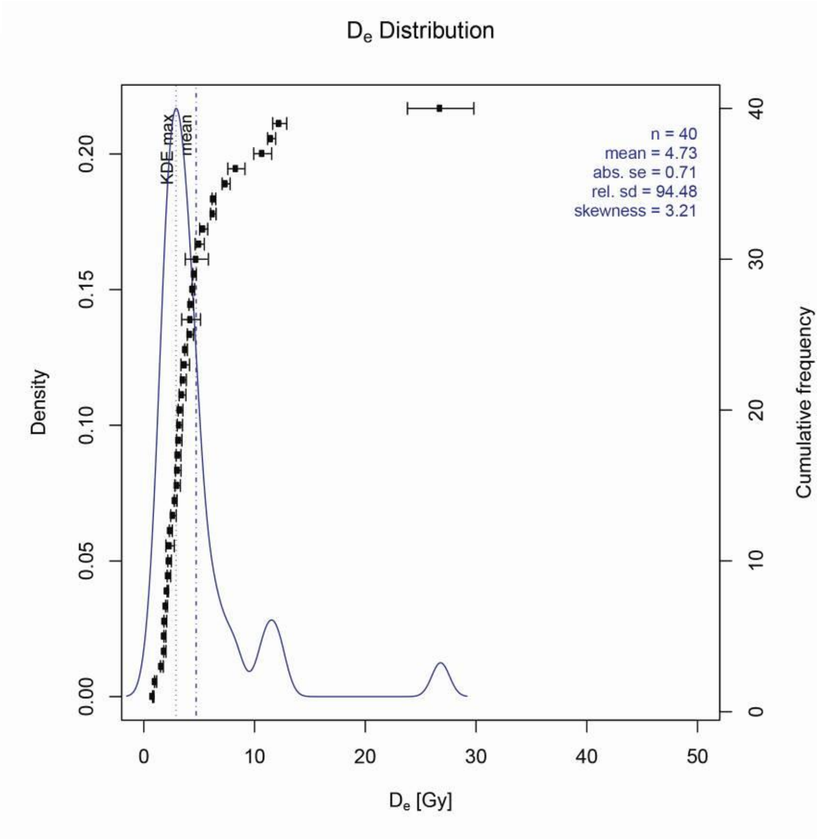
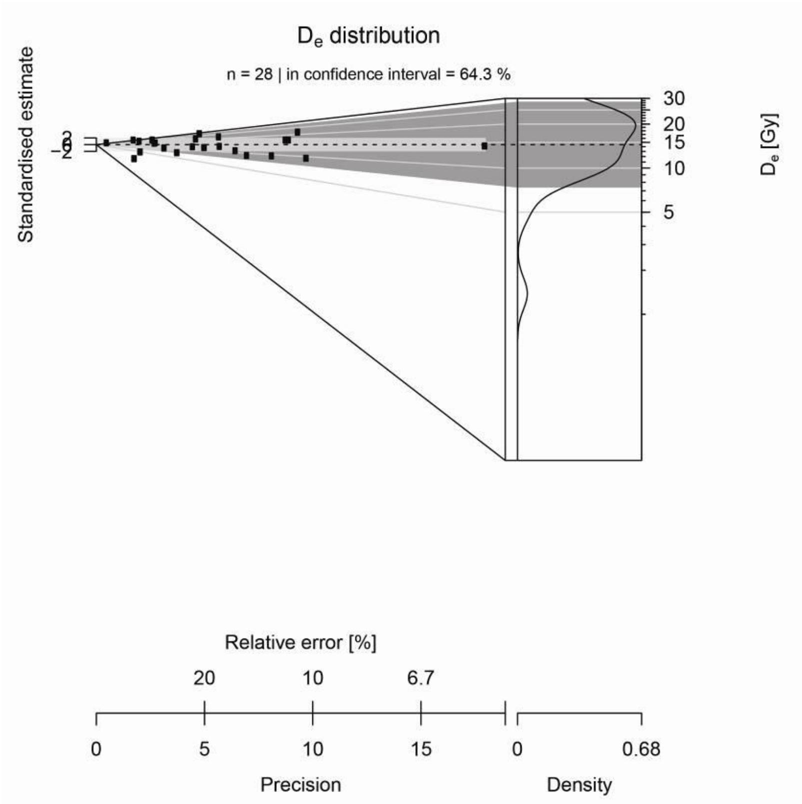


Figure C-8: Equivalent dose distributions for SUTL2735 (after Dietze et al., 2013), as (a) Abanico Plot, and (b) KDPE plot



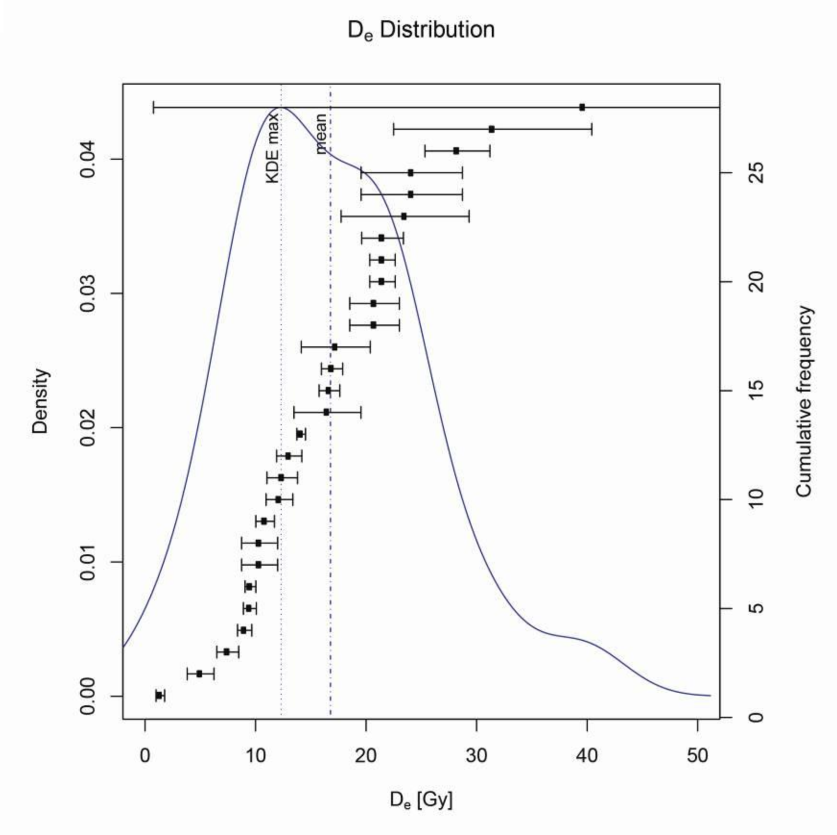
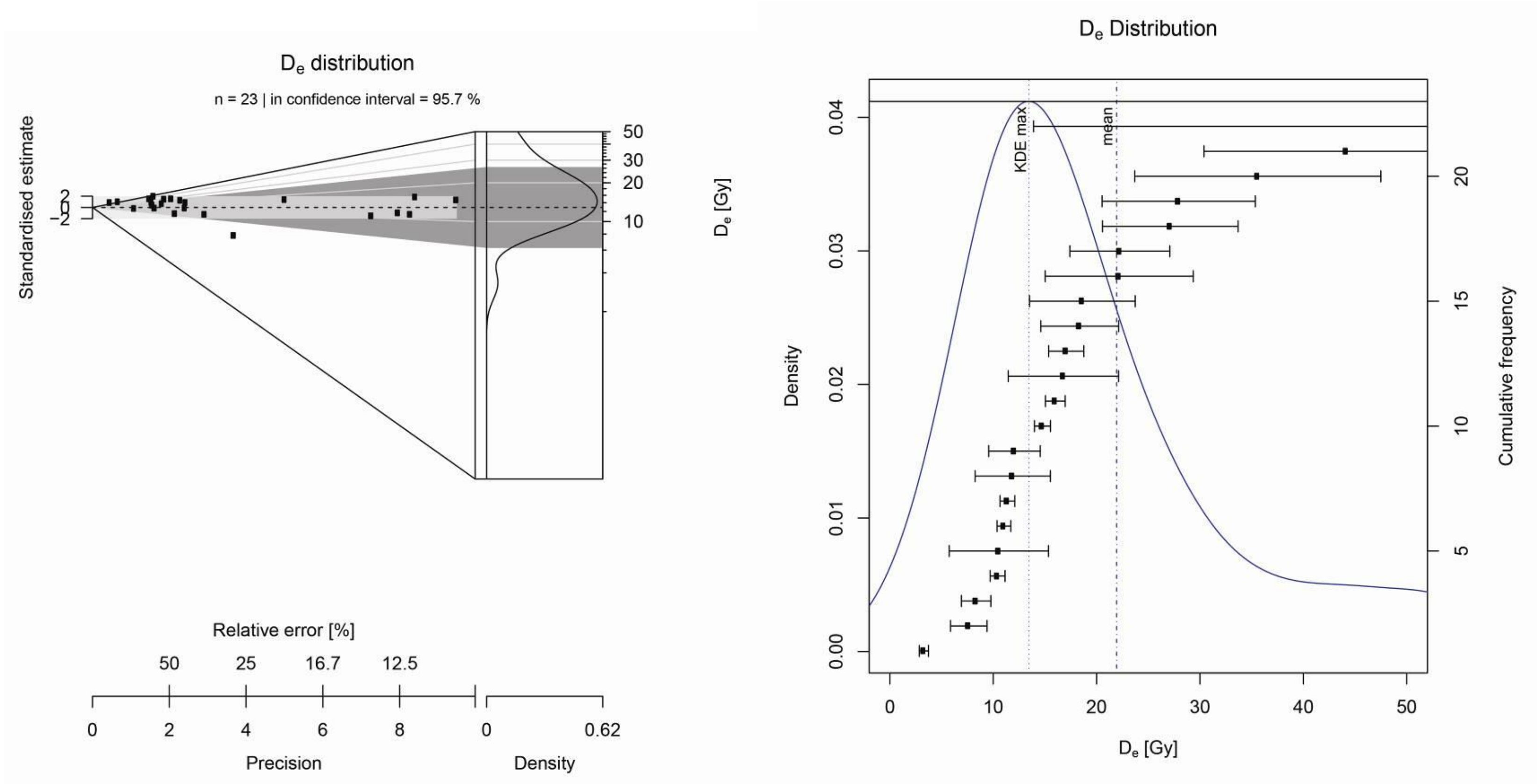


Figure C-8: Equivalent dose distributions for SUTL2736 (after Dietze et al., 2013), as (a) Abanico Plot, and (b) KDPE plot



Appendix-2.1.19 Radiocarbon dating and Bayesian modelling of the Roman ovens at Milltimber, Aberdeenshire - Derek Hamilton (SUERC)

Introduction

A total of 34 charcoal samples were submitted for radiocarbon dating by accelerator mass spectrometry (AMS) at the Scottish Universities Environmental Research Centre (SUERC). The samples were all single entities (Ashmore 1999) and either short-lived species or roundwood. The samples were pretreated following the acid/base/acid protocol (Dunbar et al. 2014) and graphitised and measured following the methods described by Naysmith et al. (2010). SUERC maintains rigorous internal quality assurance procedures, and participation in international inter-comparisons (Scott 2003) indicates no laboratory offsets; thus validating the measurement precision quoted for the radiocarbon ages.

Conventional radiocarbon ages (Stuiver and Polach 1977) are presented in Table 1, where they are quoted in accordance with the Trondheim convention (Stuiver and Kra 1986). Calibrated date ranges were calculated using the calibration curves of Reimer et al. (2013) and OxCal v4.2 (Bronk Ramsey 1995; 1998; 2001; 2009). The date ranges in Table 1 have been calculated using the maximum intercept method (Stuiver and Reimer 1986) and quoted with the endpoints rounded outward to ten years. Ranges quoted in italics are posterior density estimates derived from mathematical modelling of archaeological problems. Ranges in plain type were calculated according to the maximum intercept method (Stuiver and Reimer 1986). All other ranges (i.e. those in *italics*) were derived from the probability method (Stuiver and Reimer 1993).

Methodological approach

A Bayesian approach has been applied to the interpretation of the Milltimber Roman ovens chronology (Buck et al. 1996). Although simple calibrated dates are accurate estimates of the age of samples, this is not, usually, what archaeologists really wish to know. It is the dates of the archaeological events represented by those samples that are of interest. At Milltimber, for example, it is the date and duration of use of these features, along with the start and end of the use of the site in general, that are of most interest, rather than the dates of individual samples. The chronology of this activity can be estimated by using the absolute dating derived from the radiocarbon measurements and the relative dating information provided by the archaeological analysis.

Methodology is now available which allows the combination of these different types of information explicitly, to produce realistic estimates of the dates of archaeological interest. It should be emphasised that the posterior density estimates produced by this modelling are not absolute. They are interpretative estimates, which can and will change as further data become available and as other researchers choose to model the existing data from different perspectives. The technique used is a form of Markov Chain Monte Carlo sampling and has been applied using the program OxCal v4.2 (http://c14.arch.ox.ac.uk/). Details of the algorithms employed by this program are available in Bronk Ramsey (1995; 1998; 2001; 2009) or from the online manual. The algorithm used in the primary model can be derived from the OxCal keywords and bracket structure shown in Figure 1.

Samples and the Models

The dating strategy was two-fold and aimed to provide dating evidence that allowed the investigation of the timing of the Roman camp associated with the ovens as well as the longevity of that activity. Furthermore, the spread of the ovens over more than 200 m and the fact that they formed clearly discrete spatial groups provided the opportunity – assuming the Roman presence extended over a protracted period – to investigate the temporality of the activity from a spatial point-of-view.

All the samples of charcoal were either short-lived species or Roundwood (i.e. twiggy material). Fifteen of the samples were of charred heather, the remaining samples were of roundwood charcoal from alder, birch, elm, holly, oak, and willow. The location of the samples was as essential as the type of sample, and with the exception of the sample from oven D04, all the samples came from the lowest oven fill with suitable material. The sample from oven D04 came from the rake-out of the oven.

A second consideration was the spatial spread of the samples. While it was not necessary to date ever single oven, the dating strategy was to provide at least one date from each group of ovens, while ensuring a few groups spread across the site have three or more dates so that the internal consistency could be investigated. Furthermore, three of the ovens had duplicate measurements made on a second piece of charcoal, of a different species, to allow the statistical consistency of those paired measurements to be evaluated. In the end there are duplicate measurements from ovens B13, E03, and F19. Oven groups 1, 4, 7, 10, 12, and 13 have three or more radiocarbon measurements, while groups 2, 3, and 9 have two measurements.

The method of Ward and Wilson (1978) has been used for testing the consistency of multiple radiocarbon measurements. Firstly, looking at the entire suite of radiocarbon results, they do not pass the X^2 test (T=129.3; ν=34; T'(5%)=46.8), suggesting that the dated material is not the same age and represents deposition over some unknown period of time. Within the nine oven groups with two or more radiocarbon measurements, four failed their X^2 test (Table 2). Furthermore, the paired measurements from two out of the three ovens also failed their respective X^2 test (Table 2). In every case, the calibrated date ranges in these groups overlap at 95% confidence, suggesting that while some sets of results are not statistically consistent, there are no wild misfits in the series. The most likely explanation is that the dates contain an element of residual material, probably introduced as slightly older wood that was collected for fuel. The charcoal outlier model was used for all the modelling to help account for this.

Primary chronological model

The initial chronological model (Figure 1) has been constructed following two basic assumptions: (1) the activity associated with the Roman ovens at Milltimber was relatively continuous, and so without any significant breaks, and (2) the samples selected from across the site are uniformly distributed from throughout the period of Roman activity. Since there are no stratigraphic relationships between any of the dated ovens, the model places all of the dates into a simple unordered group. In the figures, the dated ovens are placed into their further spatial groupings.

The model has good agreement between the dates and the assumptions (Amodel=86). If the activity associated with the construction and use of the ovens at Milltimber did occur over a number of years, the model estimates that this activity began in *10 cal BC–cal AD 140* (*95% probability*; Fig. 1; *start: Milltimber Roman Ovens*), and probably in *cal AD 60–130* (*68% probability*). The activity is estimated to have ended in *cal AD 100–185* (*95% probability*; Fig. 1; *end: Milltimber Roman Ovens*), and probably in *cal AD 115–165* (*68% probability*). The overall span of the activity modelled is *1–165 years* (*95% probability*; Fig. 2; *span: Milltimber Roman Ovens*), and probably *1–85 years* (*68% probability*).

The model was constructed to also produce a single date estimate assuming the activity associated with the ovens occurred over a very short period of time, in a year. This single best date for the Roman camp at Milltimber is *cal AD 40–170* (*95% probability*; Fig 1; *Milltimber Roman Camp*), and probably in *cal AD 90–145* (*68% probability*).

Alternative model 1

Different variations on the primary model were constructed to investigate whether there is any spatiotemporal ordering of the dates, which might be the result of different groups of ovens being constructed and used at discretely different times. The first of these alternative models independently calculated the start and end date for any oven group with three or more radiocarbon dates. The first alternative model has good agreement (Amodel=107) between the radiocarbon dates and the model that places each oven group with three or more dates into its own independent bounded phase. Since each group is modelled independently, the only assumption is that the activity in each group is relatively continuous. The low number of radiocarbon results for each group will result in much lower precision than a model that utilises all of the results together (Steier and Rom 2000). However, this model is being used to explore the spatiotemporal patterning of the oven groups across the site (Fig. 3).

The probability that activity associated with one group began before another is given in Table 3. The likely order for all six of these events can be determined using combined probabilities, such that the probability *start: Group 1* is the first event is calculated by multiplying the probabilities that it is earlier than the other five events together (0.64 x 0.71 x 0.34 x 0.72 x 0.79 = 0.0879). This is done in turn for all the events, with the event with the highest probability each time being removed from the subsequent calculations. Doing this suggests that the order the ovens were used is Group 10, Group 1, Group 4, Group 7, Group 12, and finally Group 13. With the exception of Group 10 being singled out as the earliest, the general trend here is one of a N-S movement in activity.

Alternative model 2

The second alternative model aimed to look at the N-S trend a bit more broadly, by grouping dates into independently modelled Northern (Groups 1–7) and Southern (Groups 8–13) groups. Grouping the dates in this way allows a test of the N-S trend with greater precision, given the larger number of dates modelled in each of the two areas. Although the previous model indicated Group 10 was the earliest activity, despite the general N-S trend that was indicated, this model places the Group 10 dates within the Southern grouping with which it is spatially located. This model has good agreement with the dates and the assumption that in each grouping they represent a phase of relatively continuous activity (Amodel=127; Fig. 4). The model provides an 89% probability that *start: Northern groups* began before *start: Southern groups*.

Discussion

The Bayesian modelling results for the date of the activity at Milltimber are not unexpected. The 'start' and 'end' dates calculated in the Primary model place the activity securely in the period of the Flavian (AD 69–96) to Nerva-Antonine (AD 96–192) Dynasties. Whether the Roman camp was occupied for a short or long time, the radiocarbon dating suggests that the occupation was earlier in the northern portion of the site than the southern portion. The archaeological interpretation for the longevity of the occupation is important when we consider is the relationship of the dating at Milltimber to historic dates of known Roman activity in Scotland. The date probabilities from the modelling were compared to the dates for Agricola's invasion of Caledonia (~AD 84), the construction of the Antonine Wall (AD 142), and the abandonment of the Antonine Wall (AD 160). If the archaeological interpretation is that the camp was occupied intermittently over a longer period of time, such that the 'start' and 'end' dates are the more likely estimates, then there is a 57% probability that *start: Milltimber Roman Ovens* occurred after Agricola's invasion in AD 84, and 100% probability that is occurred prior to the construction of the Antonine Wall. There is a 48% probability that *end: Milltimber Roman Ovens* occurred prior to the construction of the Antonine Wall, and an 80% probability that it occurred prior to the Roman abandonment of the wall. However, if the interpretation is that the camp was occupied for a very short period of time (i.e. single-year occupation), then there is an 87% probability that this event – *Milltimber Roman Camp* – occurred after AD 84 and an 89% probability that it occurred prior to AD 142.

Figures

Figure 1: Chronological model for the radiocarbon dates on material from Roman ovens excavated at Milltimber, Aberdeenshire. For each of the radiocarbon measurements two distributions have been plotted, one in outline, which is the result of simple radiocarbon calibration, and a solid one, which is based on the chronological model use. The other distributions correspond to aspects of the model. For example, '*start: Milltimber Roman Ovens*' is the estimated date that the activity began, based on the radiocarbon dating results. The large square 'brackets' along with the OxCal keywords define the overall model exactly

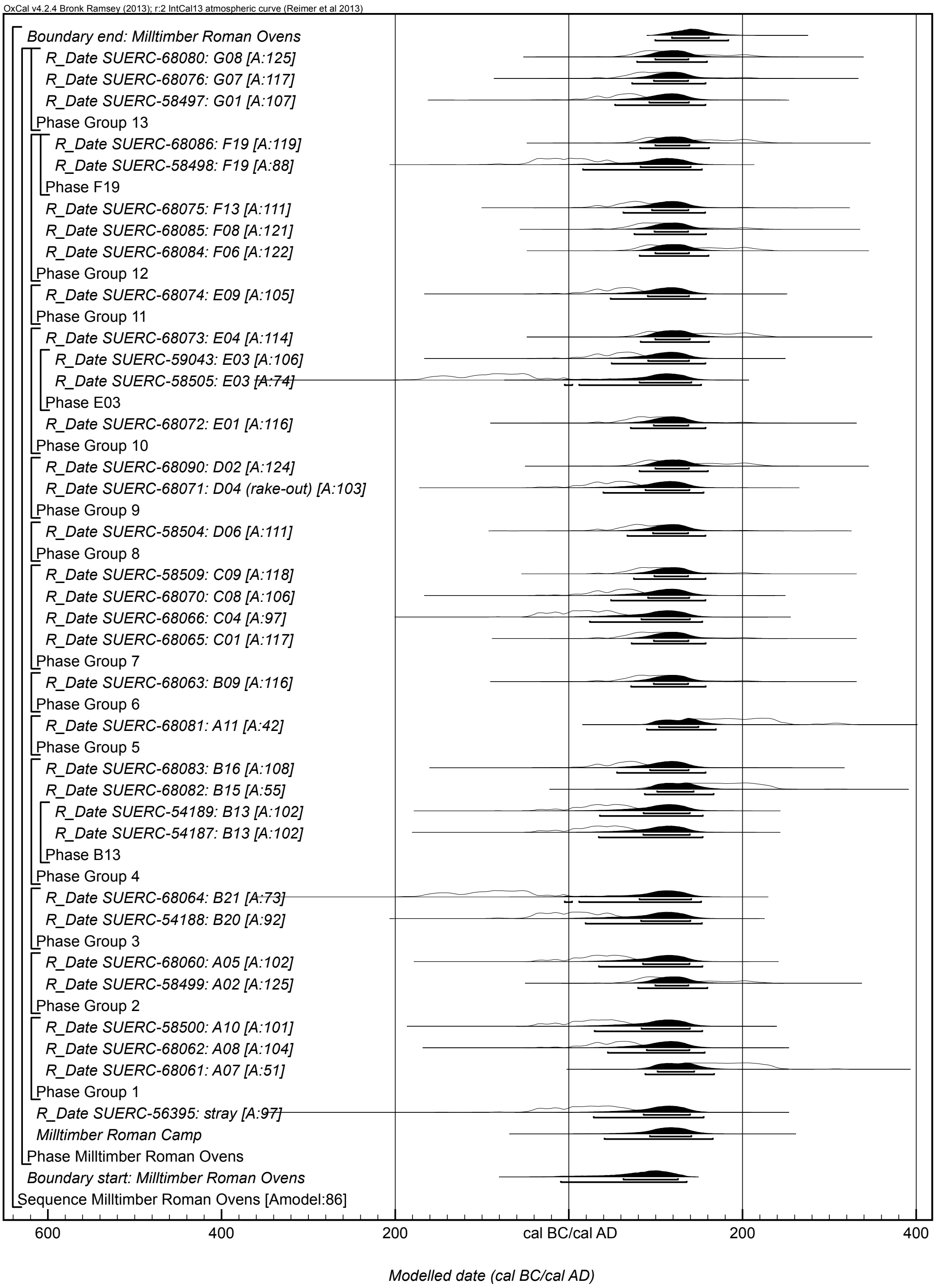


Figure 2: Overall span of the Roman oven activity as modelled in Figure 1

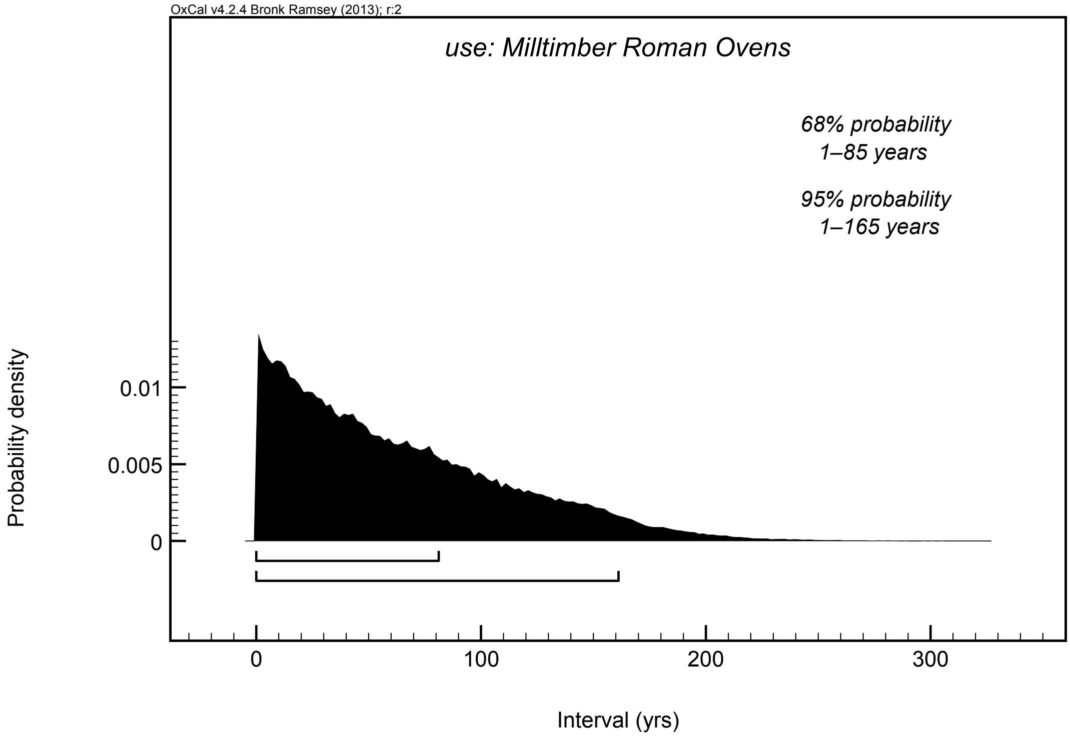


Figure 3: Alternative model number 1 for Milltimber. The ovens groups with three or more dates have been modelled independently of one another

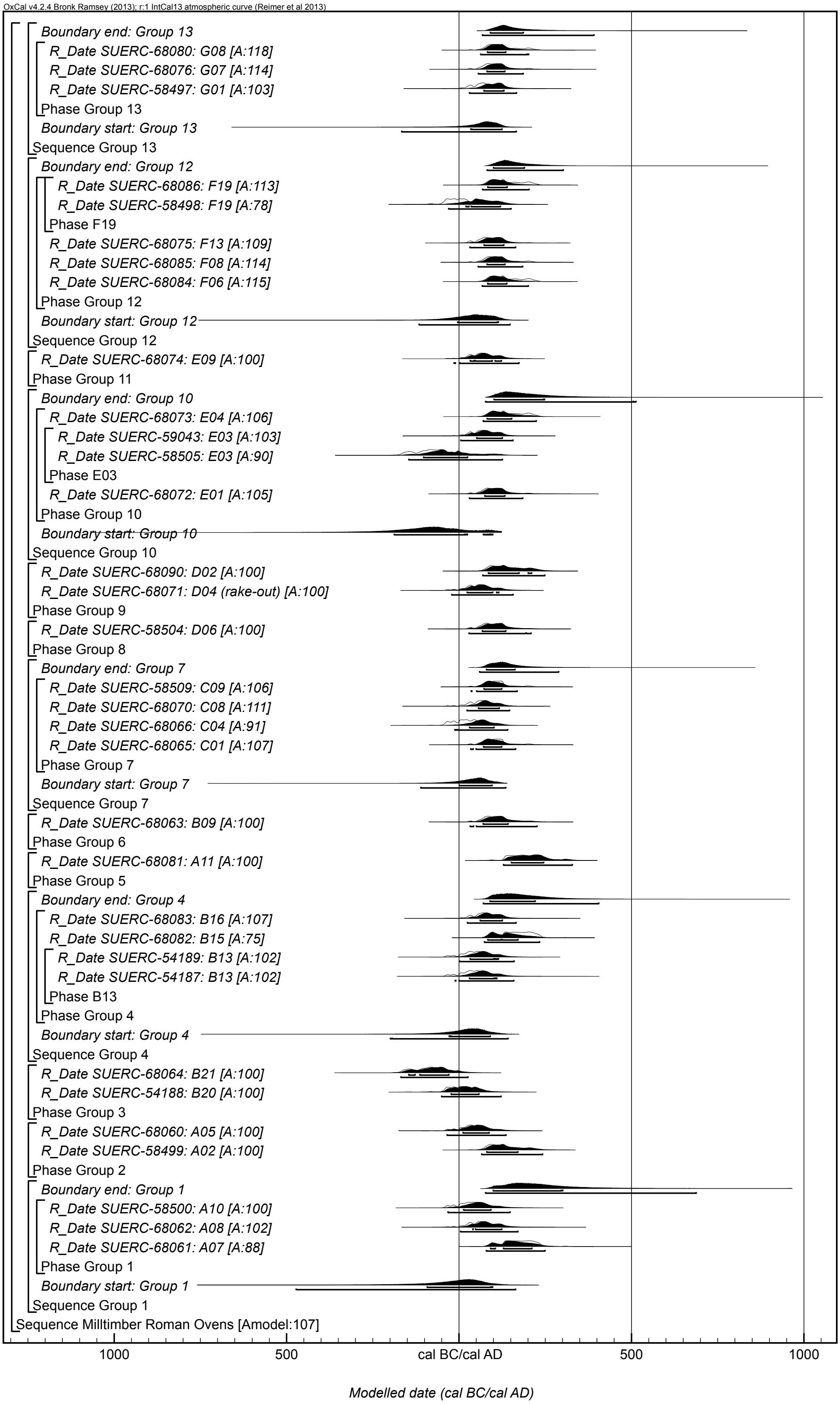


Figure 4: Alternative model number 2 for Milltimber. The ovens groups have been divided into Northern and Southern groups and modelled independently of each another

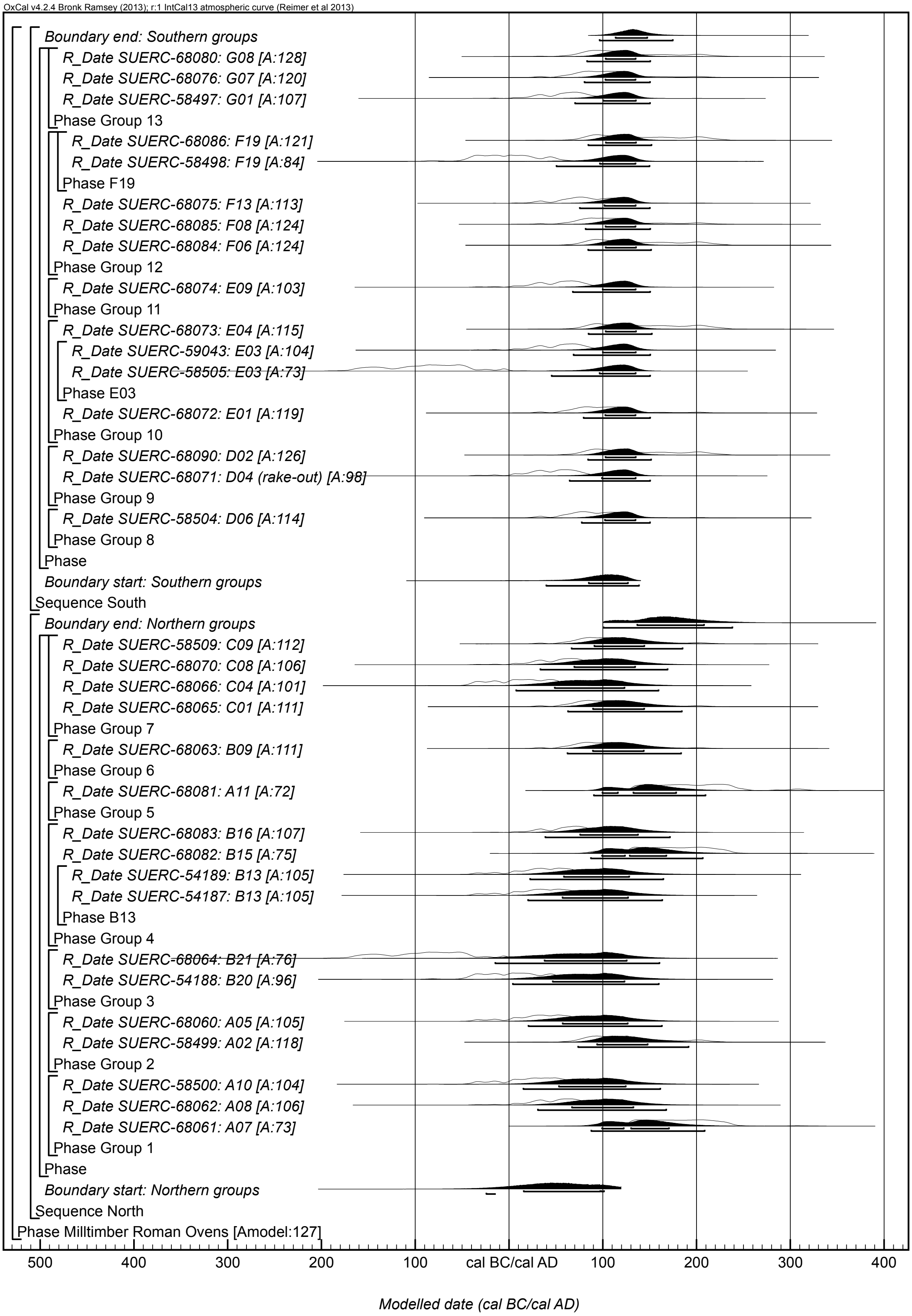


Table 1: Radiocarbon results from the Roman ovens at Milltimber, Aberdeenshire

Lab ID	Oven No.	Group	Context Ref.	Sample Ref.	Material	δ^{13}C (‰)	Radiocarbon Age (BP)	Calibrated date (95% confidence)
SUERC-58499	A02	2	2003	1073	charcoal: *Calluna vulgaris*	−26.4	1883 ±28	cal AD 60–230
SUERC-68060	A05	2	2AB-2019	2AB-1219	charcoal: *Calluna vulgaris*	−27.2	1960 ±29	40 cal BC–cal AD 120
SUERC-68061	A07	1	2AB-2227	2AB-1093	charcoal: *Calluna vulgaris*	−25.9	1838 ±29	cal AD 80–250
SUERC-68062	A08	1	2AB-2272	2AB-1086	charcoal: *Calluna vulgaris*	−25.9	1942 ±29	cal AD 1–130
SUERC-58500	A10	1	2277	1088	charcoal: *Calluna vulgaris*	−25.9	1970 ±29	50 cal BC–cal AD 90
SUERC-68081	A11	5	2AB-1080	2AB-2049	charcoal: *Calluna vulgaris*	−27.9	1818 ±29	cal AD 120–320
SUERC-68063	B09	6	2A-0083	2A-1048	charcoal: *Calluna vulgaris*	−27.0	1902 ±29	cal AD 30–210
SUERC-54187	B13	4	116	1088	charcoal: *Ulmus* sp.	−23.9	1960 ±30	40 cal BC–cal AD 130
SUERC-54189	B13	4	18	1008	charcoal: *Alnus glutinosa*	−25.7	1957 ±30	40 cal BC–cal AD 130
SUERC-68082	B15	4	2AB-0141	2AB-1098	charcoal: *Calluna vulgaris*	−27.0	1842 ±29	cal AD 80–250
SUERC-68083	B16	4	2A-0122	2A-1111	charcoal: *Betula* sp.	−25.8	1928 ±29	cal AD 10–130
SUERC-54188	B20	3	62	1046	charcoal: *Alnus glutinosa*	−25.1	1995 ±30	60 cal BC–cal AD 80
SUERC-68064	B21	3	2A-0108	2A-1071	charcoal: *Betula* sp.	−29.8	2067 ±29	180 cal BC–cal AD 10
SUERC-68065	C01	7	2A-0073	2A-1036	charcoal: *Alnus glutinosa*	−27.0	1901 ±29	cal AD 30–210
SUERC-68066	C04	7	2AB-2629	2AB-1235	charcoal: *Betula* sp.	−25.8	1984 ±29	50 cal BC–cal AD 80
SUERC-68070	C08	7	2A-0090	2A-1056	charcoal: *Alnus glutinosa*	−26.8	1937 ±29	cal AD 1–130
SUERC-58509	C09	7	49	1021	charcoal: *Ilex aquifolium*	−24.7	1897 ±28	cal AD 50–210
SUERC-68090	D02	9	2AB-2200	2AB-1125	charcoal: *Calluna vulgaris*	−25.7	1877 ±29	cal AD 60–230
SUERC-68071	D04	9	2AB-2294	2AB-1090	charcoal: *Alnus glutinosa*	−27.3	1947 ±29	20 cal BC–cal AD 130
SUERC-58504	D06	8	2038	1070	charcoal: *Alnus glutinosa*	−25.5	1911 ±28	cal AD 20–140
SUERC-68072	E01	10	2AB-2083	2AB-1103	charcoal: *Alnus glutinosa*	−29.2	1903 ±29	cal AD 30–140
SUERC-59043	E03	10	2113	1109	charcoal: *Ilex aquifolium*	−23.7	1936 ±29	180 cal BC–cal AD 10
SUERC-58505	E03	10	2111	1110	charcoal: *Quercus* sp.	−26.7	2067 ±28	cal AD 1–130
SUERC-68073	E04	10	2AB-2078	2AB-1121	charcoal: *Alnus glutinosa*	−26.4	1870 ±29	cal AD 60–240
SUERC-68074	E09	11	2AB-2028	2AB-1118	charcoal: *Salix* sp.	−28.7	1938 ±29	cal AD 1–130
SUERC-68084	F06	12	2AB-2242	2AB-1136	charcoal: *Calluna vulgaris*	−27.9	1875 ±29	cal AD 60–230
SUERC-68085	F08	12	2AB-2094	2AB-1096	charcoal: *Alnus glutinosa*	−27.6	1894 ±29	cal AD 50–220
SUERC-68075	F13	12	2AB-2119	2AB-1084	charcoal: *Corylus avellana*	−27.0	1917 ±29	cal AD 20–140
SUERC-58498	F19	12	2180	1113	charcoal: *Calluna vulgaris*	−24.4	2003 ±29	60 cal BC–cal AD 70
SUERC-68086	F19	12	2AB-2180	2AB-1113	charcoal: *Calluna vulgaris*	−23.6	1873 ±29	cal AD 60–230
SUERC-58497	G01	13	2261	1220	charcoal: *Calluna vulgaris*	−28.1	1931 ±29	cal AD 1–130
SUERC-68076	G07	13	2AB-2191	2AB-1215	charcoal: *Calluna vulgaris*	−25.9	1900 ±29	cal AD 30–210
SUERC-68080	G08	13	2AB-2433	2AB-1251	charcoal: *Ilex aquifolium*	−24.5	1885 ±29	cal AD 50–230
SUERC-56395	stray		1058	108	charcoal: *Calluna vulgaris*	−26.2	1975 ±38	50 cal BC–cal AD 130

Table 2: Results of X^2 tests from paired results in individual ovens and across oven groups

Oven/Group	T-value	T'(5%)	Pass/Fail
Oven B13	0.0	3.8 (ν=1)	Pass
Oven E03	10.6	3.8 (ν=1)	Fail
Oven F19	10.6	3.8 (ν=1)	Fail
Group 1	11.5	6.0 (ν=2)	Fail
Group 2	3.6	3.8 (ν=1)	Pass
Group 3	3.0	3.8 (ν=1)	Pass
Group 4	10.6	7.8 (ν=3)	Fail
Group 7	5.9	7.8 (ν=3)	Pass
Group 9	2.9	3.8 (ν=1)	Pass
Group 10	28.1	7.8 (ν=3)	Fail
Group 12	13.8	9.5 (ν=4)	Fail
Group 13	1.3	6.0 (ν=2)	Pass

Table 3: The probability that activity associated with a group of ovens began before another group of ovens. The probabilities are based on the modelled probabilities shown in Figure X for the Alternative model 1

Probability τ1 < τ2	**τ2**					
τ1	***start: Group 1***	***start: Group 4***	***start: Group 7***	***start: Group 10***	***start: Group 12***	***start: Group 13***
start: Group 1		64%	71%	34%	72%	79%
start: Group 4	36%		58%	21%	60%	71%
start: Group 7	29%	42%		15%	52%	67%
start: Group 10	66%	79%	85%		87%	87%
start: Group 12	28%	40%	48%	13%		63%
start: Group 13	21%	29%	33%	13%	37%	

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Appendix-2.2.1 SL/002 and AMA09 Milltimber Prehistoric Pottery Analysis - Julie Lochrie

Introduction

This report covers all prehistoric pottery retrieved from the site during excavation and sample flotation. The assemblage includes 415 sherds and 289 frags. The sherds belong to an estimated 46 vessels, albeit a very small percentage of each actually remain.

It is likely that some of the early Neolithic sherds found in close proximity to each other may belong to the same vessels, but they do not conjoin. As the early Neolithic fabrics and surface treatment are so homogenous it has proved difficult to directly attribute them to each other unless they refit.

The pottery clusters into three broad periods, early Neolithic, middle Neolithic and Chalcolithic (late Neolithic/early Bronze Age). The vast majority of these, at least 30 of the 46 vessels, are all early Neolithic in date. Nine are middle Neolithic, two are Chalcolithic and five cannot be assigned a date. A substantial suite of radiocarbon dates provides a chronological backdrop which matches the pottery assemblage. There are 11 early Neolithic dates from features which cluster within a tight date bracket of c 3970 – 3700 cal BC (SUERC-58023, 58188, 58193, 58194, 58617, 68102, 68104, 68105, 68112, 68114 and 68120). Three middle Neolithic dates spanning between c 3500 and 3090 cal BC (SUERC-58022, 58604, 58605) indicate two or three potential periods of activity but this chronological detail cannot be seen in the pottery assemblage. Finally, the Chalcolithic pottery is associated with three overlapping dates with a bracket of 2470 - 2200 cal BC (SUERC-54055, 58516, 58517).

Measurements are in millimetres (mm) and grams (g) unless otherwise stated. The following abbreviations have been used: thickness (Th), diameter (Dia) and vessel (V). Vessel numbers indicate where multiple sherds belong, or may belong, to the same pot. Terminology is defined as follows: fragment <10mm; small 10-40mm; medium 40-80mm; large >80mm. A complete pottery catalogue is provided in the finds database.

Context, Condition and Deposition

The Milltimber site covers a large area and where the pottery is retrieved from is summarised in Table 1. The discovery of the pottery assemblage can be broadly summarised by three main scenarios representing different modes of deposition which are likely related to a range of events or activities. The first of these is where a substantial quantity from a single vessel was found in a single feature (eg 2C-0050 and AMA09-2089). The second circumstance of deposition is where few sherds from up to three vessels were found within cut features. The third situation is where a few sherds of up to 17 vessels was retrieved from across a large spread of material.

All pottery from the site, excepting 02-V05 and 02-V45 is abraded to some degree. The sherds are all very small, most are below 40 cm and indicate highly fragmented vessels. The sherds are mostly body sherds which is unsurprising given the level of fragmentation and the fact that most of a vessel is comprised of the body. There are also examples of laminar breaks where the sherds have either split down the middle or lost their surface. Other notable breakage is present on 02-V40 where the vessel has broken along its coil joins. Clearly burnt examples were infrequent, only present on the vessels from 02-V03, 02-V04 and 02-V46 which were soft, delicate and completely oxidised.

Table 1 Vessel Summary

Dates	Area	Feature	Context	Vessel #	Vessel Qty	Sherd count
Early Neolithic	-	2B-2550	2B-2551, 2B-2552	02-V01	1	4
Early Neolithic	North	2D-1012	2D-1013	02-V23	1	1
Early Neolithic	North	2D-1127	2D-1093	02-V25 to 02-V26	2	9
Early Neolithic	North	2D-1399	2D-1439	02-V31	1	2
Early Neolithic	North	2D-1403	2D-1404	02-V29	1	2
Early Neolithic	North	2D-1433	2D-1435	02-V30	1	1 + 2 fragments
Early Neolithic	North	2D-1714	2D-1786	02-V37 to 02-V39	3	5
Early Neolithic	North	2D-1895	2D-1901	02-V40	1	100
Early Neolithic	North	2D-1927	2D-1928	02-V41 to 42	2	4
Early Neolithic	Zones 1-5	Spread 2D-1939	Spread 2D-1939	02-V06 to 02-V22	17	45 + 45 fragments
Middle Neolithic	North	2D-1822	2D-1751	02-V34 to 02-V36	3	56 + 111 fragments
Middle Neolithic	South	AMA09-2058	AMA09-2059	02-V43 and 02-V45	2	75 + 119 fragments
Chalcolithic	Free standing avenues	2C-0050	2C-0134	02-V05	1	Complete vessel
Chalcolithic	Free standing avenues	2C-0075	2C-0076	02-V04	1	3
Undated	-	2B-0109	2B-0110	02-V02	1	1
Undated	-	2B-2650	2B-2656	02-V03	1	5
Undated	North	2D-1086	2D-1087	02-V24	1	68
Undated	North	2D-1210	2D-1214	02-V28	1	14
Undated	North	2D-1137	2D-1149, 2D-1150	02-V27	1	6
Undated	North	2D-1495	2D-1509	02-V32	1	5 fragments
Undated	North	2D-1529	2D-1590	02-V33	1	1 fragment

Undated	West	AMA09-2080	AMA09-2081	02-V44	1	1 + 1 fragment
Undated	South	AMA09-2089	AMA09-2090	02-V46	1	13 + 6 fragments

As a strong contrast to the rest of the assemblage a complete and unbroken pot, 02-V05 was retrieved from post-hole [2C-0050]. It dates to the Chalcolithic and is one of two vessels of this date found on site. It was found in the base of a very deep post-hole and it is difficult to believe that this fine-walled pot would have been present whilst the post was in place. However, all available evidence points towards the presence of a post which rotted in situ, meaning the pot was placed under the post. The miraculous survival of the pot must relate to exactly how the post was lying as thin walled beakers found in cists are typically crushed, even when only soil sits upon them (eg at Beechwood Park the beaker was crushed with only 0.3m on top, Sheridan and Hammersmith 2006; the beaker from West Torbreck was crushed within a cist of 0.51m depth, Ballin-Smith 2014). The pot was lying on its side and the weight of the soil has flattened it slightly to be more oval-shaped in plan, other than this it is in near perfect condition. The likelihood it was thrown into the feature is very slim as the impact would probably have smashed the pot. This leaves the scenario that someone carefully reached in and laid it into the base of the feature.

No other unbroken vessels were found but at least 25% of an early Neolithic bowl, 02-V40, was found in the top of pit [2D-1895] and 80% of a middle Neolithic bowl, 02-V45, was found in pit [AMA09-2058]. The sherds from 02-V40 are larger than most sherds found on site and large sections of profile conjoin. The breaks on this vessel are mostly along the coil joins rather than an irregular breakage pattern through impact. The combination of these characteristics indicate it fragmented in situ and a large section of the vessel, if not all of it, was originally deposited. This vessel, unlike 02-V05, was in the uppermost deposits of the feature and not as protected. The sherds from 02-V45 are a little different as they have clearly been broken through impact. Of the 20% of the vessel that is missing 10% is likely to be a recent loss, indicated by recent breaks, the other broken edges appear to have happened in antiquity but as the edges are unabraded it suggests it occurred inside the pit or shortly before deposition in the pit. It is certain this vessel was complete upon deposition, with perhaps a small break to the rim. This vessel was found with broken and abraded sherds of a second vessel, 02-V43.

The small quantities of pottery spread across a mixture of features appears to be typical of domestic activity. They are low in quantity, abraded and usually small body sherds. Their likeliest functional explanation is that they derive from domestic refuse and were either deliberately dumped into the negative features or slowly slumped in over time. The pottery found in the spread has very similar condition and sherd characteristics which could derive from the same type of domestic activity which has been discarded in a midden or living surface. An alternative explanation for the pottery from the spread is that it is from two nearby areas which host Neolithic Features; the pottery could have been displaced by later archaeological occupation or ploughed out by more recent agricultural practices.

Form, fabric, manufacture and function

Early Neolithic

Almost all the pottery belongs to the early Neolithic carinated bowl tradition which has a span of use between c 3950 BC - 3650 BC. These are finely burnished, thin vessels which are bipartite in form with a round base, carination and everted neck. Such a small quantity of the vessels survive at Milltimber it is impossible to reconstruct and discuss their precise form. Nine rim sherds survive, all are simple, rounded and everted. Vessel 01-V040 has a rim which is slightly rolled over to create a small lip, but this is a variable feature, around the circumference sometimes appearing rolled and not at other sections. All the carinated bowl has been given some form of surface treatment which appears to be exclusively burnishing, this occurs almost always on both the interior and exterior surfaces. The fabric of all the Neolithic pottery is sandy with variations of sub-rounded and sub-angular quartz inclusions which are large and small but always well distributed through the vessel and never more than moderate (30%) in frequency. The fabrics all have a very fine micaceous shimmer. They have been well-fired and are of an even thickness, usually the fabric looks mid-brown and is reduced throughout.

While all the other pottery is very traditional in form, vessel 02-V01 from pit [2B-2550] is a fluted carinated bowl of Henshall's north eastern style (CBNE). These have been found in the North-East at many sites, including Blackdog (this volume), Garthdee Road (Murray and Murray 2014), Port Elphinstone (Lochrie 2013), Westgate (Lochrie 2010a), Warren Field (Sheridan 2009), Deer's Den (Alexander 2000), Boghead (Henshall 1984) and Midtown of Pitglassie (Henshall 1996). The example at Port Elphinstone returned dates of 3707 – 3636 cal BC, (SUERC-42979) which is much later than some other dates for fluted CBNE, showing it was a long-lived type.

One of the carinated bowls, Vessel 02-V40, is more substantial in size and allows closer analysis of both its overall form and how it was made. It is a traditional carinated bowl meaning it is open, everted and bipartite with a rounded base and no decoration. It has a rolled rim which begins at 4.5mm thickness, thickening to 6mm before thinning dramatically to 3.5mm before a sharply angled carination. The base is hemispherical but a little flattened right at the very base. The burnishing has left a black leathery effect on the exterior which has been worn variably across the vessel during deposition. Clay joins on the vessel run along a slight diagonally rather than horizontal which may suggest the use of a coil rather than slabs or rings but without the remainder of the vessel it is not certain.

Overall all the early Neolithic vessels impress with the talent and skill which has been taken to create them. The fabrics are hard, smooth and thin and the change in angle are a skilled achievement. The defining characteristic when identifying the CB (Carinated Bowl) at Milltimber has undoubtedly been the surface treatment and thin walls. Evidence from two vessels on site may give further clue to the manufacture of these vessels. A small sherd, 02-V39, shows almost horizontal coil joins but almost undiscernible short sharp lips along the edge. Vessel 02-V40 as already discussed has broken along several shallowly concave or convex coil joins. The way the clay has bonded together is not as secure and clearly left a point of weakness, along which they have once again become detached. This is not an uncommon feature on this pottery, it has also been noted at Kirkton of Fetteresso (Lochrie 2016) and Blackhall Road, Inverurie (Lochrie 2010a). This also points towards little manipulation of the clay at the joins, perhaps to maintain the uniform wall thickness. If the thin walls were heavily manipulated the stretching of the clay at the joins would more likely result in deeply concave/convex or oblique joins. Another way to maintain the thin and even walls would be by cutting or slicing away parts of clay. This would also account for the weak joins as well as why so much care was subsequently taken to perfect the surface by smoothing and burnishing, unfortunately this same treatment also removes the evidence this may have occurred. On 02-V39 we may be seeing possible evidence of this procedure as the lip at the very edge of the sherd could have been created by slicing off part of the face along where the clay had been joined.

Middle Neolithic

The middle Neolithic pottery includes six vessels 02-V34 to 02-V36 and 02-V43, 02-V45 and 02-V46. They are all identified by their form or decoration as belonging to the Impressed Ware tradition, a long-lived type of pottery in use between c 3500 BC and 2900 BC (Kinbeachie, 3500 – 2920 BC, MacSween 2001, Table 1, 63; Kintore, 3530 - 3340 BC, MacSween 2008, 181; Meadowend Farm, 3350 - 3000/2900 BC, Jones et al 2018).

Vessel 02-V45, from pit [AMA09-2058], comprises an almost complete vessel with a rim diameter of 135mm, a carination diameter of 150mm and a base diameter of 50mm. The form is bipartite with a closed collar-like rim. The collar is decorated with probable bone impressions and the very edge of the rim has vertical impressions or incisions. The presence of a decorated collar is similar to proto-Unstan form. Proto-Unstan vessels from Peterhead are dated to 3370-3090 cal BC but it is assumed these had round-bases and not the flat base seen on the Milltimber vessel (Johnson 2010, 20). Pots with decorated collars and trunconic forms with flat bases are also a later part of the impressed ware repertoire. They are seen at Meadowend Farm, Clackmannanshire where they radiocarbon dated to c 3350–3000/2900 BC (Jones et al 2018). The Meadowend Farm vessels are slightly more trunconic in shape and the collars slightly more pronounced than the Milltimber vessel, but the basic stylistic features are the same. Both proto-Unstan and the Impressed Ware vessels date to the latter third of the fourth millennium BC. The closest comparatives for this vessel include those from Culduthel, Inverness (P35, Sheridan forthcoming) and from Deers Den, Aberdeenshire (P49, P51 and P62, Alexander 2000, 45). Deers Den was dated between c 3300 and 3000 (3130-2910 cal BC, OxA-8177 and 3360-3030 cal BC, OxA-8176, Alexander 2000, 64). The second vessel, 02-V46, from pit [AMA09-2089] includes rim sherds which conjoin to form an inturned rim, unfortunately the overall vessel form is unclear, and the sherds are soft and burnt.

The sherds from 02-V43, which was also retrieved from pit [AMA09-2058], are from a flat-based, bipartite vessel with an upright, gently inturned, internally bevelled rim. This rim of this vessel also has linear incised decoration, directly upon the bevel. There is too small a portion surviving to discern the true pattern, but they appear to be located as pairs running parallel to the interior and exterior edges.

Hearth feature [2D-1137] includes small quantities of three vessels, 02-V34 to 02-V36. Amongst these are a simple gently curving squared rim (02-V035), a single rounded upright rim (02-V36) and five sherds decorated with diagonal lines of small, sub rectangular dot-impressions (02-V034). Vessel 02-V035 and 02-V034 belong to the middle Neolithic but the single rounded sherd 02-V36 is burnished and may be a residual sherd from an early to middle Neolithic uncarinated cup.

Chalcolithic

The pottery found in association with the timber monument includes two vessels, 02-V04 and 02-V05, both Beaker pottery. The remains of each vessel are very different than the other. Vessel 02-V05 is complete and unbroken, it is a small, squat, well-finished, low-bellied Beaker with an everted, gently rounded rim. It stands at 75mm tall and has an estimated diameter of 100-110cm. This vessel is well made with thin, even walls and well finished with evidence for smoothing and potential surface scraping. There are long facets located around the belly which may indicate where they joined together the clay or used tools to aid shaping and smoothing of the belly. Charcoal from features in the vicinity of where 02-V05 was discovered have been radiocarbon dated to between 2470 - 2200 cal BC (SUERC-54055, 58516, 58517). These dates perfectly match the date range that would be expected for this vessel form. Other sites within the Aberdeenshire area with similar early Chalcolithic dates include: the cremation complex at Midmill (SUERC-31024: 2470 – 2230 cal BC; SUERC-22014: 2460 – 2200 cal BC; SUERC-22018: 2470 – 2210 cal BC; SUERC-22019: 2300 – 2060 cal BC; Lochrie 2010b) the cist at Slap (3803 ± 35 uncal bp; Sheridan 2007).

Undecorated Beakers are not very common in Scotland but have been found in the north-east at Slap, Aberdeenshire, (Ledingham 1874), Boghead, Moray, (Burl 1984), West Torbreck, Invernesshire (Ballin Smith 2014), Beechwood Park, Invernesshire (Sheridan and Hammersmith 2006), all in burial contexts. Of all these examples the Slap Beaker would appear to be closest in profile and dimensions to the Milltimber beaker, although at 150mm it is twice as tall as the 75mm Milltimber example. However, at Ascoilemore (Davidson 1939-40) a small vessel identified at the time as a food vessel urn looks very similar to the Milltimber Beaker. It has a similar small flat base which rises and then kicks out to a low belly, everted neck and rounded rim. Its dimensions at 120mm height, 150mm rim diameter and 70mm base diameter are also closer than any other examples available (Davidson 1939-40). As an antiquarian example it has not been subject to modern analysis so little information is currently available on the pottery and the site.

The Beaker sherds comprising 02-V04 from pit [2C-0075] are much burnt and extremely delicate. The sherds join to form part of the everted neck and rim and there are clear horizontal lines all over the exterior. Unfortunately, it has not been possible to discern how they were created but based on the radiocarbon dates retrieved from site and the early form of the other Beaker they are most probably all of cord impressions (AOC dates Needham 2005).

Undated

A group of 108 sherds and 13 fragments belonging to up to nine vessels could not be identified, these are summarised in table 2.1. Five fragments, representing vessel 02-V32, from [2D-1495] are associated with an early Neolithic date, 3943 – 3709 cal BC (SUERC-58193). Two vessels are associated with middle Neolithic dates and may belong in this category. Vessels, 02-V27 is represented by six undiagnostic, greatly abraded, small body sherds and two fragments, however it is associated with a middle Neolithic radiocarbon date retrieved from charcoal within the same pit it (3363 - 3104 cal BC, SUERC-58022). Vessel 02-V33 is represented by a single fragment which is associated with charcoal radiocarbon dated to 3514 – 3355 cal BC (SUERC-58604).

Two further vessels were associated with radiocarbon dated material. The burnt sherds comprising 02-V-46, from [AMA09-2089], are associated with an early to middle Iron Age date of 358 – 105 cal BC (SUERC-74402). The pottery from [2B-0110] is associated with a date of cal AD 782 – 1013 (SUERC-68093).

Discussion

Neolithic

The early Neolithic radiocarbon dates from Milltimber cluster fairly tightly around a period during the first quarter of the 4th millennium BC. This period is the first time pottery is found in the British Isles. Traditional Carinated Bowl pottery similar to that found at Milltimber is known at other sites in Aberdeenshire (Deers Den, Alexander 2000; Pitdrichie, Lochrie 2010c; Westgate, Lochrie 2010a) with similar date brackets to those obtained from the radiocarbon dating. The date of the CBNE is likely to fall within this period and it is likely it is from the same period of activity that the traditional carinated bowls relate too. The CBNE ‘style drift’ began from as early as c 3800 BC (e.g. OxA-8132, OxA-8131, Oxa-8133, Deers Den, Alexander 2000, 17; GU-9155, Dubton Farm, MacSween 2002, 41; Warren Field, Sheridan 2009, 92).

In two instances Neolithic pottery was found in the top of Mesolithic features, [2D-1127] and [2D-1714]. The quantities of pottery are small and the abrasion makes it clear they are likeliest the result of general refuse which has accumulated in the concavities left behind from the large pits. The circumstance of deposition of 02-V40 needs to be considered in a little more detail as a much higher quantity of this vessel was found compared to the rest of the early Neolithic pottery assemblage. It was found in the top of a pit whose lower fills are thought to date to the Mesolithic. Smaller Neolithic pits being cut in the tops of larger pits are recognised at other sites (eg Blackdog, Dingwall et al 2019; Warren Fields, Murray, Murray and Fraser 2009, Chapelfield, Squair and Jones 2002; Port Elphinstone, Lochrie 2013). In all these examples the earlier features were Mesolithic in date. At Garthdee Road, it is highly plausible that the knowledge of older habitation led to an active change in habits which took into account the memory of others before them. Despite this unusual ritualistic activity, the early Neolithic pottery assemblage on the whole is typical of domestic activity.

Middle Neolithic

The evidence for middle Neolithic activity is small but a solidly identified group. It primarily comes from six middle Neolithic Impressed Ware vessels from the North and South of the spread, a couple of lithics in the West and three radiocarbon dates from the North spanning between 3500 and 3090 cal BC (SUERC-58022, 58604, 58605). These radiocarbon dates show a different pattern to the 'tight' group from the early Neolithic. They probably represent at least two repeated visits as the earliest and latest dates have no overlap, they are unlikely to represent occupation through its entirety as the artefactual evidence comprises too small a group to support that level of continuous occupation.

To the north and south of the Mesolithic lithic scatter were two pits which contained the six Impressed Ware vessels. Despite being a long-lived ware, which dates between c 3500 BC and 2900 BC (Kinbeachie, 3500 – 2920 BC, MacSween 2001, Table 1, 63; Kintore, 3530 - 3340 BC, MacSween 2008, 181; Meadowend Farm, 3350 - 3000/2900 BC, Jones et al 2018) the type of vessel found in [AMA09-2058] could be narrowed to a probable date of between around 3300 and 3000 BC. The remarkable thing about the vessel from [AMA09-2058] is how complete it is. This is not representative of the pottery found at Milltimber and could draw parallels with the complete Beaker ceremonially placed under an avenue post-hole in the Chalcolithic. A small broken section of the Impressed Ware pot may have been missing to necessitate its discard, but it must have been placed consciously into the pit to have avoided further breakage. This type of deposition carries more care and action than the usual discard into middens or refuse pits and the pit must have been filled not long after its inclusion to have prevented further fragmentation.

Chalcolithic

The most interesting aspect of the Milltimber Beaker is its context of discovery. It is not funerary which is almost the only place where finely made non 'domestic' Beaker is found. However, this is not unique as Beaker pottery deposition as a closing ritual at Neolithic sites is a documented occurrence (Lelong and Macgregor 2008; Mercer 1981; Barclay 1983) and may explain its being placed in the base of a post-hole of the avenue. This would also account for why there is so little accompanying material culture from around this period, the activity itself was a co-ordinated and discrete event.

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Appendix-2.2.2 SL/003B Nether Beanshill Prehistoric Pottery Analysis - Julie Lochrie

Introduction

The prehistoric pottery numbers 247 sherds from 27 features, representing up to 22 vessels (03-V01 to 03-V22). The pottery was found in two areas; a cremation cluster to the north east and a roundhouse, Building 1, to the south west, with 203 and 44 sherds retrieved respectively. Some outlying features also yielded pottery numbering a total of 12 sherds. The entire site dates to the middle Bronze Age and the cremation cemetery and the roundhouse may have been in use at the same time.

Measurements are in millimetres (mm) and grams (g) unless otherwise stated. The following abbreviations have been used: thickness (Th), diameter (Dia) and vessel (V). Vessel numbers indicate where multiple sherds belong, or may belong, to the same pot. Terminology is defined as follows: fragment <10mm; small 10-40mm; medium 40-80mm; large >80mm. A complete pottery catalogue can be found within the finds database.

Context, Condition and Deposition

The cremation cemetery has very clearly been disturbed to a large degree. The vessels used to hold the cremations would have been placed complete into a pit or a shallow scoop and covered over with soil or stones. Small sherds were present through many contexts and had clearly been come from smashed or crushed vessels which were also abraded indicating some movement. In many instances the pottery sherds did not appear to be deliberately placed in the contexts they were found. For this reason caution has been exercised when assigning how many vessels were actually present. The only contexts which contained substantial quantities were [3B-0003], [3B-0104] and [3B-0182]. It is likely these were the only contexts originally containing cremation urns. The better rate of survival for base sherds indicates the vessels were interred upright. Dating of cremated bone held within urn 03-V03 from [3B-0104] returned a date of 1434 – 1286 cal BC (SUERC-58844).

Table 1 Assemblage Summary

Area	Feature	Context	Sherd count	Fragments
Cremation Complex	3B-0003	3B-0004	110	200g
	3B-0045	3B-0046	8	4
	3B-0047	3B-0048	1	5
	3B-0070	3B-0071	2	4
	3B-0104	3B-0105	73	86
	3B-0182	3B-0183,3B-0184	14	18
	3B-0202	3B-0203	1	-
Roundhouse Complex	3B-0039	3B-0040	2	7
	3B-0049	3B-0059	1	1

	3B-0056	3B-0057	1	1
	3B-0094	3B-0095	-	1
	3B-0111	3B-0112	1	-
	3B-0123	3B-0122	6	-
	3B-0140	3B-0141	1	1
	3B-0150	3B-0149	7	-
	3B-0159	3B-0160	-	1
	3B-0164	3B-0165	1	1
	3B-0195	3B-0196	-	1
	3B-0199	3B-0200	2	-
	3B-0218	3B-0220	1	-
	3B-0219	3B-0221	-	2
	3B-0231	3B-0232	-	2
	3B-0285	3B-0286	-	1
	3B-0291	3B-0292	1	3
Outlying	3B-0269	3B-0270	12	3

The pottery from the roundhouse is spread out in low very fragmented quantities with thick undiagnostic body sherds dominating. None of the pottery bearing contexts are directly associated with radiocarbon dates but the dating for the building are between 1506 – 1411 cal BC (SUERC-58510), 1496-1302 cal BC (SUERC-58515).

Form, fabric, manufacture and function

The fabric is very similar across all the vessels from both the cremation cemetery and the roundhouse assemblages. The wall thickness is thick with a sandy fabric containing moderate and very coarse angular rock inclusions, granite and what looks like a pink coloured quartzite seem to be the most common.

Due to the truncation of the cremation complex not much remains of the urns other than their bases. Vessel 03-V01 is mostly represented by a base of 110mm diameter and lots of very small sherds and fragments which are practically ground to dust. The base is flat but uneven on the interior, thickening towards the middle. The exterior corners of the base have been pinched into shape given an almost footed appearance, the pinching has left little folds of clay and the whole thing has a course and unfinished appearance. The walls are substantially thinner than the base (6mm versus 16.5mm). The only other detail about this vessel came from amongst the crushed sherds and came from a very small everted body sherd. This suggests some kind of feature on the upper body such as ridges or cordons.

Vessel 03-V02 comprised conjoining base sherds and some body sherds. The basal sherds provided a diameter of 170mm. Although few sherds were present the base revealed some interest aspects to its manufacture. Along the very edge of the base are pinch marks and nail marks for where the clay has been squeezed to the correct angle. A very clear clay join can be seen in the section which begins on the interior base and carries out diagonally to the very foot of the exterior. The efforts to join these two sections together can be seen in the shallow finger smoothing groove around the interior basal circumference. This pushing has made the base thicker on the interior and convex in section. The manufacture process for this likely involved the initial creation of a large, thick, flat, circular 'puck' to which the walls have been connected. This also explains the subsequent breakage pattern of 03-V01 and 03-V03 which were probably made in a similar way.

The largest remaining urn was Vessel 03-V03 which included the entire base, complete and a few rim sherds. The base has a diameter of 180mm, the largest of the three and it must have been a sizable urn. The urn was lifted complete but shortly after excavation the walls broke away from the base, in the same manner as the other vessels and this is almost certainly the original point at which the clay was joined. This vessel has a smooth surface and a little more care seems to have been taken in its appearance. The base is smooth with rounded corners and the walls flare out gently.

Other small sherds were scattered around the cremation cemetery, including a very small rim sherd from feature [4D-0070]. This sherd is likely to belong to one of the three urns described above, it was squared and slightly lipped on the interior.

Table 2 Summary of vessels

Area	Vessel #	Dates	Feature	Context
Cremation Complex	03-V01 03-V02 03-V03	1410 – 1231 cal BC - 1434 – 1286 cal BC	3B-0003 3B-0182 3B-0104	3B-0004, 3B-0007, 3B-0023 3B-0183, 3B-0184 3B-0105
Roundhouse Complex	03-V04	-	3B-0039	3B-0040
	03-V05	-	3B-0049	3B-0059
	03-V06	-	3B-0056	3B-0057
	03-V07	-	3B-0094	3B-0095
	03-V08	-	3B-0111	3B-0112
	03-V09	-	3B-0123	3B-0122
	03-V10	-	3B-0140	3B-0141
	03-V11, 03-V12	-	3B-0150	3B-0149
	03-V13	-	3B-0159	3B-0160
	03-V14	-	3B-0164	3B-0165
	03-V15	-	3B-0195	3B-0196
	03-V16	-	3B-0199	3B-0200
	03-V17		3B-0218	3B-0220
	03-V18		3B-0219	3B-0221
	03-V19		3B-0231	3B-0232
	03-V20		3B-0285	3B-0286
	03-V21		3B-0291	3B-0292
Outlying	03-V22	-	3B-0269	3B-0270

The roundhouse contained similarly fragmented pottery and in only two cases it is possible to say anything more about the vessels. Vessel 03-V05 was represented by a small upright rounded rim sherd but Vessel 03-V09 is the best represented out of the roundhouse vessels and comprises six sherds including three rim sherds, two of which conjoin. Vessel 03-V09 has a T-shaped rim which has a convex top providing a 'pillowed' appearance. On the exterior, directly below the rim, are two shallow grooves providing a ridged appearance. The shaping and smoothing of the rim has been carried out with small tool which must have been flat with a squared end, like a small spatula. It is been used in two ways, firstly it has been pushed into the exterior of the rim directly below the horizontal arms of the 'T'. This makes a nice sharp and well defined lip on the exterior. The individual lines where the tool has been pushed in can still be seen. Its second use has been employed on the interior where the tool has been smeared down vertically from right to left, leaving overlapping impressions. This has not been smoothed over in any further way to hide these marks but finger smoothing has been carried out between the exterior ridges and may even be how it was created.

Discussion

The proximity of the cremation cemetery and roundhouse complex so close to each other with overlapping dates is an interesting one and perhaps suggests that the cremation complex functioned as a small family burial ground. While the radiocarbon dates overlap it still remains they may not have been actively in use at the same time. Sadly the pottery assemblage has proved too disparate to suggest any relationship on this alone. The more interesting similarities are between the ridged vessel and other ridged vessels found at other middle Bronze Age sites.

This distinctive shape of Vessel 03-V09 is also seen on a vessel at Chapel of Stoneywood (A2.2.4) that is associated with radiocarbon dates of 1377-1231 cal BC (SUERC-49725) and 1395 – 1291 cal BC (SUERC-57933), only slightly later than Building 1. At the site of Old Meldrum, Aberdeenshire located around 17km north two pots also demonstrated similar ridges (P86 and P89, Johnson 2010, 13). At Old Meldrum both of these pots are from a middle Bronze Age building (White and Richardson 2010, 22). Ridges, cordons and finger grooves to middle Bronze Age vessels seems to be a further widespread trend and could potentially have developed from cordoned urns. There was one present at Echline Fields, South Queensferry, which dated to 1379 – 1123 cal BC SUERC-39754 (Robertson, Lochrie and Timpany 2013, 122) and looking south west to the Bronze Age unenclosed platform settlements of Lanarkshire there are examples of ridged and cordoned vessels at both Lintshie Gutter (Terry 1995) and Green Knowe (Jobey 1978-80).

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Appendix-2.2.3 SL/004 Gairnhill Pottery Analysis - Julie Lochrie

Introduction

The pottery assemblage numbers 297 sherds and a high quantity of fragments (summarised in Table 1) A total of 25 vessels are estimated to be present, in various states of preservation and fragmentation. Excepting an early Neolithic sherd the entire assemblage is middle or later Bronze Age. Gairnhill site is spread out over a large area and includes a burnt mound in the south, a roughly central isolated pit, a roundhouse and a group of six roundhouses in the north.

Measurements are in millimetres (mm) and grams (g) unless otherwise stated. The following abbreviations have been used: thickness (Th), diameter (Dia) and vessel (V). Vessel numbers indicate where multiple sherds belong, or may belong, to the same pot. Terminology is defined as follows: fragment <10mm; small 10-40mm; medium 40-80mm; large >80mm. A complete pottery catalogue can be found in the database.

Context, Condition and Deposition

The Neolithic pot sherd was found in isolated pit [4C-0001] along with a flint flake. It is likely the remnants of Neolithic occupation but it was located at the limit of excavation and no other evidence was discovered.

The 24 remaining vessels were found across six buildings (Gairnhill 1-5 and 7). Gairnhill 7 is middle Bronze Age, radiocarbon dated to 1491 – 1298 cal BC (SUERC-58515). The other six buildings are idle Bronze Age with a spread of dates between c 1150 and 800 BC. The pots are typically represented by a small quantity of abraded sherds which feature organic residues from foodstuffs. Two examples do not conform to this pattern, 04-V08 from [4D-0392] and 04-V20 from [4D-0381]. In both these instances partially complete sections from the circumference of the rim survived, although the bases were missing. They may have been deposited complete and inverted, perhaps as a ceremonial/votive offering or may represent disturbed cremation burials. The latter may be supported by the unstratified presence of a highly vitrified plano-convex knife, a type of tool typically associated with early Bronze Age cremation burials.

Table 1 Summary of assemblage

Area	Feature	Context	Vessel Qty	Sherd count	Fragment count (unless otherwise stated)
Neolithic Pit	4C-0001	4C-0002	1	1	-
Gairnhill 1	4D-0013	4D-0014	1	3	1
	4D-0042	4D-0043	1	2	20
	4D-0051	4D-0052	1	5	-
Gairnhill 2	4D-0102	4D-0103	1	109	155g
Gairnhill 3	4D-0348	4D-00358	1		2
	4D-0386	4D-0549	1	1	1
	4D-0392	4D-0390	1	5	2
	4D-0433	4D-00412	1	1	-
	4D-0444	4D-0420	1	2	-
Gairnhill 4	4D-0065	4D-0067, 4D-0238	3	56	18

	4D-0074 4D-0240	4D-0186 4D-0066			
Gairnhill 5	4D-0017	4D-0018, 4D-0045	1	9	-
	deposit	4D-0026	1	14	-
	4D-0121	4D-0126	1	2	-
	4D-0138	4D-0161	1	2	-
	4D-0151	4D-0164, 4D-0226, 4D-0227	2	12	3
	4D-0381	4D-0360	1	38	7
Gairnhill 7	4B-0002	4B-0003, 4B-0011, 4B-0013	3	32	9
	4B-0006	4B-0007	1	1	-
	4B-0040	4B-0037	1	2	-

The buildings appear to show slightly different patterns of pottery deposition. Gairnhill 1 had the least pottery of all the roundhouses. Gairnhill 2 had a substantial quantity of pottery but only from one feature, belonging to one vessel. Gairnhill 4 and 5 were similar in sherd counts and distribution but the Gairnhill 5 assemblage represented almost twice as many vessels. Another difference unique to Gairnhill 4 was that sherds from the same vessels were spread across several contexts. These differences could be due to many variables, function of the dwelling, how its use came to an end and possibly also a chronological preference which reflects itself in the pottery assemblage.

Form, fabric, manufacture and function

The pottery from fill (4C-0002) of Pit [4C-0001], located in the south west, is a burnished rim sherd from a small uncarinated cup of the carinated bowl tradition. This pot type dates between c 3950 BC - 3650 BC.

Table 2 Summary of Vessels

Area	Vessel #	Dates	Feature	Context
Neolithic pit	04-V01		4C-0001	4C-0002
Gairnhill 1	04-V02 04-V03 04-V04		4D-0013 4D-0042 4D-0051	4D-0014 4D-0043 4D-0052
Gairnhill 2	04-V05		4D-0102	4D-0103
Gairnhill 3	04-V06 04-V07 04-V08 04-V09 04-V10		4D-0348 4D-0386 4D-0392 4D-0433 4D-0444	4D-0358 4D-0549 4D-0391 4D-0412 4D-0420
Gairnhill 4	04-V11 04-V12 04-V13		4D-0065, 4D-0074, 4D-0240 4D-0240 4D-0240	4D-0067, 4D-0238, 4D-0186, 4D-0066 4D-0066 4D-0066
Gairnhill 5	04-V14 04-V15 04-V16 04-V17 04-V18 04-V19 04-V20		4D-0017 - 4D-0121 4D-0138 4D-0151 4D-0151 4D-0381	4D-0018, 4D-0045 4D-0026 4D-0126 4D-0161 4D-0164, 4D-0226 4D-0227 4D-0360

Gairnhill 7	04-V21 04-V22 04-V23 04-V24 04-V25		4B-0002 4B-0002 4B-0002 4B-0006 4B-0040	4B-0003 4B-0011 4B-0013 4B-0007 4B-0037

The pottery from the roundhouses is dealt with below; any trends or comparatives between the buildings will form part of a larger discussion. In general few features sherds were present but where they were present they will be described in detail.

Gairnhill 7

Gairnhill 7 is the earliest of the Bronze Age houses with a middle Bronze Age radiocarbon date (1491 – 1298 CAL BC, SUERC-58515). Thirty five sherds representing five vessels (04-V21 to-V25) were associated with this building. The vessels are highly fragmented small to medium thick body sherds (up to 14mm in thickness). The only sherd out of this sub-group which provides information on the overall shape of the vessel is a base sherd from 04-V22. This has a very straight sided wall which is unlike most of the assemblage where the walls tend to kick out, creating a wider body. There are not enough vessels to say whether this indicates a chronological preference at the site, bucket and barrel shapes are prevalent through the middle and later Bronze Age with no evidence to suggest straighter sided vessels date to the middle of the period.

Gairnhill 1

Sherds from this building account for vessels 04-V02 to 04-V04. Vessels 04-V03 and 04-V03 were from post-holes external to the building and 04-V02 is from a hearth. Vessels 02-V02 and 02-V03 are fairly undiagnostic small body sherds. Vessel 04-04 includes five medium sherds including a base sherd. The base sherd is flat with visible undulations from finger pinching around its edge. The base is a little too small to provide a diameter but it shows walls that kick out.

Gairnhill 2

The single vessel discovered at Gairnhill 2 which comprised a large quantity of mostly small but some medium sized sherds almost entirely from the upper body. The vessel is bucket-shaped, with a slight shoulder and an obliquely angled internal bevel. Almost none of the basal sherds appeared to remains but two small abraded sherds were found. They are from the very corner of the base and show very little details. The vessel has both exterior and interior organic residue. It also has a surface treatment rare within the assemblage. It has been smoothed over with a clay slurry, providing a slip-like appearance.

Gairnhill 3

The sherds from Gairnhill 3 represent five vessels, 04-V06 to 04-V10. All except 04-V08 are small undiagnostic body sherds. At least 50-60% of Vessel 04-V08remains, its base is missing but around 75% of its circumference is intact. The base has broken off along a distinctive elongated S-shaped clay join. An identical join to this was noted on another vessel (04-V11) from Gairnhill 4. The rim of 04-V08 is internally bevelled and slightly lipped on the exterior. It appears almost shouldered in shape but the rim is still the widest point. The urn has a 145mm rim diameter and would have been quite small when complete. The sherds are all large and conjoin together well with no edge abrasion and likely broke in situ with the base lost to ploughing, this scenario indicates it was sitting inverted in the pit. The urn has interior organic residue indicating it has been used to cook or prepare foodstuffs.

Gairnhill 4

This building revealed the remains of three vessels, all from within the surviving portions of the ring ditch [4D-0065], [4D-0074] and [4D-0240. Every vessel, 04-V11 to 04-V13 has a rim sherd present. Vessel 04-11 is represented by the most sherds and took the form of a bucket-shapw with gently curving walls. The rim has a very oblique internal bevel which has folded down on the interior to variable degrees around the vessel. This gives the appearance that someone has quickly gone around the edge in a hurried manner, pushing down and inwards to create the bevel, leaving excess clay patted down on the interior. The walls are thick and finger smoothed unsystematically with patchy areas including vertical and horizontal smoothing, at some points the marks are so evident the clay appears fluted. All these manufacturing marks give the impression of a crude and fast hands-on approach which is not overly concerned with refinement. The vessel has broken along an almost identical S-shaped clay join that appeared on Vessel 04-V08 from Gairnhill 3. Much less remains of the other two vessels, both from feature [4D-0240]. One, 04-V12, is a straight bodied and squared rim sherd of quite a fine, sandy but ungritty fabric. The second is quite a coarse sand with few large inclusions but gritty with fine sub rounded rock particles. This vessel is shouldered and much thinner than most vessels from site (7-8mm). It has an exterior lip and an internal bevel which is concave.

Gairnhill 5

This building contained seven Vessels 04-V14 to 04-V20. Vessels 04-V16, 04-V17 and 04-V19 are body sherds about which not much more can be said. Vessel 04-V19 is unusually thick at 16mm but could be from a base. The other vessels all include rim or base sherds and diameter estimates were achievable in three cases.

Vessel 04-V15 is from a deposit where14 sherds had survived. The rim sherds indicate a base diameter of c 150mm. The base and wall are of uniform thickness, the external basal corner is nicely rounded and the sherd generally gives the impression of a well-made and well-finished vessel. The wall does not kick out but gradually angles outwards. Vessel 04-V14 is similar in thickness and its straighter walls. Five of the nine sherd from 04-V14 s are rim sherds and three of these conjoin to provide a diameter of c275mm, a sizable vessel. The rim is gently squared and the body of the vessel is gently barrelled in shape. The exterior surface has been wiped and the overall appearance is smooth and even. Vessel 04-V18 includes a small rounded rim sherd with thick interior residue which other than being used for cooking doesn’t provide much more information.

The circumstances of vessel from [4D-360] is unusual to the building and accepting 04-V08 to the entire assemblage. A long conjoining section of the rim is present with fresh breaks indicating recent post-depositional loss of further sherds. The vessel is very thin and it is difficult to estimate an accurate diameter but it appears to be between c 280 – 320mm and must have been very large in size. The rim is very irregular and uneven with a slight lip that varies across the sherds. The body is very gently shouldered but as lower body sherds are missing it is impossible to reconstruct fully.

Appendix-2.2.4 NL/001C Chapel of Stoneywood Prehistoric Pottery Analysis - Julie Lochrie

This report covers all prehistoric pottery retrieved from the site during excavation and sample processing. The pottery numbers 43 sherds and 21 fragments from four vessels. There were also four small abraded fragments of fired clay, possibly daub, weighing 3g from (1C-0099).

Measurements are in millimetres (mm) and grams (g) unless otherwise stated. The following abbreviations have been used: thickness (Th), diameter (Dia) and vessel (V). Vessel numbers indicate where multiple sherds belong, or may belong, to the same pot. Terminology is defined as follows: fragment <10mm; small 10-40mm; medium 40-80mm; large >80mm. A complete pottery catalogue can be found in the finds database.

Forty-two of the sherds were recovered from charcoal-rich deposits in curvilinear gully [1C-0007], which are likely to relate to the abandonment of Structure A. These sherds represented up to three vessels, one of which (01-V04) was found spread across two deposits (1C-0095) and (1C-0099), suggesting it may have been dragged or trampled. A single sherd was found within possible post-hole [1C-0065] (part of Ring A, interpreted as an internal partition) and may have slumped in during or after abandonment depending on if the posts were left in situ or removed. The abandonment of Structure A has been dated to the middle Bronze Age (1377-1231 cal BC SUERC-49725 and 1395 – 1291 cal BC SUERC-57933) by radiocarbon dated charcoal.

The pottery is in a highly fragmented and abraded condition, consistent with refuse debris. The fabric of the vessels is generally gritty the fabric is sandy, and the addition of large angular granite and quartz gives a very coarse appearance. The thickness of the walls goes some way to disguise this on the surface of the sherd but some of the inclusions do protrude. Very little can be said about vessels 01-V01 to 01-V03 other than a description of their fabric. Vessel 01-V04 on the other hand has a distinctive shape. The 38 sherds reveal an internally bevelled rim with two exterior finger-smoothed cavettos, creating a ridged upper body. The interior also has a shallower, less pronounced finger-smoothed hollow. There is not much indication of manufacturing techniques other than the ridges being created by horizontal finger smoothing.

This distinctive shape of vessel 01-V04 is also seen at middle Bronze Age sites in Aberdenshire. It is seen at Nether Beanshill and on two vessels from Old Meldrum, Aberdeenshire located around 17km north (P86 and P89 in Johnson 2010, 13). At Old Meldrum both of these pots were found in middle Bronze Age House 2 (White and Richardson 2010, 22). Ridges, cordons and finger grooves seem to have been widespread on middle Bronze Age vessels and could have developed from cordoned urns. There was one present at Echline Fields, South Queensferry, again, associated with a contemporary date of 1379 – 1123 cal BC (SUERC-39754, Robertson et al, 2013, 122). Looking south-west to the Bronze Age unenclosed platform settlements of Lanarkshire there are examples of ridged and cordoned vessels at both Lintshie Gutter (Terry 1995) and Green Knowe (Jobey 1978-80).

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Appendix-2.2.5 NL/006A Goval Prehistoric Pottery Analysis – Julie Lochrie

Introduction

This report covers all prehistoric pottery hand-collected during excavation and retrieved from sample flotation. The assemblage includes 111 sherds and 70 frags, weighing 2.7kg, from nine vessels. Of the nine vessels seven are Neolithic and two are likely to be of Bronze Age or Iron Age date.

Measurements are in millimetres (mm) and grams (g) unless otherwise stated. The following abbreviations have been used: thickness (Th), diameter (Dia) and vessel (V). Vessel numbers indicate where multiple sherds belong, or may belong, to the same pot. Terminology is defined as follows: fragment <10mm; small 10-30mm; medium 30-70mm; large >70mm. A complete pottery catalogue can be found in the database.

Context, Condition and Deposition

The pottery was found in six features spread over a very large area, summarised in Table 1. The pottery from the north is modified Carinated Bowl pottery of the early to middle Neolithic and the pottery in the south-east is middle Neolithic Impressed Ware. The few sherds from the east and south of Goval are undiagnostic but likely to be Bronze Age and Iron Age respectively due to dating for associated features.

Table 1 Goval prehistoric pottery assemblage summary

Area	Vessel	Feature	Context	Sherd	Frags	Weight (g)	Type
North	06-V01	6A-0006	6A-0007	53	23	120	Modified Carinated Bowl
	06-V02	6A-0006	6A-0007	5	-	56	Modified Carinated Bowl
South-east	06-V03	6A-0032	6A-0033	2	2	3	Impressed Ware
	06-V04	6A-0036	6A-0037	7	-	79	Impressed Ware
	06-V05	6A-0036 6A-0041	6A-0037 6A-0042	2	10	165	Impressed Ware
	06-V06	6A-0036 6A-0041	6A-0037 6A-0042	8	2	48	Impressed Ware
	06-V07	6A-0041	6A-0042	30	30	2246	Impressed Ware
East	06-V08	6A-2059	6A-2060	2	1	11	Undiagnostic Coarseware
South	06-V09	6A-0049	6A-0050	2	2	2	Undiagnostic Coarseware

The vessels were generally represented by few, small, lightly abraded sherds, the signs of typical domestic refuse, usually from the mid-section or rims. The one exception to this is vessel 06-V70 from south-east pit [6A-0041] which weighed over 2kg and represents at least 50% of the original pot. It was discovered lying on its side and fresh lateral breaks suggest the missing wall section was ploughed away. The edges of the lowest body sherds are not fresh and are slightly abraded, indicating the base itself was probably lost prior to deposition. A second pit [6A-0036] was found directly next to [6A-0041] and some sherds from the same vessels (06-V05 and 06-V06) were found in both. These are the only two features containing pottery that can be considered contemporary and the date from 06-V07 (3510 – 3348 cal BC, SUERC-68133) is likely to date all pottery from these two features.

Form, fabric, manufacture and function

Modified Carinated Bowl

Vessel 06-V01 and 06V02 are both round-based vessels from the early middle Neolithic and belong to the modified Carinated Bowl (CB) tradition. Vessels 06-V01 is in many small, delaminated sherds and fragments. They belong to a round bellied vessel with a slightly everted rim. The frequent large and granular rock inclusions probably account for the delamination of the sherds. Despite the very coarse temper the sherds look finer and smoother than expected due to thorough wiping of the interior and exterior surface. Vessel 06-V01 has comparatives from Kintore in Aberdeenshire (V403, Macsween 2008, 175) and further afield at Meadowend Farm, Clackmannanshire (P20, Jones et al 2008). Both these examples and the Goval example exist only as rim sherds but the curvature of all sherds point towards a round based vessel with no carination. Vessel 06-V02 is represented by one rim sherd and five body sherds. The body sherds have a slight curvature and the rim is fairly upright with an expanded T-shaped rim. The curvature of the body sherds along with the upright rim may suggest the presence of a carination which does not survive. These sherds are thinner than vessel 06-V01 (5.8-12mm compared to 9-12mm) and they do not have the same coarse and granular temper. They do however have similar wipe marks and surface appearance.

Impressed Ware

The pottery from pits [6A-0036] and [6A-0041] should be considered as a group since sherds from the same vessels were found in both pits. Sherds from 06-V04 were only found in pit [6A-0036], sherds from 06-V07 were only found in [6A-0041] and 06-V05 and 06-V06 were found in both pits. Vessel 06-V04 is comprised of seven conjoining sherds, the breaks are post-depositional, and this would have formed one large sherd. The original dimensions of the vessel would not have been very large, the rim indicates a diameter of around 190mm. There is a concave strip directly below the rim exterior and the walls gently curve inward. The rim itself expands on the exterior and interior and is gently squared down on top (a rough T-shape). The walls undulate slightly in thickness, being thinnest at the points where sections of clay were joined together. Clay folds are visible along the interior lip where the clay was flattened down and while the interior wall has been smoothed no attempt has been made to disguise the clay fold at the rim. The type of smoothing on the interior appears to have been carried out with horizontal finger/hand smoothing. Three shallow stab marks 74mm down appear to have been accidentally caused by the fingernails. On the exterior there are similar folds where the rim has been pushed down and the concave band has been finger smoothed, as once again there are traces of horizontal lines and possible fingernail marks. An entirely different technique has been used to finish the vessel exterior which has resulted in vertical lines created by an unknown implement.

Vessel 06-V05 includes a decorated rim sherd from [6A-0037] and a large body sherd of almost identical fabric and thickness from [6A-0042] although they do not conjoin. The rim sherd indicates a very narrow vessel of 120mm diameter which must have had a saggy or baggy base. The rim has been initially rounded then gently pushed out from the interior to create a slight lip. The base of the lip on the exterior has been smoothed by the fingers to enhance and refine the shape. The rim itself is very thin (7mm) when compared to the thick walls (12mm). Like Vessel 06-V04 there is evidence for the use of tooling during manufacture, in this case possibly a small smoothing spatula which has left three lines on the interior wall. The decoration takes the form of a row of deep finger pinching, 37mm from the rim exterior. The lower finger has pushed as far as the nail while the upper finger has pushed deeper into the clay, pulling out and downwards to create a raised effect.

Vessel 06-V06 is the only vessel from these two contexts with no feature sherds. These eight small body sherds were identified in both pits [6A-0036] and [6A-0041] due to the difference in the appearance of the fabric itself. The sherds are friable and have delaminated. They have a smoothed buff exterior, sandy quartz-rich fabric and grey toned interior with strong mica sheen due to several large mica platelets and frequent small micaceous particles.

Vessel 06-V07, from pit [6A-0041] is missing its base but it would have been very large and baggy shaped in profile. The vessel has a rim diameter of 240mm and the two small handles on either side (c 50 x 15 x 10) would have helped facilitate handling but would probably not have taken the weight of the entire pot let alone any contents. The rim has been flattened and bevels internally although varies around the vessel with one half having a slight exterior lip and the other half showing a slight interior lip. This is not the only time the vessel shows variation; its decoration also takes two different forms. One side, from lug to lug is decorated with fingernail impressions, they are bordered at one end by three diagonal slashes. Much of the other half of the vessel is missing but it shows the diagonal slashes continuing beyond the lugs. It is not possible to say whether this continued across the entirety of the missing section but a small non-conjoining rim sherd from within this area also has the incised lines. The vessel has extremely undulating walls where the clay rings used in its creation have been joined. The thin joins have left the vessel very weak at these points and they correspond to several pre- and post-depositional breaks. The join can be viewed in section and shows the clay was pushed down on the interior and up on the exterior. The horizontal bands where the clay has been joined have been excessively finger smoothed, leaving deep channels on the interior. Like other vessels from these two pits 06-V07 has diagonal lines to its body which are the result of a small spatula like device most likely used to smooth and even out the walls. This large vessel was most likely a cooking pot and the residue adhering to the interior lower two thirds and exterior upper third clearly shows it has been used for this purpose. It is also likely to have been repeatedly used as there are signs of repair. Two post-firing perforations (and a failed third attempt) are positioned either side of a crack which would have allowed binding to hold it together and prevent further damage.

All that remains of Vessel 06-V03 are two small body sherds and two small fragments. They are fairly undiagnostic except from a small circular depression which may be impressed decoration. This may suggest Impressed Ware, the same pottery type as Vessels 06-V04 to 06-V07, also located in the south-east of the site. The presence of Impressed Ware in the south-east of the site only may suggest a similar date for all three features.

Undiagnostic Coarseware

The sherds from Structure A post-hole [6A-2059] and Structure B hearth [6A-0049] are undiagnostic. The former of these comprises two, small, thick, coarsely rock tempered sherds. They give no indication of form but are from the post-hole of a Bronze Age roundhouse and likely to date to this time. The sherds from hearth [6A-0049] comprise two small abraded, sherds and are associated with an Iron Age radiocarbon date (AD 70-126 SUERC-57928).

Discussion

The two vessels from the north of the site are modified Carinated Bowl pottery of the early middle Neolithic (c 3600 – 3300 BC). There is no associated radiocarbon dating from the Goval Carinated Bowl so the date range for the vessel type cannot be refined any further. What is of particular interest is a radiocarbon date of 3510 – 3348 cal BC (SUERC-68133) was retrieved from the residue of Impressed Ware vessel 06-V07. This date sits almost precisely within the date range for the modified Carinated

Bowl pottery. The dating implications for Goval are that the modified Carinated Bowl and the Impressed Ware all belong to the same date bracket of 300 years between 3600 – 3300 BC. They were found some distance apart and it does not necessarily connect the pottery and the features with the same periods of activity, but it equally does not rule them out.

Impressed Ware mostly appears in the archaeological record between 3300 and 2900 BC (Meadowend Farm, 3350 BC - 3000/2900 BC, Jones et al 2018) which places the Goval Impressed Ware at a very early point of its manufacture. Similarly early dates have been discovered in the last 20 years that mean this mid fourth millennium date is now generally accepted as the start of the Impressed Ware tradition (Kinbeachie, 3500 – 2920, MacSween 2001, Table 1, 63; Kintore, 3530 BC – 3340 BC, MacSween 2008, 181).

The Goval lugged vessel has comparatives from the early to later Neolithic. The appearance of lugs on Neolithic Carinated Bowl pottery are one of the earliest variations to Carinated Bowl pottery and are specifically seen as defining a north-eastern style of CB variant (CBNE). Lugged modified CB at Kintore had dates spread through the early middle to middle Neolithic (P50 3810 - 3650 BC, P21 3710 - 3620 BC and ST12 31030 – 2920 BC and 3030 – 2880 BC). In addition to this a lugged and decorated Impressed Ware vessel from Kintore was associated with the date 3530 - 3340 cal BC (SUERC-1322).

The type of deposition taking place at Goval appears to relate to domestic refuse. This includes the large section of vessel 06-V07; given its poor construction joins, weight and large size it is highly likely that the base broke off in its entirety and the remainder was directly discarded into an open pit. It is highly probable there was a domestic structure in the vicinity which has left no trace.

The very low quantity of pottery relating to the Bronze Age and Iron Age occupation at Goval could be explained in two ways: either the site has been cleared prior to abandonment; or containers were primarily organic in composition (ie leather, wood).

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Appendix-2.2.6 SL/012 Blackdog Prehistoric Pottery Analysis – Julie Lochrie

Introduction

This report covers all prehistoric pottery retrieved from the site during excavation and sample flotation. The Blackdog assemblage is small, numbering 50 sherds, 19 frag and weighing 803g. The majority of this belongs to vessel 12-V01, a total of five vessels are estimated to be present, in various states of preservation and fragmentation (12-V01 to 12-V05). All pottery is believed to be early Neolithic in date with provisional radiocarbon dating indicating two phases of activity.

Measurements are in millimetres (mm) and grams (g) unless otherwise stated. The following abbreviations have been used: thickness (Th), diameter (Dia) and vessel (V). Vessel numbers indicate where multiple sherds belong, or may belong, to the same pot. Terminology is defined as follows: fragment <10mm; small 10-40mm; medium 40-80mm; large >80mm. A complete pottery catalogue can be found in the finds database.

Context, Condition and Deposition

The context and condition of the pottery is perhaps the most important thing to acknowledge before attempting to interpret their meaning. There is stark contrast with vessel condition and fragmentation from Pit [12-0001] compared to the rest of the assemblage. This is a large feature with pits recut into its upper contexts within which was deposited 50% of a well-made fluted Carinated Bowl (12-V01) containing a few sherds of a second round based vessel (12-V02). The condition of the two vessels suggests different biographies. The edges of the former include both modern and antiquated breaks indicating that while it was unlikely to have been deposited complete, a portion of the vessel has been lost in recent years to plough or machine truncation. Vessel 12-V02 is mostly composed of poor quality delaminated sherds broken in antiquity. Three other deposits contained pottery but in such negligible quantity that their inclusion cannot be considered deliberate. Spread (12-0022) contained a single small, sherd of pottery and pit [12-0023] contained two fragments (one from each fill). The fabric and surface treatment of these are materially similar to 12-V01 and point towards a Neolithic date. The sherds from pit [12-0030] are more numerous but have de-laminated beyond identification.

The presence of almost an entire pot, when compared with the remains at the rest of the site certainly stands out. The deposition of 12-V01 and 12-V02 within the recut of a larger pit indicates it must have been visible at the time. It is so centrally located as to be highly implausible that it was not consciously located. Smaller Neolithic pits being cut in the tops of larger pits are recognised at other sites (eg Milltimber, Dingwall et all 2019; Warren Fields, Murray, Murray and Fraser 2009, Chapelfield, Squair and Jones 2002; Port Elphinstone, Lochrie 2013). In all these examples the earlier features were Mesolithic in date. There is no evidence for this at Blackdog from either the finds or radiocarbon dating. At Garthdee Road, it is highly plausible that the knowledge of older habitation led to an active change in habits which took into account the memory of others before them.

The deposition of the majority of a single vessel suggests a single act or event. Interestingly the majority of the vessel comes from one side and this is also the case at Milltimber (A2.2.1), Port Elphinstone (Lochrie 2013) and Chapelfield (Squair and Jones 2002). It was theorised at Chapelfield that specific parts of the pot were selected for deposition (Squair and Jones 2002, 162). There certainly appears to be something more complex occurring than simple deposition of rubbish, after for example a feast or ceremony. The occurrence of one large section of the vessel could be explained by deliberate breaking of the pot before placing it in the ground, perhaps the section which was held was retained and deposited while the pieces that broke away were left behind.

Form, fabric, manufacture and function

Vessels 12-V01 and 12-V02 are the only ones with discernible form and belong to the Carinated Bowl tradition's earliest style drift. 12-V01 is a very well made open carinated bowl with an open, flaring neck, gentle carination and shallow belly. The fabric is hard and thin and burnished to a leather-like finish. This is hidden behind a thin layer of organic black residue which is adhering to the exterior of the rim and neck area. The manufacture of the vessel has effectively been hidden by how well it has been made and the surface treatment. A series of breaks occurring shortly below the carination may indicate the point of coil joins. The fluting to the vessel would have been created with the fingers and is placed around the carination and the very top of the rim. The overall effect is a fine, thin elegant bowl. It would have most likely been used for a variety of purposes but the residue shows it was certainly used for cooking. The form of the vessel makes it suitable for a variety of uses, the open neck would have allowed pouring (helped further by the decorative fluting to the rim) and aided with handling. When used for cooking the rounded base would have been nestled into the embers of the fire. The fact the vessel was valued is shown by two repair holes, and a third abandoned attempt, which have allowed binding on either side of a crack. This also suggests the vessel was not newly made and would have had a longer history of use.

Fluted Carinated Bowl pottery have been found in the north east at many sites, including Milltimber (A2.2.1), Garthdee Road (Murray and Murray 2014), Port Elphinstone (Lochrie 2013), Westgate (Lochrie 2010), Warren Field (Sheridan 2009), Deer's Den (Alexander 2000), Boghead (Henshall 1984) and Midtown of Pitglassie (Henshall 1996). What is most striking is the range of sites the pot is found at, which bearing in mind its versatility for storage, cooking, drinking and serving may not be so unusual. The example at Port Elphinstone returned dates of 3707 – 3636 cal BC (SUERC-42979) which is later than some other dates for fluted CBNE, showing it was a long-lived type (Murray and Murray 2013). The Blackdog pot is closest to Vessel 1 from Garthdee Road (2014) and V16 at Warren Field (Sheridan 2009). Both of these pots have quite shallowly hemispherical bellies and long open necks.

Vessels 12-V03 to 12-V05 are represented by rather poor remains. The small quantity, lack of features or even original surfaces precludes any discussion of form. Fabric and surface treatment however may reveal al little about their origin.

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Appendix-2.2.7 AMA22 Wester Hatton Prehistoric Pottery Analysis - Julie Lochrie

Introduction

This report covers all prehistoric pottery retrieved from the site during excavation and sample flotation. The assemblage includes 858 sherds and 790 frags. The sherds belong to an estimated 84 vessels. Out of these 84 vessels 43 have been dated to the Neolithic, the remainder are likely to date from the early to middle Bronze Age. One of vessels, 06-V78, comprising two sherds, is vitrified and may be a crucible fragment.

The high number of fragments almost match the same quantity of sheds. The explanation for this high number of fragments is likely down to several explanations. The first is that the site has been occupied through several periods and phases, this would have disturbed and further fragmented previous remains. The pottery itself, expecting some specific examples of the finer Neolithic fabrics, is coarsely tempered with large rock inclusions which add to the fragmentation and higher number of small body sherds and fragments. Finally, the fact that all the pottery appears to represent domestic debris means it was discarded when no longer needed, or when already broken, without the care you would associate with structured deposition and burial.

In addition to the pottery there is also a small quantity of fired clay, weighing 271g found in small quantities in the following contexts, (AMA22-6025), [AMA22-6188], [AMA22-6223], [AMA22-6266/6273], [AMA22-6278] and [AMA22-6273]. Much of the fired clay has impressions which indicate they were likely part of daub superstructures such as wattle walls.

Measurements are in millimetres (mm) and grams (g) unless otherwise stated. The following abbreviations have been used: thickness (Th), diameter (Dia) and vessel (V). Vessel numbers indicate where multiple sherds belong, or may belong, to the same pot. Terminology is defined as follows: fragment <10mm; small 10-40mm; medium 40-80mm; large >80mm. A complete pottery catalogue can be found in the finds database.

Context, Condition and Deposition

The site has been divided into several areas formed of pit/post-hole clusters and buildings. The dating in table 6.1 is, in the first instance, based on the pottery identification. When the pottery could not be identified the radiocarbon dating programme for the site has been used to find its likeliest date.

Only in one instances was a full profile present, Vessel 06-V12, a bipartite, collared vessel. Most of the pottery was represented by small sherds and lots of fragments. All the pottery was abraded to some degree and it all appears to be from domestic occupation. This is not only surmised by its condition by frequent remains of carbonised organic material on the interior of the vessels, indicating cooking and serving of food.

Table 1 Vessel Summary

Dates	Area	Feature	Context	Vessel #	Vessel Qty	Sherd count
Early to middle Neolithic	Pit Cluster 1	AMA22-6051	AMA22-6052	06-V1 to 06-V4	4	21 + 11 fragments

Early to middle Neolithic	Pit Cluster 1	AMA22-6053	AMA22-6054	06-V6	1	19 + 2 fragments
Middle Neolithic	Pit Cluster 1	AMA22-6055	AMA22-6056	06-V5	1	9 + 2 fragments
Middle Neolithic	Pit Cluster 2	AMA22-6063	AMA22-6064	06-V7	1	3
Middle Neolithic	Pit Cluster 2	AMA22-6061	AMA22-6061, AMA22-6062	06-V8	1	15 + 26 fragments
Middle Neolithic	Pit Cluster 2	AMA22-6073	AMA22-6074	06-V9	1	34 + 35 fragments
Middle Neolithic	Pit Cluster 2	AMA22-6075	AMA22-6076	06-V10	1	3 + 11 fragments
Middle Neolithic	Pit Cluster 2	AMA22-6066	AMA22-6067, AMA22-6068	06-V11	1	11 + 36 fragments
Middle Neolithic	Post-hole Cluster 4	AMA22-6228	AMA22-6227	06-V12	1	65 + 30 fragments
Middle Neolithic	Post-hole Cluster 4	AMA22-6234	AMA22-6235	06-V13	1	29 + 69 fragments
Middle Neolithic	Wester Hatton 2	AMA22-6238	AMA22-6239	06-V14	1	
Middle Neolithic	Wester Hatton 2	AMA22-6243	AMA22-6253	06-V15	1	3
Middle Neolithic	Wester Hatton 2	AMA22-6263	AMA22-6263	06-V16	1	11
Middle Neolithic	Wester Hatton 2	AMA22-6273	AMA22-6268	06-V17 to 06-V18	2	13 + 31 fragments
Middle Neolithic	Wester Hatton 2	AMA22-6278, AMA22-6273	AMA22-6279, AMA22-6281	06-V19 to 06-V20	2	104 + 86 fragments
Middle Neolithic	Wester Hatton 2	AMA22-6273	AMA22-6281	06-V21	1	1
Middle Neolithic	Wester Hatton 2	AMA22-6273	AMA22-6274	06-V22	1	15 + 21 fragments
Middle Neolithic	Wester Hatton 2	AMA22-6269	AMA22-6270	06-V23 to 06-V24	2	5 + 3 fragments
Middle Neolithic	Wester Hatton 2	AMA22-6269	AMA22-6271	06-V25 to 06-V28	4	26 + 16 fragments
Middle Neolithic	Wester Hatton 2	AMA22-6278	AMA22-6279	06-V29	1	8
Middle Neolithic	Wester Hatton 2	AMA22-6266	AMA22-6272, AMA22-6280	06-V30	1	74 + 99 fragments
Middle Neolithic	Wester Hatton 2	AMA22-6266/ AMA22-6273, AMA22-6266	AMA22-6267, AMA22-6280	06-V31	1	3
Middle Neolithic	Wester Hatton 2	AMA22-6266	AMA22-6280	06-V32	1	1
Middle Neolithic	Wester Hatton 2	AMA22-6282	AMA22-6283	06-V33 to 06-V40	8	108 + 176 fragments
Middle Neolithic	Wester Hatton 2	AMA22-6284	AMA22-6285	06-V41	1	10 + 8 fragments

Middle Neolithic	Wester Hatton 2	AMA22-6287	AMA22-6288	06-V42 to 06-V43	2	24 + 21 fragments
Early Bronze Age	Wester Hatton 2	AMA22-6238	AMA22-6239	06-V44 to 06-V46	3	
Early Bronze Age/undated	Wester Hatton 2	AMA22-6243	AMA22-6244	06-V47	1	2 + 4 fragments
Early Bronze Age/undated	Wester Hatton 2	AMA22-6240	AMA22-6241	06-V48	1	1
Early Bronze Age/undated	Wester Hatton 2	AMA22-6258	AMA22-6259	06-V49	1	1
Early Bronze Age	Wester Hatton 2	AMA22-6261	AMA22-6260	06-V50	1	1 + 1 fragment
Early Bronze Age/undated	Wester Hatton 2	-	Surface	06-V51		1
Early Bronze Age/undated	Wester Hatton 2	AMA22-6264	AMA22-6265	06-V52	1	3 + 2 fragments
Middle Bronze Age/undated	Pit AMA6188	AMA22-6188	AMA22-6187	06-V80	1	1 + 1 fragment
Middle Bronze Age/undated	Pit 6188	AMA22-6188	AMA22-6190	06-V81	1	3
Middle Bronze Age/undated	Pit 6163	AMA22-6163	AMA22-6165	06-V82	1	1
Middle Bronze Age/undated	Pit 6163	AMA22-6163	AMA22-6164	06-V83	1	7
Middle to Late Bronze Age/undated	Wester Hatton 3	AMA22-6179	AMA22-6179	06-V53 to 06-V54	2	3
Middle to Late Bronze Age/undated	Wester Hatton 3	AMA22-6193	AMA22-6180	06-V55	1	1
Middle to Late Bronze Age/undated	Wester Hatton 3	AMA22-6200	AMA22-6201	06-V56	1	1
Middle to Late Bronze Age	Wester Hatton 4	AMA22-6144	AMA22-6149	06-V57	1	2 + 2 fragments
Middle to Late Bronze Age/undated	Wester Hatton 4	AMA22-6141	AMA22-6140	06-V58	1	5 + 5 fragments
Middle to Late Bronze Age /undated	Wester Hatton 4	AMA22-6128	AMA22-6129	06-V59	1	2
Middle to Late Bronze Age /undated	Wester Hatton 4	AMA22-6130	AMA22-6131	06-V60	1	1 + 2 fragments

Middle to Late Bronze Age	Wester Hatton 4	AMA22-6025, AMA22-6030	AMA22-6025, AMA22-6028	06-V61	1	10
Middle to Late Bronze Age	Wester Hatton 4	AMA22-6030	AMA22-6028	06-V62, 06-V64, 06-V66 to 06-V67, 06-V69	5	9 + 3 fragments
Middle to Late Bronze Age	Wester Hatton 4	AMA22-6025	AMA22-6025	06-V63, 06- V65, 06-V68, 06-V70 to 06-V72	6	55 + 28 fragments
Middle to Late Bronze Age /undated	Wester Hatton 5	AMA22-6122	AMA22-6127	06-V73	1	1
Middle to Late Bronze Age /undated	Wester Hatton 1	AMA22-6102	AMA22-6101	06-V74	1	2 + 1 fragment
Middle to Late Bronze Age /undated	Wester Hatton 1	AMA22-6105	AMA22-6106	06-V75	1	4 fragments
Middle to Late Bronze Age /undated	Wester Hatton 1	AMA22-6298	AMA22-6299	06-V76	1	1
Middle to Late Bronze Age /undated	Wester Hatton 1	AMA22-6079	AMA22-6080	06-V77	1	1 fragment
Middle to Late Bronze Age	Wester Hatton 1	AMA22-6096	AMA22-6097	06-V78 to 06-V79	2	81 + 46 fragments
Middle to Late Bronze Age /undated	-	AMA22-6172	AMA22-6174	06-V84	1	2 + 3 fragments
Middle to Late Bronze Age /undated	Wester Hatton 4	AMA22-6025, AMA22-6030/ AMA22-6155	AMA22-6025, AMA22-6151	n/a		6

The pottery from Pit Cluster 1 includes early to middle Neolithic pottery types while Pit Cluster 2 and Post-hole Cluster 4 includes middle Neolithic pottery types. There dating of individual pottery types will be discussed further below but their broad dating is in line with a radiocarbon date retrieved from Pit Cluster 1, Pit [AMA2-6052] 3341 – 3095 cal BC (SUERC-7440).

The pottery from Wester Hatton 2 represents two different date ranges, the earliest is middle Neolithic and the later date is early Bonze Age. These are reflected by two radiocarbon dates, one from pit [AMA22-6269], 3312 – 2920 cal BC (SUERC-74399) and one from [AMA22-6238], 1747-1566 cal BC (SUERC-73583). In only one of these features, ditch [AMA22-6238], was middle Neolithic pottery found alongside early Bronze Age pottery. This suggests that the ditch is a later feature and the middle Neolithic pottery has become residually mixed into its deposits. This also means that some of the other contexts could also contain residual Neolithic pottery, however most of it is concentrated on the pits to the east of the ditches. These pits are grouped together as Pit Cluster 5.

Much of the remaining pottery could not be easily dated. This was not the case for, 06-V44, 06-V50, 06-V57, 06-V61, 06-V63, 06-V64, 06-V69, 06-V70, 06-V87 and 06-V79, which are recognisable flat-rimmed ware forms, dating to the Bronze Age. However, it is acceptable to assume that the pottery found in each of the various structures and areas has a similar date to that indicated by the radiocarbon dating programme. Pit AMA22-6188 and Pit AMA22-6163 are Middle Bronze Age (1526 – 1421 cal BC, SUERC-74401 and 1401 – 1211 cal BC, SUERC-73591) and Wester Hatton 3, 4, *5,* Middle to Late Bronze Age (1376 – 1121 cal BC, SUERC-73584; 1260 – 1047 cal BC, SUERC-73586; 1210 – 1015 cal BC, SUERC-73585; and 1112-927 cal BC, SUERC-73587).

Form, fabric, manufacture and function

Vessels 06-V1 to 6-V43 are all Neolithic in date. They mostly include Impressed Ware with a few modified carinated bowls. The dating of Impressed Ware, previously termed 'Later Neolithic Impressed Wares' has changed dramatically over the last couple of decades. More and more radiocarbon dates have made it clear that it first appears in the mid-4th millennium and this is now accepted as a type of middle to later Neolithic ware (Kinbeachie, 3500 – 2920 (MacSween 2001, Table 1, 63; Kintore, 3530 BC – 3340 BC, MacSween 2008, 181; Meadowend Farm, 3350 - 3000/2900 BC, Jones et al 2018). These earlier dates have also led to a consideration of the links between Impressed Wares and carinated bowl pottery. There are common features between the two: lugs; baggy shapes; bipartite forms; and decoration confined to the upper zone. It may be that a continuity of regionalisation can be seen between Henshall's 'north-eastern' style of the Carinated Bowl tradition (Henshall 1984; Henshall 1996) and the Impressed Wares of eastern Scotland (MacSween 2007, 369; MacSween 2008, 181).

Neolithic Pottery

The remains of up to three vessels could all be termed modified Carinated Bowl of Henshall's 'north-east' style. The first and only of its kind are three sherds comprising Vessel 06-V1, from Pit [AMA22-6051], which is a fluted Carinated Bowl. Very little remains but one sherd is a fluted, everted rim sherd. It is thick at 11mm and is unfortunately too small to give a reliable indication of vessel diameter. Fluted Carinated Bowl pottery have been found in the north east at many sites, including Blackdog (A2.2.6), Milltimber (A2.2.1), Garthdee Road (Murray and Murray 2014), Port Elphinstone (Lochrie 2013), Westgate (Lochrie 2010), Mosstodloch (Johnson 2012), Warren Field (Sheridan 2009), Deer's Den (Alexander 2000), Boghead (Henshall 1984) and Midtown of Pitglassie (Henshall 1996). Dates for CBNE suggest its appearance at c 3800 BC at the earliest (e.g. OxA-8132, OxA-8131, Oxa-8133, Deers Den, Alexander 2000, 17; GU-9155, Dubton Farm, MacSween 2002, 41; Warren Field, Sheridan 2009, 92). At Port Elphinstone and Kintore date range from 3707 – 3636 cal BC, (SUERC-42979) (Murray and Murray 2013) and 3810-3650 cal BC to 3710-3620 cal BC (MacSween 2008, 179) which suggest a long period of use. Interestingly an outlying date of 3030-2880 cal BC was associated with one at Kintore (MacSween 2008, 179) and the nearest associated radiocarbon date from Wester Hatton is 3312 – 2920 cal BC. That aside, the lithics report suggests evidence for earlier Neolithic activity and this vessel is still likeliest to date between c 3800 – 3600 BC.

The other two vessels which fit within this group are two lugged vessels, 06-V05 and 06-V06, from pit [AMA22-6055] and [AMA22-6053] respectively. Vessel 06-V05 was very partial and the lug from this was a completely detached applied lug measuring 8mm x 8mm x 10mm. This lug was different in shape from that on 06-V6 which was longer and flatter, measuring 36mm x 19mm x 17mm. Both these lugs would have helped aid the grip of the vessels, but in the case of the small vessel on 06-V05 it is unlikely they could have been held by these alone. More remains of Vessel 06-V06 providing a rim diameter of c180 – 190mm and a vessel form with gently curving sides and an upright, rounded rim. There were no basal sheds for either, but they are likely to have been baggy-based. Lugs added to vessel is another early modification to Carinated Bowl pottery which continues into the Impressed Ware tradition. A lugged, decorated example was found at Goval (A2.2.5) which was associated with a radiocarbon date of 3510 – 3348 cal BC (SUERC-68133). At Kintore lugged vessels classified as modified Carinated Bowl were associated with a spread of dates between 3810 and 2880 cl BC (P50 3810 - 3650 cal BC, P21 3710 – 3620 cal BC and ST12 3130 – 2920 cal BC and 3030 – 2880 cal BC) and luged impressed Ware associated with the date 3530 - 3340 cal BC (SUERC-1322).

Sherds from two very similar profiles from Wester Hatton 2, Post-hole [AMA2-6271] and Pit [AMA2-6282] may be small uncarinated cups. Both, Vessels 06-V26 and 06-V38 have small gently squared rim sherds with curvature that suggests they are round-based. Another uncarinated cup, 06-V3, may come from Pit Cluster 1, this one is a little different as it may have decoration. It comprises a medium rim and body sherd, the rim is gently curving and quite thin with rows of fingernail marks which may be decorative or accidental, they appear on the interior and exterior. It could be round, saggy or baggy based.

The remainder of the Neolithic Vessels are likely to be Impressed Ware, numbering a total of 37 vessels, 06-V2, 06-V7 to 06-V25, 06-V27 to 06-V37 and 06-V37 to 06-V43. In very few instances do large portions of the vessels survive but when they do, they show mostly bipartite forms.

The only vessel in the whole assemblage which provides a full profile is vessel 06-V12 from Pit [AMA22-6228]. This vessel is bipartite, standing 115mm tall, but with a very trunconic shape. It has a short collar around 28mm in length, inturned neck and leads down to a small flat base of c 70-80mm. The vessels rim diameter could not be estimated as very little of the rim remains, but the carination is 240mm in diameter. This vessel is decorated with comb-impressed lines in panels around the collar. They alternate between horizontal and vertical lines. The very edge of the rim has short vertical lines.

The shape of the vessel is similar to vessel 02-V45 found at Milltimber. Parallels were drawn between this vessel and the Proto-Unstan vessels from Peterhead, which are dated to 3370-3090 cal BC but these vessels have round-bases. A closer comparison are pots with decorated collars and trunconic forms and flat bases found elsewhere within the Impressed Ware repertoire (eg Meadowend Farm, Clackmannanshire, c 3350–3000/2900 cal BC, Jones et al; and Deer's Den, 3130-2910 cal BC, OxA-8177 and 3360-3030 cal BC, OxA-8176, Alexander 2000, 64).

The rims themselves are either rounded or with internal bevels, often expanded out to a T-shaped section. The vessel forms, rim types and decoration appear in different combinations throughout the assemblage and don't seem to show any correlation to where or how the decoration is applied and vessel form. Table 6.2 summarises the rim forms, overall forms and decoration. Since decoration was typically on the rim or upper half of the vessels there are not many other decorated examples that don't appear in table 6.2.

Decorated sherds from vessels with no rim sheds surviving, include stab marks on 06-V15, small sub-circular impressions on 06-V17 and probable comb-impressions on 06-V36. One interest impression appears on sherd 06-V24, it may be decorative or could be from a tool marks. The impression is in the shape of a small, shallow square which has been driven in from one side, with two appearing on the shed. This could be decorative of from a small spatula used to help form the vessel, such as the marks seen on the vessel from Goval.

Table 6.2 Impressed Ware rim forms and decoration summary

Vessel	Overall form	Rim form	Rim diameter	Decoration	Decoration location
2	-	Rolled, T-shaped		n/a	
7	-	Upright, flattened	c230-240	fingernail and sub-circular impression	Top of rim
9	-	Rounded		n/a	
12	Bipartite, collared	Rounded		comb-impressed	Collar and edge of rim
13	-	T-shaped, internally bevelled		stab and drag, sub-circular impressions	Bevel and body
16	-	Internal bevel		Fingernail	
18	-	Internal bevel		Stab	bevel
19	-	Internal bevel	c210	Bid-bone	Bevel and body
20	-	Internal bevel		Fingernail	Bevel
21	-	Internal bevel		Stab	Bevel
23	Bipartite, sharp carination	T-shaped, internal bevel	215-220	Stab and drag (panelled)	Bevel
25	Bipartite, rounded carination	Oblique internal bevel	c210	Fingernail	Bevel
30	-	Internal bevel		Stab	bevel
31	-	Internal bevel		Fingernail	bevel
33	Bipartite, collared	Internal bevel	290	Herringbone, incised (panelled)	Collar and bevel
34	-	Internal bevel		Fingernail	Bevel
35	-	Rounded		-	-
37	-	Rounded		-	-
42	-	T-shaped internal bevel	190	Stab	Bevel
43	-	rounded		Stab, fingernail, incised	Exterior and top of rim

The most common form of decoration is fingernail impression and the second is stab or stab and drag. The most common location of this is on the rim, either on a bevel or along the very top. Table 6.2 summarises the rim decoration. This was the location for decoration on all the vessels.

Rim diameters could be estimated on seven of the Neolithic vessels and show sizes ranging from c180 to c290 mm, which is a good repertoire of sizes. The overall capacity of the vessels would have been dependant on the overall vessel form, but a range of sizes tends to suggest a mixed range of uses within cook and service ware.

Bronze Age Pottery

The Bronze Age pottery is in a much poorer state of preservation and for the bulk of the assemblage, 31 vessels, only small to medium, abraded body sherds remain.

From Wester Hatton 2 there are two vessels with identifiable forms. Most remains of Vessel 06-V44 which is bucket-shaped with an internal bevel which has been folded on the interior. It is quiet small at only 170mm for its rim diameter. The second vessel is a small slightly inturned rim sherd which is flattened on top and creates a very subtle P-shape. This rim is too small to indicate the vessel size. It is very similar to the rim sherds from Vessel 06-V61 from Wester Hatton 4.

Wester Hatton 4 contained the most vessels with recognisable forms but despite the survival of six rim types (06-V57, 06-V61, 06-V63, 06-V64, 06-V69 and 06-V70), only one possible basal sherds was identified (06-V63). Vessels 06-V57 and 06-V70 are both primarily comprised of internally bevelled rim and a few small body sherds. All that survives of 06-V69 is a corner shed from a rim of uncertain form. The two vessels for which more remains are Vessel 06-V61 and Vessel 06-V63. The former is comprised of two conjoining rim sections which indicate a vessel of around 220mm rim diameter. The rims are slightly inturned and flattened on top but with a rounded exterior edge and sharper interior edge, like the rim sherd from Wester Hatton 2 (06-V50). Vessel 06-V63 is bucket-shaped with an upright rounded rim of 125 – 145mm diameter and a possible flat base sherd. This vessel is very irregular and has lots of organic surface impressions.

Vessel 06-V64 is a single rim shed but shows a recognisable middle Bronze Age form found at other Aberdeenshire sites in this volume. The rim is upright and very gently squared, like many of the other Bronze Age pots, but this one has the addition of two finger grooves to the exterior, located 17mm apart and beginning 12mm from the rim. This shape was present at both from Nether Beanshill 01-V04 from Chapel of Stoneywood (A2.2.2 and A2.2.3) both are dated to a broadly comparable period during the middle Bronze Age. At the site of Old Meldrum, Aberdeenshire located around 17km north two pots from a middle Bronze Age building also had similar ridges (P86 and P89, Johnson 2010, 13). Ridges, cordons and finger grooves to middle Bronze Age vessels seems to be an even further widespread trend and could potentially have developed from cordoned urns (Echline Fields, South Queensferry,1379 – 1123 cal bc SUERC-39754; Lintshie Gutter, Lanarkshire, Terry 1995; and Green Knowe, Jobey 1978-80).

Wester Hatton 1 has no radiocarbon dating to refine where it fits into the phasing for the rest of the Bronze Age assemblage. Two vessels were found here, one of which is so vitrified with such a small rim it may be a crucible rather than pottery. The other vessel is a large bucket-shaped pot with a rim diameter of 210mm. It has a rounded very irregular rim and straight walls which kick out from a flat base. This vessel is a very typical form of ‘flat-rimmed ware’ dating to this period. Its feature-less shape makes any chronological refinement problematic.

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Appendix-2.2.8 ABSL13-2D and AMA09, the Aberdeen Ring Road Project

The lithic assemblage

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INTRODUCTION

In connection with the construction of a ring road around the western periphery of Aberdeen, Headland Archaeology Ltd. carried out investigation of selected locations along the planned route (Spanou 2015). During this work, a number of prehistoric and later sites were examined by trial trenching and excavation, dating to various parts of the prehistoric period.

Along the Aberdeen Western Peripheral Route/Balmedie-Tipperty (Southern Leg), a number of sites were discovered near a location called Milltimber. One of those (Site 2D; NGR NJ 385645, 801096) included an extensive lithic scatter and a number of 'satellite scatters'(11, 784 pieces), most of which was flint. Features have been radiocarbon-dated to a number of different prehistoric and later periods, but the vast majority of the lithic finds are thought to date to the Mesolithic, supplemented by a small probably Late Upper Palaeolithic sub-assemblage, and handfuls of Early and Middle Neolithic objects.

No radiocarbon-dates relate to the Palaeolithic visit to Site 2D. The site's Mesolithic radiocarbon-dates cover most of the Late Mesolithic period, with the earliest indicating a visit to the site around 8222-7965 cal BC (SUERC-68101) and the latest at 4685-4501 cal BC (SUERC-68110). Early Neolithic dates are generally confined to the period's first half, between 3966-3707 cal BC, and dates from three Middle Neolithic hearths indicate a visit to the site between 3514-3094 cal BC. Towards the end of the fieldwork, three areas were excavated on the western, southern, and eastern periphery of Site 2D, but where the central parts of the site had their surfaces excavated, as well as all relevant features, in these parts of the site only the cut features were excavated. A small number of radiocarbon-dates, as well as some pottery sherds, suggest activity in these areas in the middle and later mesolithic, the Neolithic, and Early Bronze Age periods, but it is generally thought that the flints in these features are residual.

Features were discovered throughout the site, but most are solitary or small groups of postholes, pits, hearths and tree-throw holes. Only features and contexts towards the eastern periphery of the site form the remains of a structure. Dating evidence, such as a leaf-shaped point from a pit and two radiocarbon-dates (SUERC-58194, SUERC-68114), indicates that this structure may be an Early Neolithic house, but the associated lithic material is (apart from the leaf-shaped point) small-sized knapping debris. Most of the location's postholes, pits and hearths were found in the site's northern part, at the base of the slope. Some of these features appear to be pits initially constructed during the Mesolithic, and redug in the Early Neolithic. They generally contain few lithic finds, most of which are residual pieces, but some of the pits redug during the Early Neolithic also had pottery of the Carinated Bowl Tradition inserted in their upper parts.

Site 2D is generally defined by its lithic finds, with microblades, conical cores, microliths, and microburins characterizing the site's dominating Late Mesolithic component, and with impressively large blades, numerous preparation flakes (crests and core tablets), a relatively large opposed-platform core, and a small number of points and point fragments defining the small Late Upper Palaeolithic sub-assemblage. Most likely, the lithic concentrations identified across the site are the remains of a number of short-term hunting camps, situated along a palaeo-channel of the River Dee (Spanou 2015, 21).

The purpose of this report is to characterize the lithic assemblage in detail and discuss general research questions, such as: the nature and date of the assemblage, lithic procurement and technology, as well as intra-site spatial patterns and site behaviour, and the site and its lithic material are compared with relevant contemporary sites and assemblages.

The site as a whole is perceived as having significant research potential, and on the basis of the composition of the lithic assemblage, its distribution and associated features, as well as the available radiocarbon-dates, a number of specific topics were selected for special attention:

1) The site's main Late Mesolithic settlement
2) The site's Late Upper Palaeolithic component
3) Neolithic activity across the site
4) The pit cluster at the base of the slope, the lithics in this area, and the relationship between Late Mesolithic and Early Neolithic activity in this part of the site
5) The Early Neolithic building towards the east (Zone 6) and its lithic assemblage
6) Microlith production and microlith forms
7) The unusual, not to say unique, assemblage of polished-edge implements from the easternmost of the site's two main scatters (Zone 5)
8) General activity patterns at Site 2D

METHODOLOGY

This section explains some of the key definitions applied in connection with the characterization and analysis of the lithic assemblage from Site 2D, as well as methodological choices made.

Chronology

The basic chronological framework applied in connection with this analysis corresponds to that defined in Spanou (2015, 141), and it is presented in Table Intro.1.

Table Intro.1. Basic chronological framework.

Period	*Date Range*
Mesolithic	10,000 – 4000 BC
Early Neolithic	4,000 – 3,500 BC
Middle Neolithic	3,500 – 3,000 BC
Late Neolithic	3,000 – 2,500 BC
Chalcolithic	2,450 – 2,150 BC
Middle Bronze Age	1,550 – 1,150 BC
Roman	AD 43 – 410

Early Historic	AD 410 – 1200
Medieval and Post-Medieval	AD 1200 – 1750
Modern	AD 1750 +

Spanou (ibid) does not define any periods dating to the time before the Mesolithic, as at the time the assemblage was not expected to include finds of this age. However, as explained below, a small, but notable, proportion of the finds from Zone 4 are likely to be of a Late Upper Palaeolithic date, with some Palaeolithic artefacts having been found outside this area, mainly in the adjacent Zones 3 and 5.

Apparently, the Scottish Late Upper Palaeolithic period is aligned with contemporary industries on the north-west European mainland (listed earliest to latest: the Hamburgian, *Federmesser-Gruppen*, and the Ahrensburgian techno-complexes), rather than with industries towards the south (eg, the Creswellian), and it is suggested to use these material cultural terms (rather than for example those suggested in Barton & Roberts 1996) to allow comparison with these complexes, with which people in Late Upper Palaeolithic Scotland would have been in touch, across the then dry Doggerland (Ballin 2016d; Ballin & Bjerck; Brooks *et al.* 2011; Sturt *et al.* 2013). It is suggested to define the Late Upper Palaeolithic as covering the time-span 13,000-10,000 cal BC, and with the above complexes roughly fitting into each their millennium during this period.

Traditionally, the Scottish Mesolithic is subdivided into an early and a late part (the Early and Late Mesolithic periods), defined by the dominance of either broad or narrow blades/microliths. It is recommended not to use the terms 'broadblade' and 'narrowblade' as period-defing terms, as blades on the Scottish west-coast and on the east-coast differ in terms of width, with blades from the former region being narrower than those from the latter region due to the availability of differently sized flint pebbles in those areas. Using the terms 'broadblade industries' and 'narrowblade industries' as periods would mean that the transition between these two periods (if broad and narrow blades are defined by blades broader and narrower than 8mm; below) would differ, with the transition being earliest in the west.

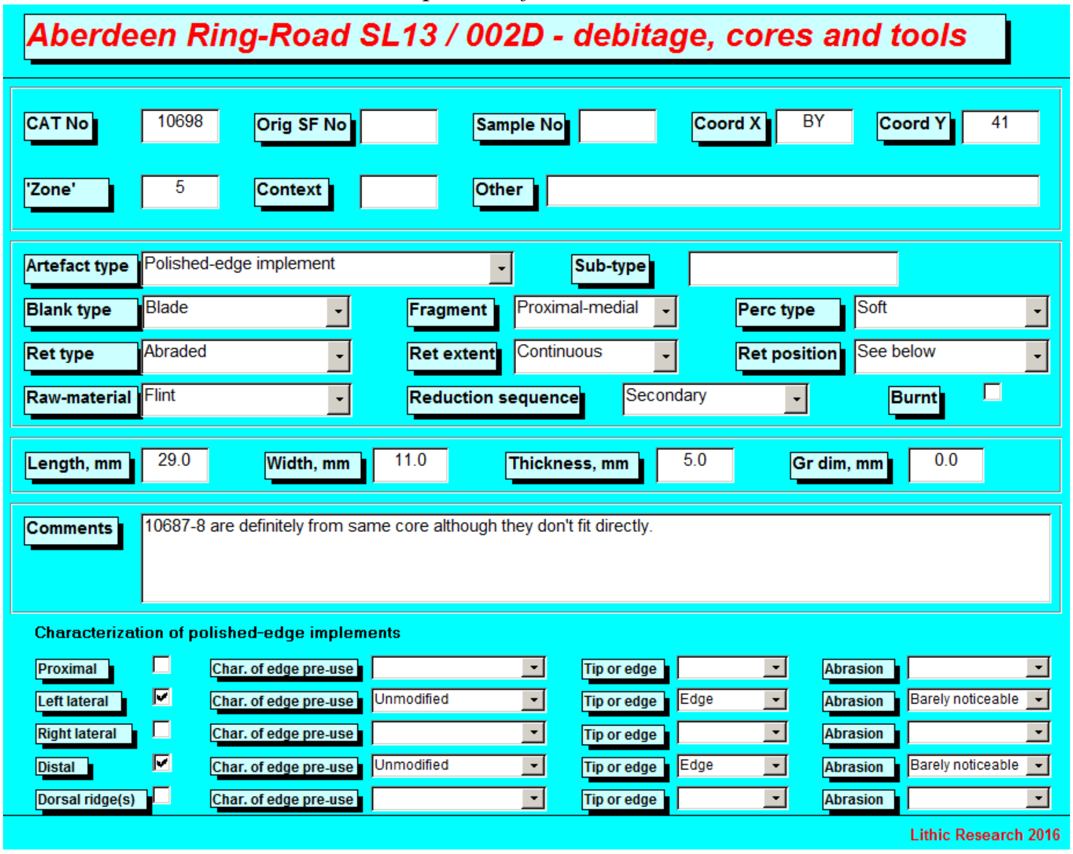
Instead, it is suggested to defined the early and late parts of the Mesolithic (the 'Early Mesolithic' and the 'Late Mesolithic') as periods defined primarily by broad and narrow microliths (based on broad and narrow blades), but with the two groups of microliths being characterized not only by different *sizes*, but first and foremost by different sets of microlith *forms*. Although idiosyncratic microlith forms occur at all times through the Mesolithic (cf. Butler 2005), the Early Mesolithic period is associated *mainly* with obliquely blunted points and isosceles triangles, and the Late Mesolithic period *mainly* with scalene triangles, crescents and edge-blunted pieces. As a rule of thumb, the transition between the two Mesolithic periods could be defined as the time when isosceles triangles were replaced by scalene triangles. For a discussion of microlith terminology in general, please see the presentation of the lithic finds from Site 3B.

The transition between the Scottish Early and Late Mesolithic periods is defined as in Saville (2008). On the basis of an analysis of the microliths from Cramond, Edinburgh, and the radiocarbon-dates relating to these finds, he suggested that the switch from broad to narrow microliths took place at approximately 8500 cal BC.

Cataloguing principles

As part of the processing of the lithic finds from Site 2D (as well as Site 3B), a database format (Microsoft Access) was defined for the characterization and cataloguing of the lithics. This format was then adapted to fit the individual sites and assemblages. Fig. Intro.1 shows the database form applied in connection with the processing of the lithic finds from Site 2D, and it includes a section for the characterization of the unusual polished-edge implements from Zone 5. The form applied in connection with the processing of the finds from Site 3B does not (for the sake of simplicity) include this section.

Fig. Intro.1. The applied database format showing the data relating to CAT 10698, a polished-edge implement from Zone 5.



Due to the involved artefact numbers, the complexities of the sites, and the limited amount of time available for the analysis, it was decided to be strict in terms of which attributes were recorded, and how they were recorded. It was therefore agreed within the project to focus only on attributes which were certain to be of relevance to the discussion of the present project's sites, including Sites 2D and 3B, drawing on the analyst's recent experience with the cataloguing and discussion of other large assemblages, such as 1,670 flint cores and tools from the *c.* 30,000-piece mainly Mesolithic assemblage from Nethermills Farm in Aberdeenshire (Ballin 2013a), *c.* 10,000 mainly Neolithic quartz artefacts from RUX6 (the Udal Project) on North Uist (Ballin 2015b), and *c.* 10,000 mainly Early Bronze Age flint and quartz artefacts from the Barabhas dunes on Lewis (eg, Ballin forthcoming b). The following principles were followed:

Chips: These pieces of debitage are defined by being equal to or smaller than 10mm and it is not necessary to know whether they measure 8mm or 3mm across – not to be measured.
Flakes: The measurements of these pieces are only rarely used in connection with the analysis of prehistoric lithic assemblages, and although in some cases it would be interesting (technologically speaking) to know whether the blades and the flakes form one continuum or two separate clusters (cf. Figs 4.1-2), These measurements are not strictly necessary – not to be measured.
Blades/microblades: These pieces (and not least their sizes and technological attributes) are of some diagnostic value, and they are also important as blanks of microliths. It is suggested to measure intact pieces in three dimensions, and in the case of fragments, only the width (which is the key diagnostic dimension).
Indeterminate pieces: Like the flakes, these pieces are not measured.
Cores (incl. frags of cores which can be identified to type): To be measured in three dimensions.
Core frags (which can't be referred to any formal type): GD only.
Tools and core preparation flakes (crested pieces and platform rejuvenation flakes) and their frags: Three dimensions.
Microliths: It is suggested to measure intact pieces in three dimensions, and in the case of fragments, only the width (which is the key diagnostic dimension). As the only group of artefacts, the microliths and their fragments are measured with one decimal. This is the generally accepted standard, as the absence of this decimal would result in many microliths 'landing' on top of each other in a diagram showing their sizes, distorting the visual impression of these pieces.

General lithic definitions

The definitions of the main lithic categories are as follows:

Chips: All flakes and indeterminate pieces the greatest dimension (GD) of which is ≤ 10mm.
Flakes: All lithic artefacts with one identifiable ventral (positive or convex) surface, GD > 10mm and L < 2W (L = length; W = width).
Indeterminate pieces: Lithic artefacts which cannot be unequivocally identified as either flakes or cores. Generally the problem of identification is due to irregular breaks, frost-shattering or fire-crazing. *Chunks* are larger indeterminate pieces, and in, for example, the case of quartz, the problem of identification usually originates from a piece flaking along natural planes of weakness rather than flaking in the usual conchoidal way.
Blades and microblades: Flakes where L ≥ 2W. In the case of blades W > 8mm, in the case of microblades W ≤ 8 mm. In this report, the term narrow-blades is used to describe blades only slightly larger than microblades.
Cores: Artefacts with only dorsal (negative or concave) surfaces – if three or more flakes have been detached, the piece is a core, if fewer than three flakes have been detached, the piece is a split or flaked pebble.
Tools: Artefacts with secondary retouch (modification).

Av. dim.: Average dimensions
GD: Greatest dimension.
LHS/RHS: Left-hand side and right-hand side.

Typo-technological details

In connection with the characterization of the assemblage from Site 2D, a number of typo-technological terms used in the report were thought to need clarification to avoid confusion or misunderstandings.

Definition of percussion techniques: In Scottish prehistory, flakes would usually have been detached by either hard percussion or bipolar technique, whereas the blades and microblades would have been manufactured in a variety of usually more delicate ways. The choice of percussion technique (or selection of percussion techniques) would then form one of the elements defining an industry's operational schema. As shown in connection with the presentation and discussion of the finds from Zone 4, and particularly the definition of the Late Upper Palaeolithic operational schema responsible for the production of that area's large blades, operational schemas are frequently highly diagnostic.

Usually, lithics specialists operating in Scotland refer to a limited number of general percussion techniques (hard, soft and bipolar), despite the fact that many more exist. As shown by for example Sørensen (2006), it is possible to distinguish between direct and indirect techniques, as well as techniques involving a large variety of hard, medium and soft percussors in stone, wood and antler. However, only the most skilled lithics specialists and experimental knappers are able to distinguish between these numerous technological approaches, and although these highly detailed studies are of great value in terms of defining industries, periods and phases, such detailed studies would usually also have as a consequence that the number of potential readers of a paper would fall drastically. This analyst has therefore chosen to follow the more general, commonly used approach and terminology.

Broadly speaking, hard and soft percussion form one group of approaches (based on the reduction of platform cores) and bipolar technique another (based on the reduction of pebbles and exhausted platform-cores on anvils). In general terms, soft percussion blanks are defined by having a discrete bulb-of-percussion, whereas hard-hammer blanks tend to have a pronounced bulb. However, bulbs are not always well-defined, probably partly as a result of the choice in prehistory of more or less hard percussors, and when this analyst defines a blank as one thing or the other he also takes other attributes into account (cf. Inizan *et al.* 1992; Madsen 1992; Sørensen 2006), such as 1) the presence or absence of bulbar/*erraillure* scars and the size of these scars; 2) the presence or absence of circular/semi-circular points of impact on the platform remnant (occasionally associated with the detachment of the full percussion cone); 3) the size and shape of the platform remnant; and 4) fracture patterns (eg, split-bulb fractures or *Accident Siret*).

Hard-hammer blanks tend to have larger bulbar scars than soft-hammer blanks (when present); occasionally they would have circular ring cracks on the platform remnant (where soft-hammer blanks tend to have none); they would usually have broader and deeper platform remnants; and on occasion, blanks detached by robust approaches (hard percussion/bipolar technique) suffer *Accident Siret*, that is, they split throught the bulb-of-percussion (rarely seen in connection with the application of softer approaches).

Definition of preparation flakes and associated problems: Usually, preparation flakes are subdivided into two categories, namely crested pieces (in most cases blades) and core rejuvenation flakes (also referred to as core tablets). Crested pieces were formed when so-called guide ridges were struck off. Guide ridges were created either as part of the initial preparation of core rough-outs, usually in connection with the decortication process ('first generation crests', where small flakes were detached to either side of the dorsal ridge), or between blade series to adjust the shape of the core ('second generation crests', where small flakes were detached to one side of the dorsal ridge).

Core rejuvenation flakes were struck off between blade series, in most cases to adjust the angle of the platform-edge, or to adjust the shape of the platform itself, and they may be either complete (ie, they removed the entire platform), or they may be partial. In addition, the platform-edges may have been prepared by trimming (the removal of series of minuscule chips) or abrasion before the detachment of blades. Occasionally, platforms were finely faceted, and a small spur may have been formed in connection with the definition of the individual impact points (*en eperon* technique). The latter approach was only used systematically in connection with the production of blades during the Hamburgian, Creswellian and late Magdalenian periods (cf. Inizan *et al.* 1992, Fig. 32).

In connection with the characterization of the finds from Sites 2D and 3B, the definition of crested pieces, platform rejuvenation flakes and pieces with finely faceted platform remnants proved difficult, and during this process many pieces were redefined:

- Some elongated pieces which were originally defined as crested blades had to be redfined as platform rejuvenation flakes, with the defining element being the curved nature of the crest at the platform-edge. The difficulty of identifying these pieces correctly was mainly an effect of the elongated nature of the platforms of the Late Upper Palaeolithic opposed-platform cores (cf. Madsen 1992, Fig. 81.B; Weber 2012, Fig. 32).
- During the formal classification of the assemblage, a group of mainly flakes were defined as having finely faceted platforms (an approach also seen during the Scottish later Neolithic; Ballin 2011a), but closer scrutiny of these pieces resulted in some of these pieces being redefined as core rejuvenation flakes. The true identity of some of those objects became obvious when it was possible to conjoin up to three 'finely faceted pieces' dorsal-ventrally (cf. Cziesla *et al.* 1990; Ballin 2000), demonstrating that the 'fine faceting' was actually the trimming of the rejuvenated core, and that the dorsal faces of these pieces were in fact platform surfaces.

It is quite likely that some, if not most, of the pieces defined in the project's lithics database as 'finely faceted pieces' may in fact be 'platform rejuvenation flakes', but it was not possible to prove this in the remaining individual cases.

The measurement of cores: The dimensions (L x W x T) of cores are measured in the following ways: in the case of platform cores, the length is measured from platform to apex, the width is measured perpendicular to the length with the main flaking-front orientated towards the analyst, and the thickness is measured from flaking-front to the often unworked/cortical 'back-side' of the core. In the case of bipolar cores, the length is measured from terminal to terminal, the width is measured perpendicular to the length with one of the two flaking-fronts orientated towards the analyst, and the thickness is measured from flaking-front to flaking-front. More 'cubic' cores, like cores with two platforms at an angle and irregular cores, are simply measured in the following manner: largest dim. by second-largest dim. by smallest dim.

Artefact orientation: General consensus amongst lithics analysts is (eg, Inizan *et al.* 1992, 34) that cores are orientated (when described verbally and illustrated) with their platforms up, whereas flakes and blades are orientated with their bulbar ends down. In a sense this is illogical, as it means that the striking direction of the parent pieces (the cores) and that of the 'off-spring' (the flakes and blades) do not match, but in this report general consensus is followed.

In the present report, the orientation (and subsequently the use of terms like 'left' and 'right') of the microliths and microlith-related implements also follows general consensus (eg, Martingell & Saville 1988, 10), although it would have been less confusing if it had been decided by the lithics specialist community to follow the practice adhered to when orientating other lithic artefacts, that is, with the bulbar end consistently down, as it is not always easy, or indeed possible, to define which end of a fragment was the tip end:

- A microlith is generally orientated with its tip up, and, as a microlith is defined as having been produced by removing its proximal end to form its tip, this usually means with the proximal end up.
- A microlith fragment (or a fragment assumed to have formed part of a microlith) is generally orientated with the proximal end up, as it is assumed that it is most likely to have had its tip at this end.
- A 'fragment of a microlith or backed bladelet' is orientated in the same way, as these pieces are more likely to have been microliths than backed bladelets. At Site 3B, for example, the ratio microliths/microlith fragments:backed bladelets is 85:15.
- A backed bladelet is orientated with its distal end up, as this end is supposed to have formed its tip.
- A microburin is orientated with its proximal end up, to fit the consensus regarding the orientation of a microlith.
- For the same reason, a microlith preform is orientated with its proximal end up.

Bipolar flakes vs flakes with platform collaps: A platform flake is generally defined by having a flat platform remnant at its proximal end, having been removed from a platform core, whereas a bipolar flake is defined by having a crushed ridge, or terminal, at either end, due to its having been violently 'bashed' on an anvil. In the project's lithics database, 107 flakes and flake fragments were defined as bipolar, due to the presence of one or more crushed terminals, but only nine bipolar cores were recovered. Although some of these bipolar cores are unusually small specimens (eg, CAT 10086), bipolar cores are generally easily recognisable, and the recovered pieces show that bipolar reduction did take place at Site 2D. However, compared to the number of soft and hard percussion flakes and blades retrieved from the site (2,548 pieces) it is obvious that bipolar technique did not form an integral part of the identified Late Upper Palaeolithic or Late Mesolithic operational schemas identified at the site, but that some bipolar reduction did take place, either as an expedient element of the above-mentioned operational schemas, or in connection with brief later visits to the location. In Ballin (2014a) it was suggested that in eastern Scotland bipolar technique was not used systematically prior to the Middle Neolithic period; that it became more commonly used during the later Neolithic; and that it dominates some Bronze Age assemblages.

The question is – as the lithic assemblage from Site 2D appears to consist almost entirely of material left by industries which hardly ever applied bipolar technique – whether many of these pieces may actually be flakes which suffered platform collapse? Platform collapse is mostly seen in connection with the use of excessive force, such as hard percussion, but it may also occasionally be experienced in connection with soft percussion, when a pressure flaker or punch was placed too near a platform-edge. Platform-collapse is occasionally also a result of the character of the raw material used, with some forms of pitchstone and Southern Uplands chert being notably brittle (eg, Ballin *et al.* 2008; Ballin & Ward 2013).

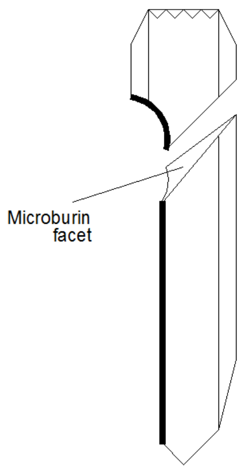
A total of 386 flakes and blades from Site 2D were defined as probably having suffered platform collapse, leaving a jagged fracture at the proximal end. It is highly likely that some of the flakes from the site, which were defined as bipolar blanks on the basis of the presence of what appeared to be a crushed terminal, may actually be platform flakes with jagged proximal fractures, that is, the remains of flakes which suffered platform collapse.

Microliths and 'microlith-related implements': In the archaeological literature, the term microlith is defined in a number of different ways, adding some confusion to the discussion of the category and its dating. In the present report, 'microlith' is defined as in the analyst's previous reports on early prehistoric assemblages (eg, Ballin *et al.* 2010):

> *Microliths are small lithic implements manufactured to form part of composite tools, either as tips or as edges/barbs, and which conform to a restricted number of well-known forms, which have had their (usually) proximal ends removed (Clark 1934, 55). This definition secures the microlith as a diagnostic (pre Neolithic) type. Below, microliths* sensu stricto *(ie, pieces which have had their usually proximal ends removed) and backed microblades (with surviving proximal ends) are treated as a group, as these types are thought to have had the same general function.*

It has been attempted to keep the microlith typology basic, and only general formal types are included (cf. Saville 1981). The most frequently used microlith typologies, such as those of Clark (1934) and Jacobi (1978), include numerous sub-types, characterized by various forms of fine ancillary edge-retouch (also see Butler 2005). It is, however, the analyst's view that most of these forms of additional modification represent the finer shaping of the pieces, determined by the specific original shape of the individual microlith blank, and that this fine retouch has little relevance to the understanding of the category, an assemblage or a specific site. The main formal types, on the other hand, may generally represent mental templates of the flint-knapper, and they may be chronologically or regionally diagnostic.

Fig. Intro.2. The distal part of this microblade (with the microburin facet) is the most common form of Krukowski 'microburin'. The dark line represents the retouch of the piece. In this case, the Krukowski piece was produced by breaking a lamelle a cran*, leaving a typical proximal microburin as a waste product.*



Krukowski 'microburins' (Krukowski 1914): These objects are defined as parts of microblades (proximal or distal) with a surviving unmodified microburin facet at one end. Distal Krukowski pieces are the most common ones (Fig. Intro.2; also see Inizan *et al.* 1992, Fig. 24.5-6). In some cases (eg, Bille Henriksen 1976, Fig. 75.35), the microburin facet is orientated differently in relation to the long retouched edge – where a 'standard' Krukowski piece has an obtuse angle where the retouched edge and the microburin facet meet, other pieces may be characterized by an acute angle at this point.

Basically, the term is a misnomer, and these pieces are *not* microburins. On a true microburin, the remains of the microburin notch and the microburin facet form a spur roughly one-third or one-half of the microblade width in from one lateral side, where the microburin facet of a Krukowski piece is unbroken, running from one lateral edge to the other, as it does on true microliths.

A number of interpretations of the Krukowski pieces have been offered:

- They are actual microburins (Vardi & Gilead 2009, 131).
- They represent production failures, that is, microliths which broke during modification of a lateral edge (de Wilde & de Bie 2011, 730), or during use.
- Or, they are microliths, or preforms of microliths, with unmodified *piquant triédre* facets, and in the case of the most typical form of Krukowski microliths these pieces have a scalene triangular outline (the interpretation favoured by this analyst). Fig. Intro.2 (redrawn from Inizan *et al.* 1992, Fig. 24.6) shows how a Krukowski microlith was formed by breaking a *lamelle a cran*.

It is recommended to refer to the group as 'Krukowski pieces' rather than 'Krukowski microburins', as it is highly likely that the group includes few or no actual microburins.

Zonation

In connection with the excavation of Site 2D, it was noted that the lithic artefacts present at the location formed a large scatter, and that it was possible to subdivide this scatter into a number of more or less discrete concentrations. As it was thought that the individual concentrations might represent individual visits to the site in prehistoric times, the site was subdivided into a number of 'zones' to allow this hypothesis to be tested. The spatial definition of these zones is shown in Figs Intro.3-5.

Fig. Intro.3. The zonation of Site 2D – Zones 1 to 6.

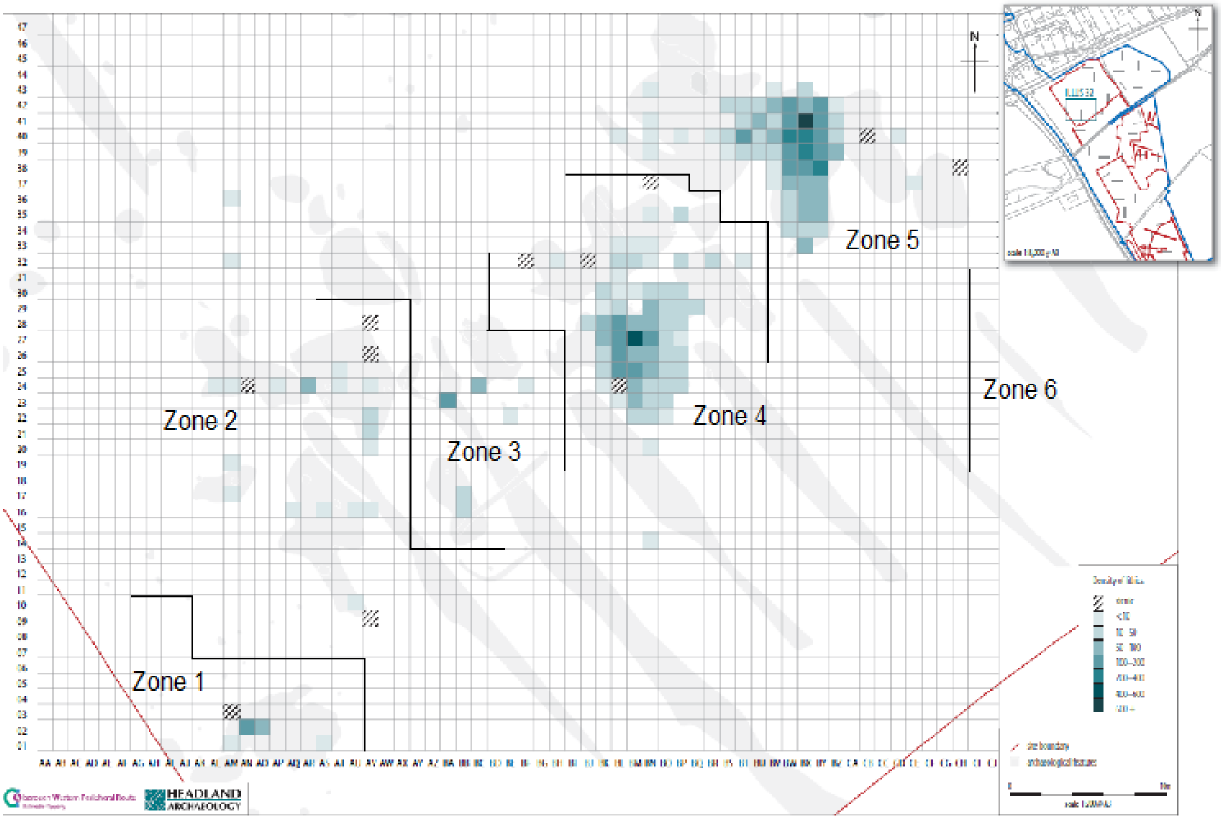


Fig. Intro.4. The zonation of Site 2D – Zones 1-6 and the 'base of the slope'..

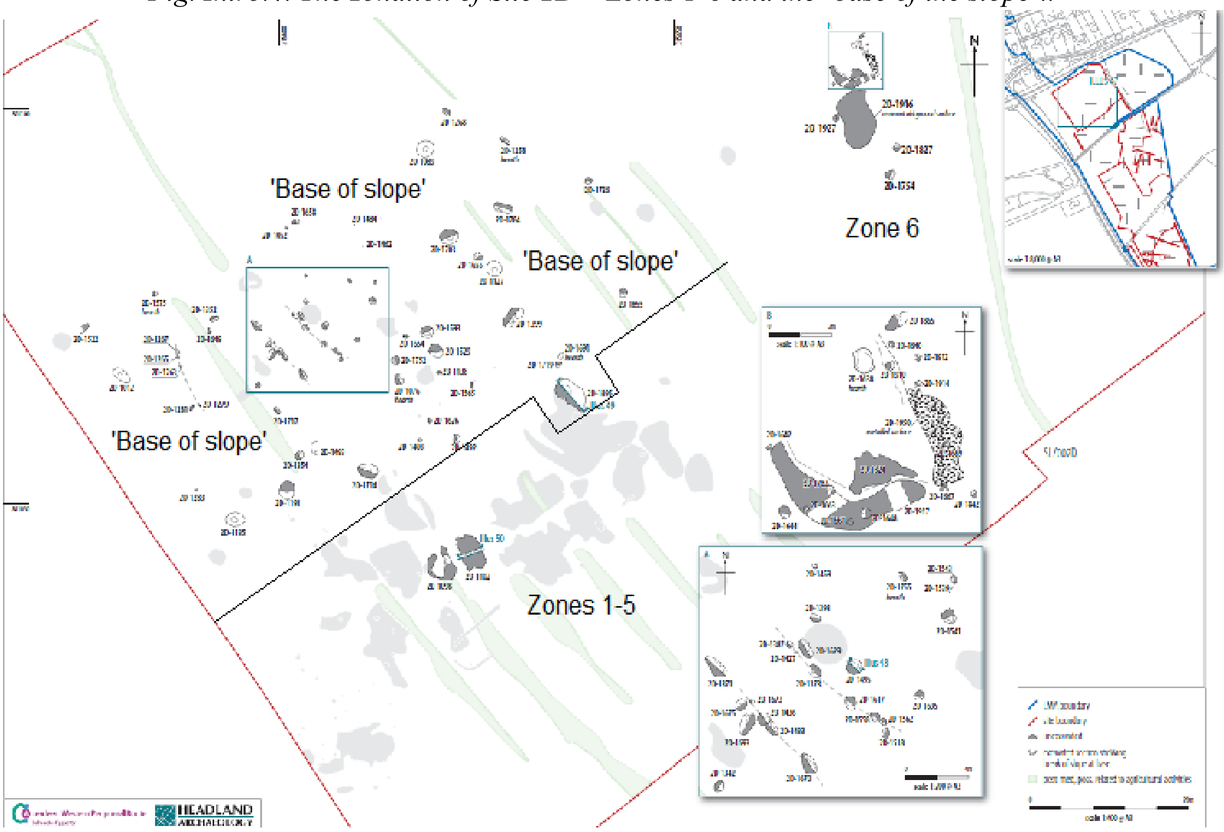
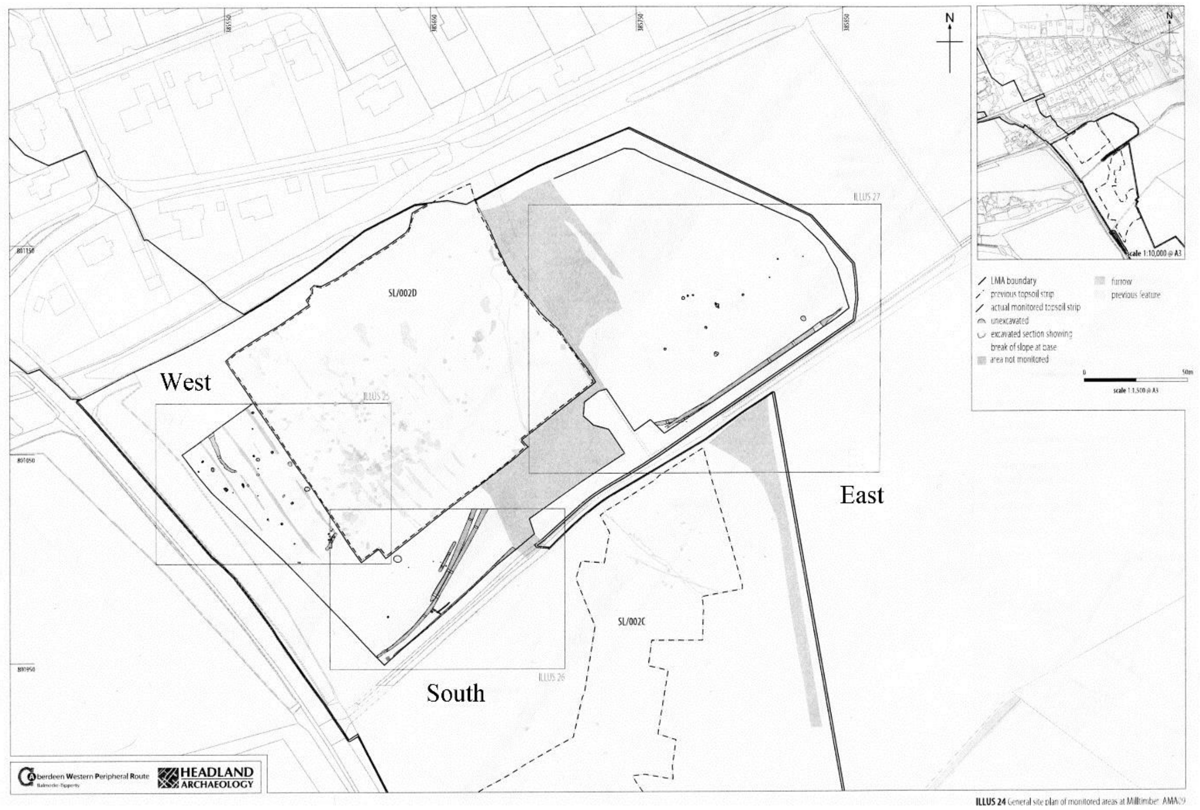


Fig. Intro.5. The zonation of Site 2D – Zones West, East and South.



Initially, seven zones were defined, namely Zones 1-5 towards the south of the original excavation area, Zone 6 towards the east, and one zone was referred to as the 'Base of the Slope', towards the north. Zones 1-5 are mainly defined by concentrations of flint, with some features being present in some of the zones; Zone 6 is mainly defined by the presence of a set of features and contexts, interpreted as a prehistoric house; and 'Base of the Slope' is mainly defined by clusters of pits and postholes, some of which contained worked flint, pottery or both. Following the excavation of these areas, work continued west, east and south of the original excavation trenches, in Zones West, East and South (Fig. Intro.5). In these areas, only cut features were excavated.

In connection with the presentation of the finds (below), a further two 'zones' were defined, namely Zone 0 and Zone 4/5. The finds referred to 'Zone 0' derive from a number of different contexts with limited interpretational value, with the most numerous sub-categories being the pieces from 'Topsoil', 'Natural', 'Hill-wash' or 'Unstratified'. This group of artefacts probably include pieces recovered through-out Site 2D, although the absence of polished-edge implements (below) suggests that few of these pieces were found near Zone 5. The finds referred to 'Zone 4/5' are predominantly finds from the initial investigation of the site and which can only be defined as deriving from either Zone 4 or Zone 5. The assemblage is numerically small (242 pieces), and it does not include any typo-technological elements which would have influenced the perception of Zones 4 and 5, had it been possible to refer individual pieces to one or the other of these two zones.

Spatial analysis

The internal chronology of the two numerically richest and most complex scatters, Zones 4 and 5, was tested by the application of intra-site spatial analysis; and spatial analysis was also applied to gauge prehistoric site activities. There are numerous different forms of spatial analysis available (Cziesla 1990), but in connection with the analysis of small hunter-gatherer sites, the present analyst favours 1) the use of contour maps for the presentation of distributions of artefact types present in large numbers; 2) dot-mapping for the presentation of distributions of artefact types present in smaller numbers; and 3) the application of a Binfordian approach and terminology in terms of the interpretation of the distribution patterns (Binford 1983).

The most important elements of the Binfordian approach are: 1) the distinction between drop-zones (small pieces of waste 'dropped' and left where they were produced) and toss-zones (larger pieces 'tossed' into the site periphery immediately after production to avoid future problems to traffic across the site); and 2) the distinction between two different site maintenance strategies, preventive maintenance (tossing) and *post hoc* maintenance (the collection and removal of larger pieces of waste to middens some time after production).

Table Intro.2. Distribution analysis of Mesolithic sites. Suggestion for basic standard approach (from Ballin 2013b).

Step	*Artefact categories*	*Activity areas*	*Centre/periphery*	*Drop/toss zones*	*Mapping*
1	Burnt lithics	Hearth	Centre	-	Contour
2	Chips, blades	Knapping floor	⇓	Drop zone	Contour
3	Tools, blades	Other activity areas	⇓	-	Contour/point
4	Heavy lithics	Disposal areas	Periphery	Toss zone/midden	Contour/point

The combination of the mapping strategy indicated above, and a Binfordian approach, allows a number of general spatial zones to be identified, such as the central hearth, the knapping floor(s), other activity areas, and disposal areas (Table Intro.2).

THE FULL ASSEMBLAGE

General overview

From the excavation at Site 2D, 11,784 lithic artefacts were recovered. They are listed in Table Full.1. In total, 94% of this assemblage is debitage, whereas 1% is cores and 5% tools.

Table Full.1. General artefact list – the full assemblage.

Debitage	
Chips	4,717
Flakes	3,679
Blades	1,341
Microblades	864
Indeterminate pieces	444
Crested pieces	84
Platform rejuvenation flakes	19
Total debitage	*11,148*
Cores	
Split pebbles	1

Core rough-outs	1
Single-platform cores - conical	27
Single-platform cores - plain	9
Opposed-platform cores	2
Cores w 2 platfs at angle	1
Discoidal cores, plain	3
Irregular cores	3
Bipolar cores	9
Core fragments	4
Total cores	*60*
Tools	
Microlith preforms	1
Obliquely blunted points	8
Scalene triangles	49
Crescents	15
Edge-blunted pieces	4
Idiosyncratic microliths	1
Frags of microliths	15
Frags of microliths or backed bladelets	40
Backed bladelets	6
Truncated bladelet	1
Microburins	167
Krukowski 'microburins'	6
Idiosyncratic point	1
Frags of Havelte points	1
Backed blades (points?)	2
Leaf-shaped arrowheads	1
Discoidal scrapers	1
Short end-scrapers	17
Blade-scrapers	2
Double-scrapers	1
Side-scrapers	3
End-/side-scraper	1
Scraper-edge fragments	3
Piercers	4
Burins	1
Backed knives	1
Scale-flaked knives	1
Curved truncations	1
Straight truncations	4
Oblique truncations	5
Db truncations	1
Serrated pieces	2
Polished-edge implements	159
Combined tools (scraper-piercers)	1
Pieces w edge-retouch	49
Gunflints?	1

Total tools	*576*
TOTAL	**11,784**

Raw materials – types, sources and condition

Apart from 23 chips and flakes in quartz, 10 chips in rock crystal, and one flake, one blade and one retouched jasper flake (CAT 10264), the Site 2D assemblage consists entirely of flint (99.8%). With the exception of a few Neolithic pieces (eg, leaf-shaped point CAT 10060 from a pit in Zone 6, possible informal sickle CAT 10156 from a pit a the base of the slope, and some debitage and tools from pits in Zones West, East and South), the vast majority of the finds are thought to date to the Late Mesolithic period, supplemented by a component of Late Upper Palaeolithic pieces (centred on Zone 4). The Palaeolithic finds and the Mesolithic finds are associated with two different forms of flint, representing two different procurement patterns.

At Site 2D, blanks, preparation flakes, cores and tools identified as either Palaeolithic or Mesolithic form two different size categories. Artefacts belonging to the former category are generally fairly large, and those belonging to the latter category quite small. It is therefore suggested in connection with the discussion of the lithics from Zone 4, and the definition of two different operational schemas (a Late Upper Palaeolithic and a Late Mesolithic) that most of the flint reduced by the site's Palaeolithic knappers was procured in the form of up to 150mm long flint pebbles, whereas that reduced by the Mesolithic knappers was obtained as 40-70mm long pebbles. Although the difference between the length of the two sets of procured pebbles may appear relatively small, with the Paleolithic ones 'only' being *c*. 2-4 times longer than the Mesolithic ones, the difference in terms of volume is immense, with the Palaeolithic pebbles being between 10-50 times more massive.

In Aberdeenshire, relatively large pebbles are only available from the Buchan Ridge Gravels near Peterhead (Bridgland *et al.* 1997), and the Palaeolithic flints from Zone 4 are generally based on a type of flint considerably better (ie, fewer faults and impurities) than that available from the Buchan Ridge Gravels. Also, the colours differ, with the Buchan Ridge flint varying between different hues of brown and grey, but with other colours also being present (ibid., 46), whereas most of the Palaeolithic flint from Zone 4 is in mottled grey forms akin to so-called Yorkshire flint (cf. Ballin 2011b), although frequently somewhat discoloured.

Flint of this size would not generally have been available along the present or Mesolithic coasts of eastern Scotland, but they could probably have been procured from sources on Doggerland, those parts of the North Sea which were dry land during the early post-glacial period (Ballin 2016d; Ballin & Bjerck 2016; Brooks *et al.* 2011; Sturt *et al.* 2013). In connection with the discussion of the finds from the Hamburgian site Howburn in South Lanarkshire (Ballin *et al.* 2010), it was suggested that the highly mobile settlers from this Late Upper Palaeolithic site may have procured their stocks of large flint pebbles when they passed through Yorkshire or parts of Doggerland on their *treks*, possibly following herds of migrating reindeer.

It is generally assumed that the Mesolithic hunter-gatherers of eastern Scotland procured their flint from beach walls along the North Sea shores (eg, Ballin 2013a), and inspection of early prehistoric assemblages from the region suggests that the pebbles available from this source were fairly small. Flint artefacts from the north-east of Scotland have traditionally been associated with honey-brown, red, orange and yellow colours (eg, Stevenson 1948, 181). However, examination by the analyst of a number of Mesolithic, Neolithic and Bronze Age assemblages from the region has shown that the available flint varies greatly from location to location (see discussion in connection with the assemblage from Site 3B).

It seems that sites along the Don and the Dee and further south in Aberdeenshire may include less flint of the reddish-brown forms than those further north, with the border between the two groups of sites running immediately north of Aberdeen. All Aberdeenshire sites include numerous sub-types, such as cream, beige, grey, and black pieces, and although most are fine-grained and pure, some pieces are medium-grained, and some are characterized by impurities, such as internal chalk balls, fossils, and micro-crystals, which generally lower the knapping properties of the nodules. However, the bulk of the flint recovered from sites in the Scottish north-east, including Site 2D, is, in terms of 'knappability', of high quality.

The fine-grained light-grey mottled flint so common at the project's various sites is, in terms of appearance and quality, similar to flint from the Yorkshire area in north-east England (Ballin 2011b), and it flakes well. However, where imported Yorkshire flint usually includes some pieces with soft or soft-ish cortex, all the cortical flint from Site 2D's Mesolithic scatters have abraded cortex, suggesting that it was most likely collected at a local pebble source, such as the beaches of Aberdeenshire, where it was washed ashore from deposits in the North Sea (Harker 2002).

ZONE 0

Introduction

The finds referred to 'Zone 0' derive from a number of different contexts with limited interpretational value, with the most numerous sub-categories being the pieces from 'Topsoil', 'Natural', 'Hill-wash' or 'Unstratified'. This group of artefacts probably include pieces recovered through-out Site 2D, although the absence of polished-edge implements suggests that few of these pieces were found near Zone 5 (below).

Fig. 0.1. shows the widths of the recovered blades and microblades, and the fluctuating nature of this curve indicates that the sub-assemblage may include finds from a number of different periods. Most of the narrower pieces are likely to date to the Late Mesolithic period, and some of the broadest blades (W *c*. 20mm) may be early pieces and form part of the Late Upper Palaeolithic component identified in connection with the processing of the finds from Zone 4 (below).

General overview

This group of finds embraces 597 lithic artefacts. They are listed in Table 0.1. In total, 95% of this assemblage is debitage, whereas 2% is cores and 3% tools.

Table 0.1. General artefact list – Zone 0.

Debitage	
Chips	262
Flakes	198
Blades	64
Microblades	20

Indeterminate pieces	19
Crested pieces	4
Platform rejuvenation flakes	1
Total debitage	*568*
Cores	
Core rough-outs	1
Single-platform cores - conical	4
Single-platform cores - plain	1
Cores w 2 platfs at angle	1
Discoidal cores, plain	1
Bipolar cores	1
Core fragments	1
Total cores	*10*
Tools	
Crescents	1
Edge-blunted pieces	1
Frags of microliths	1
Frags of microliths or backed bladelets	3
Microburins	5
Short end-scrapers	1
End-/side-scraper	1
Backed knives	1
Combined tools (scraper-piercers)	1
Pieces w edge-retouch	4
Total tools	*19*
TOTAL	**597**

Debitage

In total, 568 pieces of debitage were recovered from this zone (Table 0.2). The debitage includes 262 chips, 198 flakes, 64 blades, 20 microblades, 19 indeterminate pieces, and five preparation flakes (four crested pieces and one core tablet). Compared to other early prehistoric assemblages from Scotland, the chip ratio is quite high (*c*. 46%), which is likely to reflect the fact that consistent sieving was undertaken (for sampling strategy, see elsewhere in this volume). As demonstrated in Ballin (1999), the chip ratio of sieved assemblages usually varies between *c*. 30% and 55%.

Table 0.2. Relative composition of the debitage.

	n	*%*
Chips	262	46
Flakes	198	35
Blades	64	11
Microblades	20	4
Indeterminate pieces	19	3

Preparation flakes	5	1
Total debitage	*568*	*100*

Although high, the chip ratio is considerably lower than that of the small Late Mesolithic single-occupation site ABNL-3B (see elsewhere in this volume), which was as high as 64%. This difference probably reflects the fact the the finds from Site 3B were recovered from undisturbed pits and hollows, whereas the present sub-assemblage includes finds from disturbed contexts like topsoil and hill-wash.

It is thought that these differences partly reflect recovery and context, and partly chronology, where the assemblage from Site 3B dates entirely to the Late Mesolithic period, whereas the present assemblage is chronologically mixed, with a dominating Late Mesolithic component, supplemented by some Late Upper Palaeolithic material (see below).

Fig. 0.1. The width of all unmodified blades and microblades from Zone 0 (blue). A trendline (moving trendline) has been inserted (red) (84 pieces).

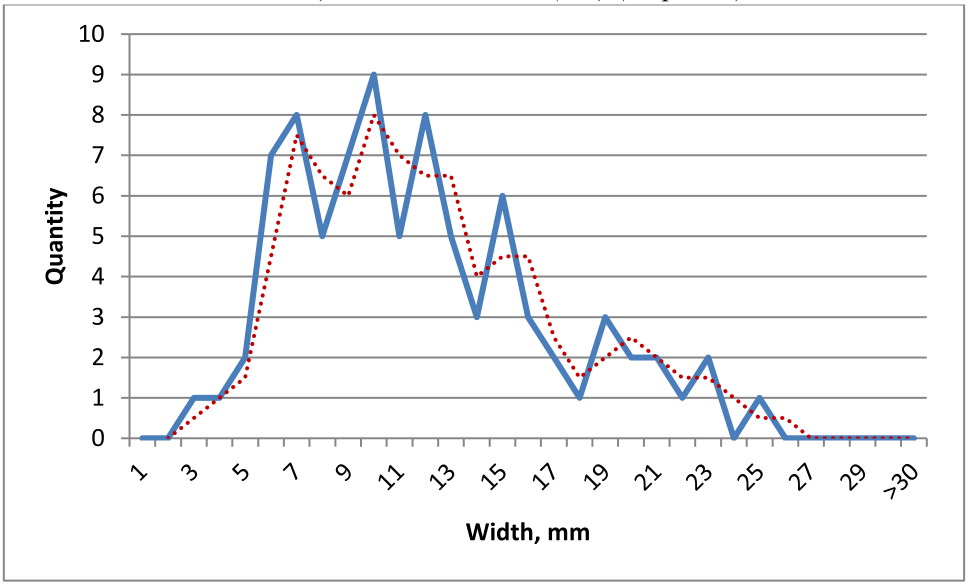
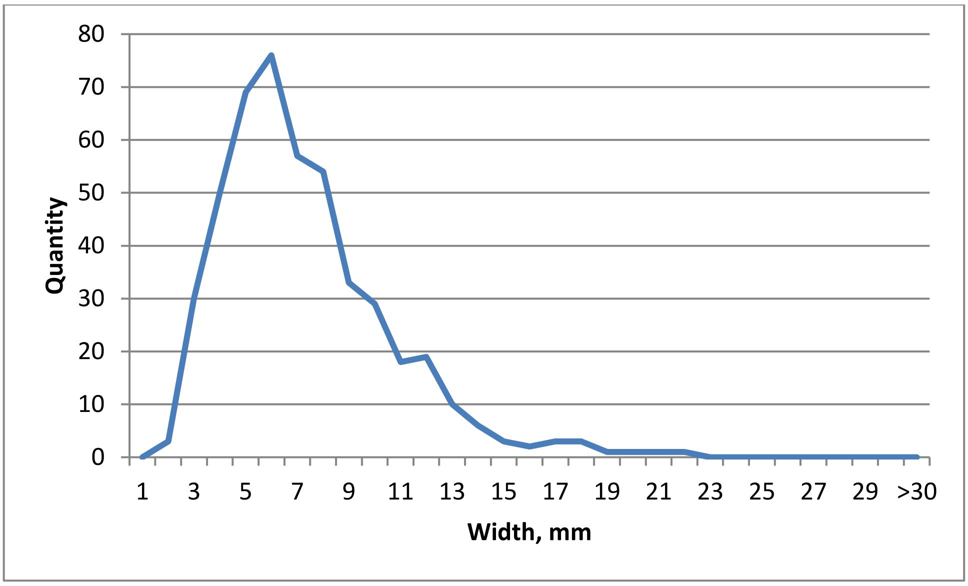


Fig. 0.2. The width of all unmodified blades and microblades from Site 3B.



This impression is further supported by the width of the blades and microblades from Zone 0 (Fig. 0.1). Where the curve showing the widths of the blades from the Late Mesolithic Site 3B (Fig. 0.2) is narrow and approximately bell-shaped (or at least single-peaked), the widths of the blades from the present zone form a broad, multi-peaked and jagged curve, indicative of a mixed assemblage (see dating section). The curve for Zone 0 could to an extent owe its appearance to the small numerical size of the category (84 pieces), but where the insertion of a moving trendline may occasionally remedy statistical weaknesses, forming a slightly more regular curve, this is not the case in the present situation. As shown in Fig. 0.1, the moving trendline may at best be described as consisting of a broad, 'table-topped' peak, formed by relatively narrow pieces, and a smaller peak, formed by broad blades.

Only five preparation flakes were recovered from this zone, including four crested pieces and one core rejuvenation flake. Two of the crests (CAT 10107, 10111) are fairly large, chunky pieces (av. dim.: 60 x 24 x 17mm), the other two (CAT 10108, 10141) are slender, relatively thin blades (55 x 16 x 8mm and 29 x 7 x 5mm). Zone 0's solitary platform rejuvenation flake (CAT 10120) is a very large, robust hard-hammer blade (83 x 32 x 16mm), with the curved remains of a neatly trimmed old platform at its proximal end. This piece was removed from an exceptionally large core with an elongated platform, and its right lateral edge shows wear from having been used as an unmodified knife. CAT 10120 probably forms part of the assemblage of likely late Upper Paleolithic material centred on Zone 4.

Cores

In total, 10 cores were recovered from Zone 0. They include the following core types: one core rough-out, five single-platform cores, one core with two platforms at an angle, one discoidal core, one bipolar core, and one core fragment. The cores were measured following the principles described in the methodology section.

CAT 10094 is a *core rough-out*, and it demonstrates the first stages in the production of a conical core very clearly. The piece measures 69 x 45 x 31mm, and it has a plain striking platform, shaped either by removing a primary flake or by splitting a pebble (see Site 3B). It has two opposed lateral crests, as well as a trimmed platform-edge. One flake was removed from this core, and when a chunk broke off one crest due to internal impurities, the piece was abandoned.

One of Zone 0's five *single-platform cores* is a small irregular piece (22 x 29 x 18mm), whereas the remainder are slightly larger, regular conical cores (av. dim.: 34 x 24 x 20mm). Apart from CAT 10061 which has an untrimmed platform-edge, all conical cores have plain, trimmed platforms. CAT 10061 has a cortical 'back-side', and CAT 10087 has had small flakes detached from the end opposite the platform, probably to maintain the core's apex and regular shape.

A *core with two platforms at an angle* (CAT 10089) is of roughly the same size (35 x 27 x 26mm) as the single-platform cores, and both platforms are trimmed. One of the platforms is plain and probably original, whereas the other platform is based on an old flaking-front, defining this as a secondary platform. CAT 10097 is a small *plain discoidal core* (34 x 22 x 15mm) based on a primary flake. A number of blanks were detached from the ventral face of the parent flake by striking various points of the core's circumference. In general, few *bipolar cores* were recovered from Zone 0 but, although appearing almost 'out of place', CAT 10090 is a typical anvil-struck core. It is diminutive (17 x 14 x 8mm), it is unifacial (ie, it has a cortical 'back-side'), and it has one reduction axis (one set of opposed terminals, or crushed ridges). In addition, a *core fragment* (GD = 32mm) was retrieved from Zone 0. This piece is the thermally detached, trimmed platform of a core, but it is not possible to define this core more precisely.

Tools

The 19 tools (Table 0.1) include six microliths and microlith-related implements, five microburins, two scrapers, one backed knife, one combined scraper-piercer, and four pieces with edge-retouch. Microlithic pieces clearly dominate the tools.

Two formal microliths include one *crescent* (CAT 10565) and one *edge-blunted piece* (CAT 10472). They are roughly the same size (av. dim.: 20.0 x 5.9 x 2.7mm), and they are both characterized by having had their left lateral side modified. One piece was defined as the *fragment of a microlith*, whereas three were defined as *fragments of microliths or backed bladelets*. These pieces are between 3.3mm and 7.9mm wide. The five proximal *microburins* have an average width of 9.2mm, and four of those had their notch in the RHS, whereas one had it in the LHS. The former four pieces successfully formed an oblique microburin facet or *piquant triédre* (see the report on the assemblage from Site 3B) when they were broken, whereas the latter simply snapped straight across.

One (CAT 10226) of the zone's two scrapers is a small *short end-scraper* (22 x 18 x 6mm), based on a hard percussion flake. Although it has been shaped by detaching small flakes along both lateral sides, its scraper-edge is distal, convex, and steep. CAT 10231 is a small *end-/side-scraper* with a working-edge at the proximal end and one along the LHS of the piece. Both scraper-edges are straight to slightly convex and steep. The distal end broke off in prehistoric times and the break facet was subsequently used as an unmodified scraper-edge. The pressure-flaked nature of the proximal modification suggests a post Mesolithic date for this piece.

CAT 10242 is a regular *backed knife* based on a hard percussion blade (42 x 16 x 10mm). The tool has robust straight blunting along its right lateral side, and along its sharp left side it has use-wear either from cutting or sickling. This assemblage also includes a *combined scraper-piercer*. This implement was formed by modifying a flake fragment, supplying it with a convex, steep scraper-edge at the distal end, and a piercer tip at the right corner of the scraper-edge. The piercer tip was shaped by merging the scraper-edge with the retouch of a small lateral notch. Four pieces and fragments with varying forms of *edge-retouch* are thought to be artefacts, or fragments of artefacts, with different functions.

Summary and discussion – Zone 0

The composition of this sub-assemblage suggests that the finds from Zone 0 represent a number of different prehistoric periods. However, due to the way the assemblage was recovered and the different contexts it was recovered from (eg, 'Topsoil', 'Natural', 'Hill-wash' or 'Unstratified'), it has not been possible to dissect the collection into period-specific groups. Yet, the presence of a number of diagnostic typo-technological elements does allow some suggestions to be made as to when the site may have been visited.

The recovery of microblades as well as narrow microliths and microburins indicate that the site may mainly have been visited during the Late Mesolithic period. This is supported by finds of regular conical microblade cores. Although the composition of the assemblage may to a degree reflect the way the artefacts from Zone 0 were recovered – with the assemblage from topsoil most likely including fewer small pieces – the three-to-one dominance of broader blades probably also indicate that the finds from the zone include artefacts from periods pre-dating or (less likely) post-dating the Mesolithic.

The exceedingly large platform rejuvenation flake (CAT 10120), for example, is likely to form part of the site's Late Upper Palaeolithic assemblage (discussed in connection with the finds from Zone 4), and the backed knife (CAT 10242) is also unlikely to date to the Late Mesolithic. This piece may either be a Late Upper Palaeolithic or, possibly, a post Mesolithic implement.

ZONE 1

Introduction

The sub-assemblage from Zone 1 was recovered predominantly from gridded squares, with a small number of artefacts deriving from the fills of five pits or postholes distributed evenly across the zone, mixed in amongst a cluster of pits. The excavated squares from this zone do not represent a coherent prehistoric surface but are sample grids within the area's find-richest parts.

Fig. 1.1. shows the widths of the recovered blades and microblades, and the resulting graph almost forms a bell-shaped curve with a small peak to either side. This suggests that the finds may generally date to one prehistoric period, although a small number of pieces may have been left by earlier or later visitors to the area. With the curve's peak at 9mm, the zone's main visit is likely to have taken place within the Late Mesolithic-Early Neolithic period, and the recovered microliths narrow the probable date down to the Late Mesolithic.

General overview

This group of finds embraces 286 lithic artefacts. They are listed in Table 1.1. In total, 90% of this assemblage is debitage, whereas 1% is cores and 9% tools.

Table 1.1. General artefact list – Zone 1.

Debitage	
Chips	82
Flakes	100
Blades	43
Microblades	14
Indeterminate pieces	19
Total debitage	*258*
Cores	
Single-platform cores - conical	1
Single-platform cores - plain	1
Bipolar cores	1
Total cores	*3*
Tools	
Scalene triangles	1
Crescents	1
Frags of microliths or backed bladelets	1
Microburins	7
Short end-scrapers	2
Side-scrapers	2
Scraper-edge fragments	1
Piercers	3
Polished-edge implements	1
Pieces w edge-retouch	6
Total tools	*25*
TOTAL	**286**

Debitage

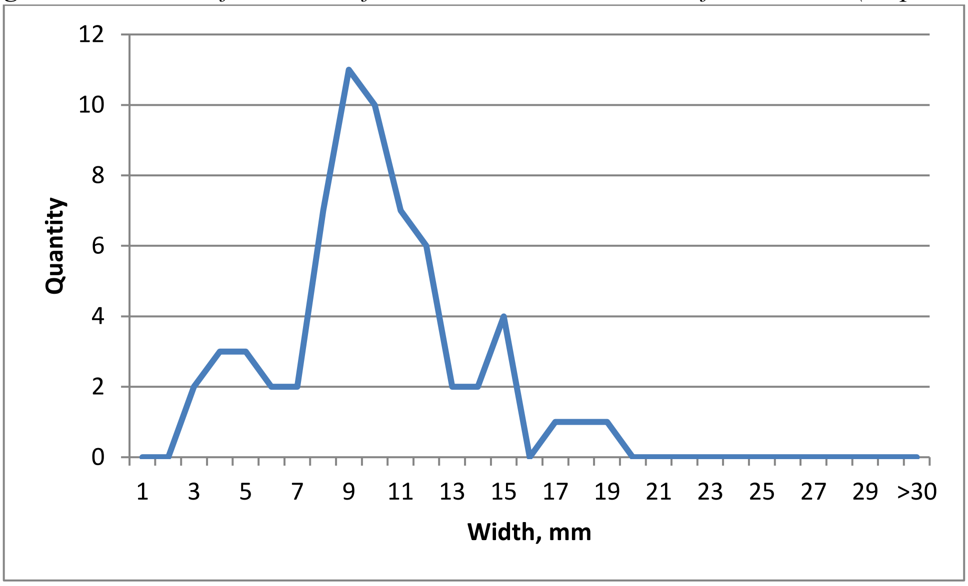
In total, 258 pieces of debitage were recovered from this zone (Table 1.2). The debitage includes 82 chips, 100 flakes, 43 blades, 14 microblades, and 19 indeterminate pieces. In Ballin (1999), the author demonstrated that the chip ratio of sieved assemblages usually varies between *c.* 30% and 55%, and the present chip ratio is within this framework. A relatively high chip ratio usually indicates that primary production took place at a location.

Table 1.2. Relative composition of the debitage.

	n	*%*
Chips	82	32
Flakes	100	39
Blades	43	17
Microblades	14	5
Indeterminate pieces	19	7
Total debitage	*258*	*100*

Fig. 1.1's representation of the widths of the blades and microblades (57 pieces) from the zone is approximately bell-shaped (one main peak), indicating that most of the finds from the zone may represent a single main visit to the site, or that most of the finds represent visits to the site within one relatively narrow segment of early prehistory. The diagram's supplementary peaks may either represent earlier or later visits to the area, or they may be waste from the preparation or adjustment of cores (cf. Site 3B, Fig. 4; this volume). Although Table 1.2 suggests a notable dominance of the blades by broad pieces (broad:narrow ratio 75:25), and although the average dimensions of 13 intact blades are 28 x 12 x 4mm, the curve has its main peak at 9mm, suggesting that the knappers of this area attempted to produce blades which were, metrically speaking, in the transitional zone between microblades and narrow-blades. The discrepancy between the blades' average dimensions (width 12mm) and the curve's peak (width 9mm) is most likely due to the fact that more delicate blades broke than sturdy ones, and that the surviving blades would be robust pieces (eg, shorter, broader and thicker than the zone's original blade population; discussed in the report on Site 3B, this volume). No preparation flakes were found within Zone 1.

Fig. 1.1. The width of all unmodified blades and microblades from Zone 1 (57 pieces).



A total of 128 pieces are affected by fire, or almost half of the sub-assemblage. As many as 91 of those (or almost three-quarters) were recovered from grid AN 02, with smaller numbers from the surrounding grids. This suggests that the test grids were chosen well, with grid AN 02 probably being situated exactly on top of the spot of the main visit's central hearth. Ten burnt pieces were recovered from the five flint-bearing pits; they are generally thought to be residual pieces predating the pits (see below).

Eighteen of the area's 19 indeterminate pieces are burnt, supporting the suggestion put in connection with the analysis of Site 3B (elsewhere in this volume) that, at the Aberdeen Ring Road sites, many indeterminate pieces were formed when flakes and blades were exposed to fire and subsequently shed their ventral faces.

Cores

In total, three cores were recovered from Zone 1, namely two single-platform cores and one bipolar core. The cores were measured following the principles described in the methodology section.

One of the *single-platform cores* (CAT 10062) is intact. It is a regular bullet-shaped conical core (41 x 29 x 22mm), and it was abandoned when a series of attempted blade detachments failed and developed deep hinge- and step-fractures. CAT 10092 is the apex of a disintegrated single-platform blade-core of uncertain specific shape (GD 40mm). It appears to have broken up due to internal impurities.

CAT 10153 is a bifacial *bipolar core* with two reduction axes (or sets of opposed terminals), and it measures 33 x 30 x 10mm. As touched upon elsewhere (Ballin 2014a), it is possible to subdivide eastern Scotland into a number of techno-complexes, where the Mesolithic and Early Neolithic periods are characterized by the production of blades and microblades by the application of soft percussion (almost no use of bipolar technique), the Middle and Late Neolithic periods by the production of blades and flakes by Levallois-like technique (increasing use of bipolar technique), and the early Bronze Age by flake production by the application of hard percussion and extensive use of bipolar technique. CAT 10153 was recovered from Pit 1084, and this piece may – in contrast to the pits' probably residual knapping waste – be contemporary with the zone's Middle Neolithic pits (see below).

Tools

Zone 1's 25 tools (Table 1.1) include three microliths and fragments of microliths or backed bladelets, seven microburins, five scrapers, three piercers, one polished-edge implement, and six pieces with edge-retouch.

One *scalene triangle* (CAT 10535) is a medial-distal fragment (width 3.3mm) with its shortest side at the distal end and blunting along its RHS; one *crescent* (CAT 10515) is a distal fragment (width 4.1mm) with retouch along its LHS; and one fragment of a *microlith or backed bladelet* (CAT 10536) is a distal fragment (width 3.0mm) with blunting along its RHS.

The seven *microburins* are evenly distributed across pieces with their notch in the LHS and pieces with their notch in the RHS, and they are also evenly distributed across pieces with a typical microburin facet and pieces which simply snapped. Six are proximal specimens, and one is a distal microburin. Their avarage width is 8.5mm, and their width varies between 6mm and 12mm.

The scrapers generally have an expedient appearance. They seem to be based on whichever blank was available, and they were given the minimum modification needed to carry out their task. Two of these pieces are *end-scrapers* (CAT 10211, 10212) and two are *side-scrapers* (CAT 10267, 10269). The blanks are short irregular waste flakes or slightly more regular elongated flakes or short blades, and the scraper-edges vary between convex and steep (the end-scrapers), and straight/slightly convex and relatively acute (the side-scrapers). Only end-scraper CAT 10211 is intact; it measures 21 x 18 x 6mm. The modification of CAT 10212 is denticulated and that of CAT 10211 inverse. One scraper-edge fragment (CAT 10210) could not be defined more precisely.

Three of Site 2D's four *piercers* were retrieved from Zone 1. They form a more homogeneous category than the area's scrapers, and they are all based on short blades or elongated flakes, which have been provided with a distal tip. CAT 10276 is intact, and it measures 27 x

15 x 4mm. CAT 20233 is the broken-off tip of a piercer, and CAT 10234 is the proximal fragment of a piercer; these two blade-based pieces have widths of 10mm and 11mm, respectively. The latter two specimens both have regular tips formed by merging two straight lateral retouches, whereas CAT 10276 has a curved, almost *Zinken*-like tip (despite its appearance, the recovery of this piece from grid AN 02 suggests that it is probably contemporary with the remainder of the assemblage, ie Mesolithic rather than Late Upper Palaeolithic).

CAT 10752 is the proximal fragment of a *polished-edge implement* (25 x 21 x 4mm), and it is based on a hard percussion flake. It has retouch along both lateral sides, and this modification, as well as the distal break facet has been abraded by use. The abraded edges of this specimen links it, and/or Zone 1, to Zone 5 at the opposite (eastern) end of Site 2D's main spread, the only other part of the site from which polished-edge implements have been recovered (157 pieces).

Six pieces and fragments with varying forms of *edge-retouch* are thought to be artefacts, or fragments of artefacts, with different functions.

Twelve of the area's tools, or approximately half of the implements, are burnt. This corresponds to the burnt ratio of the debitage. No cores have been exposed to fire. Eleven of the twelve modified pieces are from Grid AO 02 where the settlement's hearth is thought to have been. Most likely these pieces fell into the fireplace during production or use of the flakes, blades and tools.

Summary and discussion – Zone 1

The typo-technological attributes of this sub-assemblage is consistent with a date in the Late Mesolithic period. The dating elements include the presence of a small number of microliths and microburins; regular conical microblade cores; a group of regular microblades/narrow blades with a width centred around 9mm, and small expedient scrapers. The fact that the area's solitary polished-edge implement was recovered from Grid AN 02, the assumed location of the area's hearth, suggests that this piece may be contemporary with Zone 1's Mesolithic pieces. Two radiocarbon dates (SUERC-68115-6) from Postholes 1225 and 1273 date the lithic assemblage from Zone 1 to the later part of the Late Mesolithic period, between 4938 cal BC and 4550 cal BC.

Technologically, the finds represent the production of microblades/narrow-blades from well-prepared conical microblade/blade cores, with the microblades being the intended blanks for the manufacture of microliths, which were shaped by the application of microburin technique (see the discussion of the operational schema applied at Site 3B; this volume). Tools like scrapers were based on simple waste flakes, whereas the Zone 1 piercers are all made on blades or elongated flakes.

As shown in Table 1.3, more than three-quarters of all surface finds (Grids AM 01, AN 02 and AO 02) were recovered from Grid AN 02, which is also the centre of the fire-crazed pieces, and the likely location of the Mesolithic settlement's central hearth. Approximately one-quarter of the finds were recovered from five pits or postholes scattered amongst a cluster of pits distributed across the zone. Apart from one bipolar core (CAT 10153), all artefacts from pits are production waste, mostly chips and flakes. It was therefore suggested above that these finds are residual pieces which formed part of Zone 1's Mesolithic knapping floor, and which entered the pits with the back-fill. A radiocarbon date from Pit 1210 suggests that this group of pits dates mainly to the Middle Neolithic period (3514-3355 cal BC; SUERC-58604). As discussed above, it is possible that the bipolar core may be contemporary with the pits, but whether it was deliberately deposited or whether it is a Middle Mesolithic object which entered the pit (in this case an actual pit, rather than the cut for a post) with the back-fill, is uncertain.

Table 1.3. Artefact distribution across Zone 1.

Grid	*n*	*%*
AM 01	21	7
AN 02	176	62
AO 02	8	3
Pits	81	28
TOTAL	**286**	**100**

Although this is a fairly small Mesolithic assemblage, and although the zone was only sampled rather than fully excavated, it is interesting how the composition of the assemblage differs from that of Site 3B. The latter site has been interpreted as a small short-term hunter-gatherer camp, the main activity of which was the production of microblades and microliths, probably to allow damaged or missing microliths in slotted bone points to be replaced. Zone 1 has a considerably higher tool ratio (9% vs 5%), and where the tools at Site 3B are mainly microliths, with few other implement categories being present, at Site 2D's Zone 1 non-microlithic pieces dominate the tools (microlithic pieces:other tools – 88:12 and 40:60, respectively). It is also important that the tool category at the present location includes several piercers and a polished-edge implement, where at Site 3B non-microlithic implements were mainly scrapers. This suggests that, although the Mesolithic settlement at Zone 1 may also be a short-term camp, its activity pattern was probably more broad-spectred, where Site 3B is a specialised site.

ZONE 2

Introduction

The sub-assemblage from Zone 2 was recovered predominantly from gridded squares, with a small number of artefacts deriving from the fills of five pits or postholes distributed across the central and northern parts of the area. The excavated squares from this zone do not represent a coherent prehistoric surface but are sample grids within the area's find-richest parts.

As the distribution of the finds across the zone (below) does not seem to have an obvious centre, it is uncertain whether this sub-assemblage represents one or several visits to the area. The diagram (Fig. 2.1) showing the widths of the recovered blades and microblades is not unequivocal either (discussed further below). However, the diagnostic elements of this sub-assemblage are predominantly datable to the Late Mesolithic period, although a radiocarbon date from Hearth 1234 is evidence that the area may have been visited during the Middle Neolithic, although without leaving any lithic evidence.

General overview

This group of finds embraces 208 lithic artefacts. They are listed in Table 2.1. In total, 97% of this assemblage is debitage, whereas 1.5% is cores and 1.5% tools.

Table 2.1. General artefact list – Zone 2.

Debitage	
Chips	100
Flakes	63
Blades	12
Microblades	8
Indeterminate pieces	14
Crested pieces	4
Platform rejuvenation flakes	1
Total debitage	*202*
Cores	
Single-platform cores - conical	1
Discoidal cores, plain	1
Irregular cores	1
Total cores	*3*
Tools	
Microburins	2
Pieces w edge-retouch	1
Total tools	*3*
TOTAL	**208**

Debitage

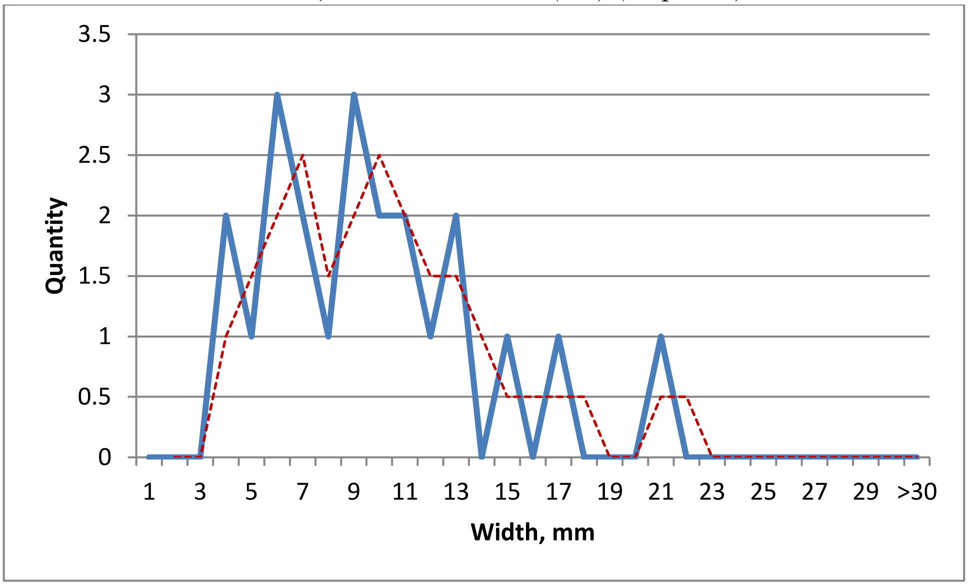
In total, 202 pieces of debitage were recovered from this zone (Table 2.2). The debitage includes 100 chips, 63 flakes, 12 blades, 8 microblades, 14 indeterminate pieces, and five preparation flakes. In Ballin (1999), the author demonstrated that the chip ratio of sieved assemblages usually varies between *c.* 30% and 55%, and the present chip ratio is within (although at the upper end of) this framework. A relatively high chip ratio usually indicates that primary production took place at a location.

Table 2.2. Relative composition of the debitage.

	n	*%*
Chips	100	50
Flakes	63	31
Blades	12	6
Microblades	8	4
Indeterminate pieces	14	7
Preparation flakes	5	2
Total debitage	*202*	*100*

Due to the low number of blades and microblades recovered from the zone (20 pieces), the curve representing the widths of these pieces (Fig. 2.1) is highly irregular. A trendline evens out the random statistical fluctuations, but only somewhat. The trendline has two peaks – one at 7mm and one at 10mm – but due to the small numerical size of the population it is uncertain whether the trendline should be interpreted as reflecting two visits to the site, or one visit producing blades with a width centred on 8/9mm (the latter would correspond to the blade population recovered from Zone 1). Either way, the general size of the blades and microblades is consistent with one or more visits to the location during the Late Mesolithic/Early Neolithic period.

Fig. 2.1. The width of all unmodified blades and microblades from Zone 2 (blue). A trendline (moving trendline) has been inserted (red) (20 pieces).



A total of 55 pieces are affected by fire, or approximately one-quarter of the sub-assemblage. Although these pieces occur across the area in general, they do cluster, with above average numbers having been recovered from Grids AR 24 (14 pieces), AV 21/22 (seven pieces), and Pit 1320 north of the main scatter (11 pieces). It is thought that the former two clusters may relate to the location of fireplaces (see discussion, below). All but two of Zone 2's 14 indeterminate pieces are burnt (see discussion of indeterminate pieces in the Site 3B section; this volume).

Only five preparation flakes were recovered from this zone, including four crested pieces and one core rejuvenation flake. Two of the crests are fairly robust pieces (CAT 10130, 10133), and two are relatively thin (CAT 10159, 10181). Two intact pieces measure 40 x 22 x 10mm (CAT 10133) and 21 x 12 x 3mm (CAT 10159), respectively. The zone's solitary platform rejuvenation flake (CAT 10148) is a thick hard-hammer specimen (34 x 34 x 15mm) from a single-platform core with a neatly trimmed platform-edge. It probably represents a failed attempt to adjust a core platform, as the core tablet split the core diagonally and left the parent core with an oblique platform.

Cores

A total of three cores were retrieved from Zone 2, namely one conical single-platform core, one plain discoidal core, and one irregular core. The cores were measured following the principles described in the methodology section.

The area's *single-platform core* (CAT 10079) is complete and it measures 33 x 23 x 21mm. It is a regular bullet-shaped conical core and it was abandoned when a series of attempted blade detachments failed and developed deep hinge- and step-fractures. Modification at the core's apex probably represents attempts at maintaining the apex, rather than producing a scraper-edge. CAT 10096 is a plain *discoidal core*, measuring 36 x 30 x 23mm. Discoidal cores include a number of different forms, with the most sophisticated type being the later Neolithic Levallois-like core (eg, Ballin 2011a; Suddaby & Ballin 2010). The present piece is simply a thick primary flake which was recycled as a core by detaching small flakes by striking it along the entire circumference of the original flake's ventral face. CAT 10071 is an *irregular core* with three platforms at approximately right angles to each other. It is a fairly chunky, or cubic, piece, measuring 37 x 36 x 32mm. It may be a recycled single-platform core, but towards the end of its 'life' it was worked by hard percussion, crushing the platform-edges and leaving numerous circular impact scars.

Tools

Only three tools were retrieved during the excavation of Zone 2, namely two microburins and one piece with edge-retouch.

The two *microburins* (CAT 10346, 10350) are both based on microblade blanks, with a width of 7.4mm and 4.0mm, respectively. They are both proximal microburins. The former has a notch in the LHS and snapped, whereas the latter has a notch in the RHS and formed at proper sharp microburin facet when it was deliberately broken.

CAT 10278 is the medial fragment of a *piece with edge-retouch*. This implement is based on a broad blade (33 x 21 x 5mm), and it has been exposed to fire. It has continuous retouch along its RHS, and the modification appears worn, probably from use as a knife. Forty-six lithics were recovered from a number of pits in the area, but most of these are production waste in the form of chips, flakes and indeterminate pieces, and it is thought that these pieces generally represent residual Mesolithic objects which entered these probably Middle Neolithic pits with the back-fill (Hearth 1234, near the zone's highest concentration of flint, was radiocarbon-dated to 3345-3094 cal BC; SUERC-58605). CAT 10278 was recovered from Pit 1320 situated at the northern end of Zone 2, between the Middle Neolithic pit cluster at the centre of the zone and that of Zone 3, and although most of the lithic finds from this pit appear to be residual Mesolithic pieces (including conical microblade core CAT 10079), this broadblade-based specimen (width 21mm) would fit a Middle Neolithic date better, and it may be a deliberate deposition. However, it might just as likely be a residual Late Upper Palaeolithic piece.

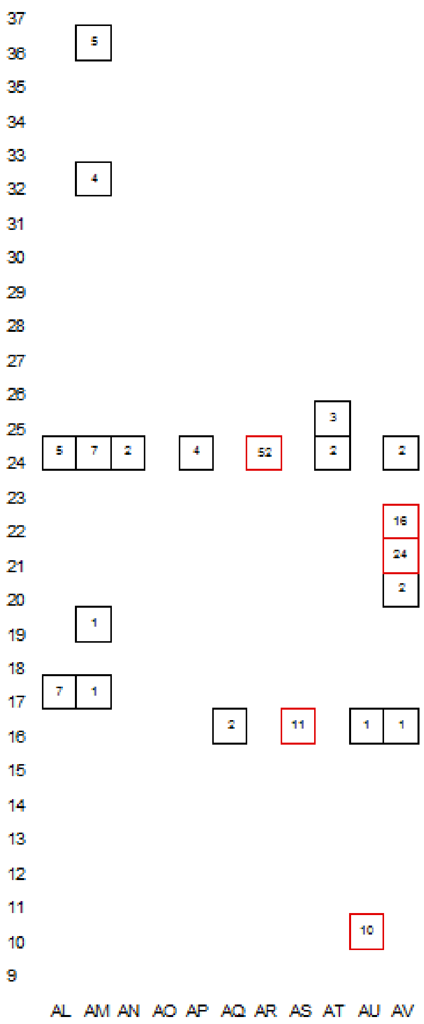
Summary and discussion – Zone 2

Apart from the edge-retouched broadblade CAT 10278 from Pit 1320, which may be either a Palaeolithic or a Middle Neolithic object, the typo-technological attributes of this sub-assemblage is consistent with a general date in the Late Mesolithic period. Diagnostic elements include microblades and narrow-blades, a conical microblade core, and two microburins. The width of the blades suggests either one or two visits to the site during this period.

With several minor concentrations, the distribution of the finds supports the assumption that the area may have been visited several times during early prehistory (Fig. 2.2). Although no other finds than the retouched blade from Pit 1320 are identifiable as potentially Middle Neolithic, the location of Hearth 1234 (radiocarbon-dated to 3345-3094 cal BC; SUERC 58605) corresponds roughly to the location of the find-richest grid square in Fig. 2.2, and it must be assumed that some knapping took place here during the Neolithic, even if no diagnostic waste, cores or tools were produced. Although sophisticated discoidal cores like Levallois-like cores are strictly diagnostic pieces dating to the Middle and Late Neolithic periods, the zone's plain discoidal core CAT 10096 is probably an idiosyncratic object, and it could be of any date.

Apart from the broadblade blank of CAT 10278, the technological evidence of this sub-assemblage relates to one or more visits to the area during the Late Mesolithic, and to the production of microblades and narrow-blades from conical cores. It is uncertain whether the crested pieces date to one or the other period, but core tablet CAT 10148 was definately detached from a single-platform core with a neatly trimmed platform-edge, probably a Late Mesolithic microblade core. The apex of single-platform core CAT 10079 displays modification, indicating that this end of the microblade cores was carefully maintained. Microliths were produced from delicate microblades/narrow-blades by the application of microburin technique (see the discussion of the operational schema applied at Site 3B; this volume).

Fig. 2.2. The distribution of worked flint across Zone 2. Red squares indicate higher than average (two-digit) find numbers.



Although possibly dominated by Mesolithic material, this sub-assemblage is likely to also include later pieces, and the site was almost certainly visited on a number of occasions (Fig. 2.2). The area is therefore best described as a palimpsest, and its assemblage has little research potential.

ZONE 3

Introduction

Approximately two-thirds of the finds from Zone 3 was retrieved from gridded squares, with *c*. one-third deriving from a number of large tree-throw holes and features within them. The excavated squares from this zone do not represent a coherent prehistoric surface but are sample grids within the area's find-richest parts.

The finds may form three parts, namely a southern (BA 16/17 with surroundings) and a northern segment (BA 23/BC 24 with surroundings) of the area's surface, and artefacts from the tree-throw holes and their associated features. The latter group of objects probably include pieces which entered the tree-throw holes when the trees fell, as well as later pieces associated with the internal features of the tree-throw holes, and it has not been possible to separate these earlier and later finds.

However, as shown below, the artefacts recovered from Zone 3's southern and northern parts probably represent different parts of prehistory, including different typo-technological elements. It is thought that the lithics from the southern part may largely be Late Mesolithic in date, and those from the northern part (including the tree-throw holes) Late Mesolithic, Early Neolithic and Middle Neolithic.

General overview

This group of finds embraces 737 lithic artefacts. They are listed in Table 3.1. In total, 98% of this assemblage is debitage, whereas 0.5% is cores and 1.5% tools.

Table 3.1. General artefact list – Zone 3.

Debitage	
Chips	427
Flakes	191
Blades	45
Microblades	35
Indeterminate pieces	11
Crested pieces	8
Platform rejuvenation flakes	4
Total debitage	*721*
Cores	
Single-platform cores - conical	1
Single-platform cores - plain	1
Irregular cores	2
Total cores	*4*
Tools	
Obliquely blunted points	1
Frags of microliths	1
Microburins	6
Short end-scrapers	1
Piercers	1
Pieces w edge-retouch	2
Total tools	*12*
TOTAL	**737**

Debitage

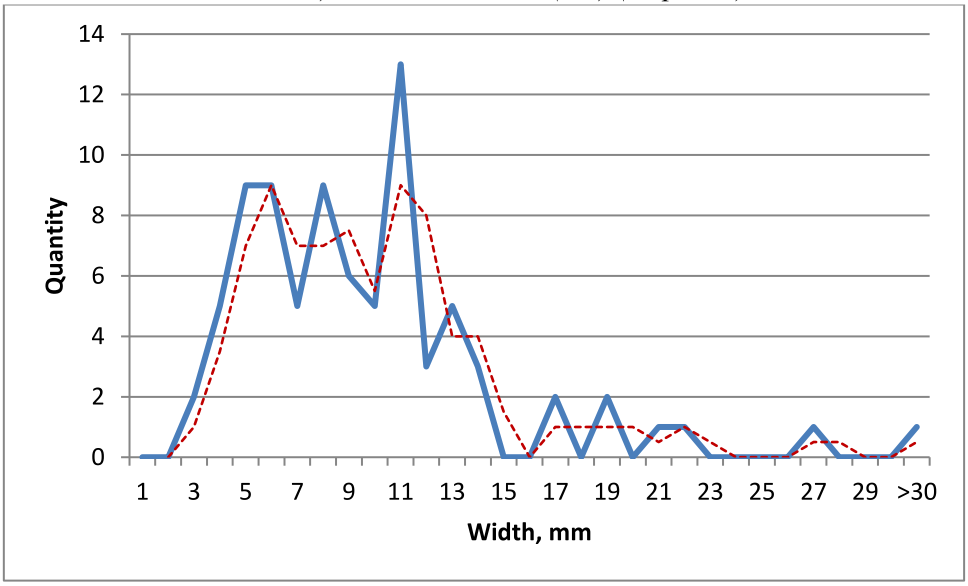
In total, 721 pieces of debitage were recovered from this zone (Table 3.2). The debitage includes 427 chips, 191 flakes, 45 blades, 35 microblades, 11 indeterminate pieces, and 12 preparation flakes. In Ballin (1999), the author demonstrated that the chip ratio of sieved assemblages usually varies between *c.* 30% and 55%, and the present chip ratio (59%) is slightly above this framework. A high chip ratio usually indicates that primary production took place at a location.

Table 3.2. Relative composition of the debitage.

	n	%
Chips	427	59
Flakes	191	26
Blades	45	6
Microblades	35	5
Indeterminate pieces	11	2
Preparation flakes	12	2
Total debitage	*721*	*100*

A total of 80 blades were recovered from the area, allowing Fig. 3.1 to be produced. The diagram's curve is highly irregular and jagged, and although a trendline evens out the random statistical fluctuations somewhat, the curve of the trendline is broad and 'table-topped' rather than regularly bell-shaped. Most likely, the left side of the 'table-topped' peak represents one or more visiots to the location in the Late Mesolithic (average width *c*. 5-7mm), whereas the right side of this peak may represent later visits (average width *c*. 11mm). It is uncertain whether the broad blades beyond width 15mm are from the initial preparation of cores produced by these Mesolithic/Neolithic visitors (see the discussion of the blades from Site 3B; this volume), or whether they may represent for example a Late Upper Palaeolithic component (see Zone 4, below).

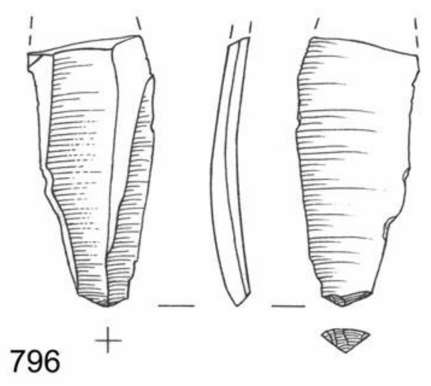
Fig. 3.1. The width of all unmodified blades and microblades from Zone 3 (blue). A trendline (moving trendline) has been inserted (red) (80 pieces).



A total of 139 burnt pieces were retrieved, or just short of 20% of the full sub-assemblage. However, the distribution of the burnt pieces is quite distinct, with finds from the surface grids only including *c*. 6% burnt pieces, whereas those from the tree-throw holes and their internal features include 44%. The composition of the finds from the tree-throw holes suggest that primary production took place around some of the features, which have been identified as hearths (eg, Features 1137 and 1152 from tree-throw hole 1136), but other more specialized activities may also have taken place which involved the use of fire, such as the roasting of hazel-nuts or flint (eg, heat-treatment; see discussion of the finds from Site 3B, this volume), or possibly, tool-making (eg, the softening of birch tar in connection with the replacement of damaged microliths from slotted bone points; Lidén 1942), or food processing (meat-smoking?; Binford 1983). However, as the finds in the tree-throw holes probably represent the overlapping remains (a palimpsest) left by people from at least three different prehistoric periods, disentangling these events and defining individual sets of activities is impossible. With one exception, all indeterminate pieces from this location are burnt pieces from features in the zone's northern part.

Twelve preparation flakes were retrieved from this area, or eight crested pieces and four platform rejuvenation flakes. The crested pieces are mostly fairly broad blades with widths between 12mm and 22mm. Three intact pieces (CAT 10099, 10106, 10117) measure on average 61 x 19 x 8mm. CAT 10117 forms part of a ventral-dorsal refit with crested piece CAT 10118 from Zone 4/5. CAT 10099 has fine use-wear from cutting along one lateral side. The four platform-rejuvenation flakes recovered within Zone 3 are an interesting group. CAT 10152 is a solitary piece, found in Pit 1890 at the centre of the location, whereas CAT 10104, 10182 and 10184 conjoin dorsal-ventrally, one on top of the other. These pieces were found in BC 24, immediately next to tree-throw hole 1102 (Fig. 3.3), and they form a series of core tablets, with the platform-edges of the lower ones having been moved a few millimetres back in relation to the one on top of it. In this case, the platform was rejuvenated every time a small number of flakes had been detached. As platform rejuvenation by the detachment of core tablets appears to be either rare or absent in connection with the main Late Mesolithic concentrations along the ring road (see for example Site 3B and Zone 4 and 5), this series of core tablets may relate to Late Upper Palaeolithic visits to Site 2D.

Fig. 3.2. En eperon *blade from Howburn, South Lanarkshire (Ballin* et al. *2010, Fig. 11; drawn by Marion O'Neil).*



Four flakes with finely faceted platforms (CAT 3724, 3746, 5757, 8564) were recovered, one from tree-throw hole 1136 and three from BC 24, the same grid as the one from which the three refitting core tablets were retrieved. During the examination of the finds from Site 2D, several pieces initially defined as having finely faceted platforms turned out to be platform rejuvenation flakes, for which reason these four pieces were meticulously inspected. It does appear, though, that they are actually flakes with finely faceted platforms, with CAT 5757 being the most obvious piece. This specimen is an elongated flake (39 x 24 x 5mm) with parallel lateral sides and dorsal arrises (probably intended to become a blade), and its platform is clearly finely faceted. At the centre of its platform-edge, it even has a small spur, a feature defining it as a possible *en eperon* blank (Fig. 3.2). The *en eperon* technique is generally associated with the production of blades during the contemporary Hamburgian, Creswellian and late Magdalenian material cultures, dating to the Late Upper Palaeolithic period (cf. Ballin *et al.* 2010, Fig. 11)..

Cores

A total of four cores were retrieved from Zone 3, namely two single-platform cores, and two irregular cores. The cores were measured following the principles described in the methodology section.

One of the two *single-platform cores* (CAT 10068) is almost intact in the sense that it has shed a thin surface layer due to exposure to fire. It is a regular bullet-shaped conical core, measuring 41 x 34 x 30mm and, like many other cores from Site 2D, it was abandoned when a series of attempted blade detachments failed and developed deep hinge- and step-fractures. CAT 10091 is a slightly less regular, and slightly smaller, single-platform core, measuring 34 x 20 x 28mm. It has its flaking-front at the end of an elongated platform and could be described as a hybrid between a conical core and a handle-core (see discussion of handle-cores in Ballin & Barrowman 2015; Ballin forthcoming a).

The two *irregular cores* differ considerably in all respects. The smaller one (CAT 10082; 28 x 27 x 18mm) has been worked from three different directions without preparation of any form – its platforms are cortical and its platform-edges untrimmed. CAT 10095, on the other hand, is much larger (48 x 41 x 28mm), and although it has been worked from numerous directions, it was clearly worked in a schematic manner at an early stage of its 'life', and parts of it appear regular, with some edges being trimmed. However, as it has been attempted to 'work down' the core and exhaust its raw material, it is now impossible to determine whether this was once a large conical core or a Levallois-like core.

Tools

A small number of tools were retrieved during the excavation of Zone 3, namely two microliths, six microburins, one scraper, one piercer, and two pieces with edge-retouch.

The two microliths are one *obliquely-blunted point* (CAT 10576), and one indeterminate *fragment of a microlith* (CAT 11565). CAT 10576 is based on the distal end of a microblade (10.2 x 3.0 x 1.6mm), and although obliquely-blunted points are generally associated with the Early Mesolithic period (eg, Morton, Fife, and An Corran, Skye; Coles 1971; Saville *et al.* 2012), the dimensions of the present piece indicates a later date. The six *microburins* include proximal, medial and distal forms, and they are of roughly the same general size (average width 8.3mm). Four pieces (CAT 10344, 11550-2) with their notch in the LHS all represent successful deliberate breakage, having deveoped typical oblique microburin facets, whereas two pieces (CAT 10357, 11553) with their notch in the RHS are failed pieces which snapped straight across.

A *short end-scraper* (CAT 10227) is based on a primary bipolar flake (30 x 27 x 14mm), and it has a regular convex, steep working-edge at its distal end. The scraper-edge was formed by the application of pressure-flaking, and the regular appearance of this piece suggests that it may be post Mesolithic, probably dating to the period later Neolithic/Early Bronze Age (see for example the intrusive scrapers from the Early Neolithic site of Garthdee Road, Aberdeen; Ballin 2016a). The zone's solitary *piercer* CAT 10241 is based on a regular hard-hammer blade (24 x 11 x 5mm), and its well-executed tip is distal. The scraper and the piercer have both been used, and they are both in a form of high-grade, light-grey flint usually associated with importation from Yorkshire during the later Neolithic period (Ballin 2011b). Two pieces and fragments with varying forms of *edge-retouch* are thought to be artefacts, or fragments of artefacts, with different functions.

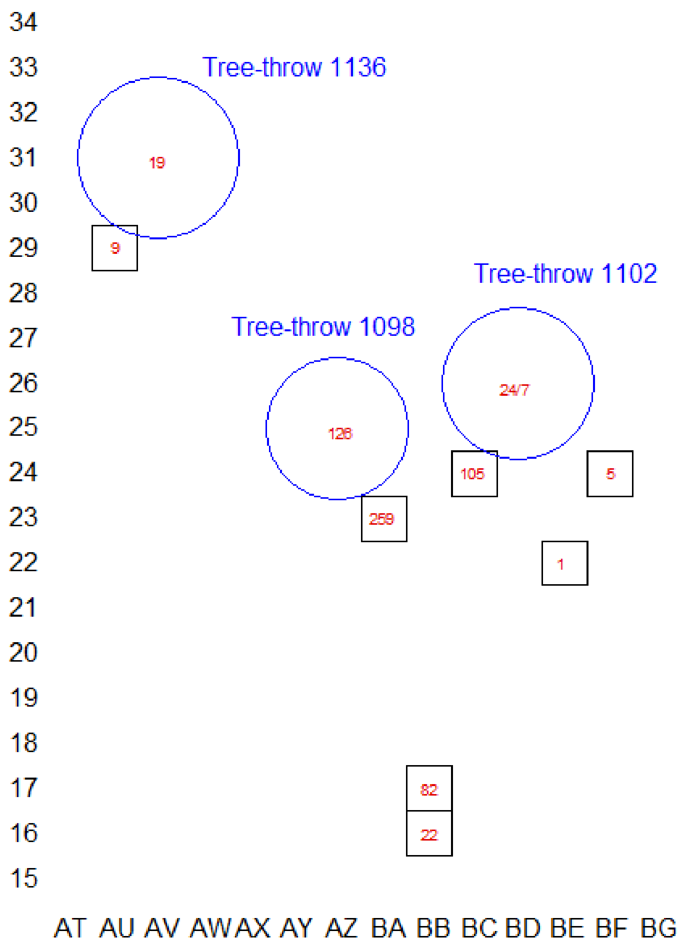
Table 3.3. The distribution across Zone 3's northern and southern parts of some chronologically relevant elements.

	BA 16/17 + surrounds	*BA 23/BC 24 + surrounds*
Blades	11	31
Microblades	12	21
Blades:microblades	1:1	3:2
Crested pieces		7
Finely faceted flakes	1	3
Platform rejuv flakes	1	3
Conical core	1	
Microliths	2	
Microburins	6	

Summary and discussion – Zone 3

The sub-assemblage from Zone 3 includes early as well as late elements (Table 3.3; Fig. 3.3), and although early and late material clearly overlaps spatially, the southern part of the area (grids BA 16/17 with surroundings) seems to be dominated by early finds, and the northern part (grids BA 23/BC 24 with surroundings) by later finds. The assemblage from BA 16/17 and neighbouring features includes a high proportion of microblades and narrow-blades, one typical conical microblade core, as well as some microliths and microburins, whereas the assemblage from BA 23/BC 24 and neighbouring features (particularly three tree-throw holes) includes broader blades, considerably higher numbers of preparation flakes (crested pieces and core tablets), and flakes with finely faceted platform remnants (which could date to the Late Upper Palaeolithic period as well as the later Neolithic; cf. Ballin 2011b; Ballin *et al.* 2010). As shown in connection with the discussion of the assemblage from Site 3B (this volume), the use of cresting and platform rejuvenation may have been minimal during the Late Mesolithic period.

Fig. 3.3. The distribution of worked flint across Zone 3. Red squares indicate higher than average (two-digit) find numbers.



Although it is generally impossible to dissect the full assemblage from Zone 3 into chronologically unmixed sub-assemblages, three radiocarbon-dates suggest that the area may have been visited at least three times during prehistoric times:

- The Late Mesolithic – 5312-5078 cal BC (SUERC-68113).
- The Early Neolithic – 3942-3707 cal BC (SUERC-68120).
- The Middle Neolithic – 3363-3104 cal BC (SUERC-58022).

The southern concentration is not covered by any of these radiocarbon dates, with the Late Mesolithic and the Middle Neolithic dates both relating to contexts within the tree-throw holes, whereas the Early Neolithic date is based on charcoal from Pit 1400 between the southern and northern concentrations. It is possible that some broad blades, broad crested pieces, refitting core tablets, and blanks with finely faceted platform remnants (not least those with apparent *en eperon* features) date to the Late Upper Palaeolithic period

Like the sub-assemblage from Zone 2, this sub-assemblage is best described as chronologically mixed, and the zone as a palimpsest with little research potential.

ZONE 4

Introduction

A total of 3,231 lithic artefacts were retrieved from gridded squares, with 16 pieces of knapping debris deriving from two post- or stakeholes in the central and northern parts of the general lithic scatter, and one simple flake from a post-medieval pit towards the southern end of the lithic scatter. The lithic artefacts make up six concentrations, each of which is thought to have had its own central hearth and which may therefore represent an individual visit to the area. Most of the finds (52%) were recovered from Concentration 1.

The combination of typological and technological lithic evidence from Zone 4 suggests that the sub-assemblage from this area includes not only finds from the Late Mesolithic, but also objects dating to the preceding Late Upper Palaeolithic period. Unfortunately, no radiocarbon-dates are available from this zone. All lithic artefacts from Zone 4 were exposed to typo-technological characterization and spatial analysis in the hope that this would increase the understanding of the zone's internal chronology and on-site behaviour.

In general terms, the Late Mesolithic finds from Zone 4 add to the evidence provided by contemporary lithic assemblages from the project, such as for example Site 3B, which may be an undisturbed single-occupation site (this volume). Most of these scatters are the remains of short-term visits during which the focus was on the production of microblades and microliths, probably to replace lost and damaged microlith inserts in composite hunting tools and weaponry.

The most interesting element of the assemblage from Zone 4 is its Late Upper Palaeolithic sub-assemblage. The relative distribution of microblades and macroblades suggests that Concentration 2 may have been the centre of the Palaeolithic settlement in the area, which is supported by the absence of microliths in and around this concentration. It is, however, likely that the scatter of large flint objects left by the pre-Mesolithic settlers was 'scavenged' or 'mined' by later Mesolithic people due to the easily accessible raw material source it represented, explaining the presence of large blades, crests and core tablets throughout Zone 4 as well as in the neigbouring Zones 3 and 5.

Due to the importance of these early pieces to the research into the first post-glacial settlers in Scotland, an effort was made to characterize them in detail, including the operational schema responsible for their production. As the Late Upper Palaeolithic material includes few implements, the definition of this group of objects as pre-Mesolithic is first and foremost based on the available technological evidence and comparison with the operational schemas of Late Mesolithic Scottish assemblages, such as those from the present project, as well as those of the main north-west European Late Upper Palaeolithic industries, the Hamburgian, *Federmesser-Gruppen*, and the Ahrensburgian.

General overview

This group of finds embraces 3,232 lithic artefacts. They are listed in Table 4.1. In total, 97.5% of this assemblage is debitage, whereas 0.3% is cores and 2.2% tools.

Table 4.1. General artefact list – Zone 4.

Debitage	
Chips	1,263
Flakes	1,048
Blades	428

Microblades	227
Indeterminate pieces	138
Crested pieces	37
Platform rejuvenation flakes	8
Total debitage	*3,149*
Cores	
Single-platform cores - conical	6
Single-platform cores - plain	2
Opposed-platform cores	1
Discoidal cores, plain	1
Total cores	*10*
Tools	
Obliquely blunted points	1
Scalene triangles	7
Frags of microliths	6
Frags of microliths or backed bladelets	7
Backed bladelets	2
Microburins	25
Krukowski 'microburins'	1
Frags of tanged or angle-backed points?	1
Idiosyncratic points	1
Backed blades (points?)	2
Db truncations (points?)	1
Short end-scrapers	3
Blade-scrapers	1
Side-scrapers	1
Straight truncation	1
Oblique truncation	1
Curved truncations	1
Pieces w edge-retouch	11
Total tools	*73*
TOTAL	**3,232**

Debitage

In total, 3,149 pieces of debitage were recovered from Zone 4 (Table 4.2). The debitage includes 1,263 chips, 1,051 flakes, 425 blades, 227 microblades, 138 indeterminate pieces, and 45 preparation flakes (37 crested pieces and eight platform rejuvenation flakes). In Ballin (1999), the author demonstrated that the chip ratio of sieved assemblages usually varies between *c.* 30% and 55%, and the chip ratio of the present collection is within this framework. A high chip ratio usually indicates that primary production took place at a location.

It should be noted that the assemblage from Zone 4 includes more than twice the number of preparation flakes than the largely Late Mesolithic assemblage from Zone 5 (this volume). It is thought that this may be due to Zone 4 having been the the focal point of the Late Upper

Palaeolithic presence at Site 2D, from which individual pieces then spread into the area around Zone 4 (see the other Site 2D sub-assemblages). The difference between the Late Upper Palaeolithic operational schema and that of the Late Mesolithic settlers in the area is discussed below (among other things characterized by high and low numbers of preparation flakes).

Table 4.2. Relative composition of the debitage.

	n	*%*
Chips	1,263	40
Flakes	1,051	33
Blades	425	14
Microblades	227	7
Indeterminate pieces	138	4
Preparation flakes	45	2
Total debitage	*3,149*	*100*

The blanks (Table 4.2) are dominated by flakes (33%), but blades and microblades are also common (21%). It is thought that the zone is characterized largely by Late Mesolithic settlement, but with a notable Late Upper Palaeolithic presence, and the two industries focused on the production of microblades/narrow-blades (primarily for microliths and to an extent cutting implements) and very large broad-blades (possibly for backed and/or tanged points, as well as cutting implements), respectively. Flakes, mainly from the shaping of the blade cores, occasionally found use as blanks for scrapers and other robust tool forms. The flake:blade ratio is 62:38.

Table 4.3. Reduction sequence of the flakes and blades.

	Quantity		**Per cent**	
	Flakes	*Blades*	*Flakes*	*Blades*
Primary pieces	99	1	9.4	0.1
Secondary pieces	378	100	36.1	15.3
Tertiary pieces	571	554	54.5	84.6
TOTAL	**1,048**	**655**	**100.0**	**100.0**

The different nature of the blades and the flakes (target blanks and mainly waste) is demonstrated by Tables 4.3 and 4.4. The flakes include many primary and secondary pieces (almost 50% of them are cortical), whereas the blades are mostly tertiary (*c.* 85% inner pieces). In addition, the flakes and blades were produced by the application of different technological approaches, where many flakes (35%) were produced by the application of hard percussion, whereas most blades (81%) were produced by the application of soft percussion (the use of either a punch or a pressure-flaker; cf. Inizan *et al.* 1992, 63; Sørensen 2006, 57).

The fact that the flakes are mostly waste from the decortication of nodules, whereas the blades are the intended products of the reduction process, should have resulted in two more distinct technological groups (Table 4.4). The fact that the difference between the two groups is not more distinct (such as the fact that 34% of the flakes were produced by the application of soft percussion), may largely be due to prehistoric 'production errors', with some intended blades turning out shorter than planned. Most soft percussion flakes from Zone 5 have regular, parallel dorsal arrises and parallel lateral sides, and they could be defined as failed blade blanks.

Table 4.4. Applied percussion techniques: definable unmodified flakes and blades.

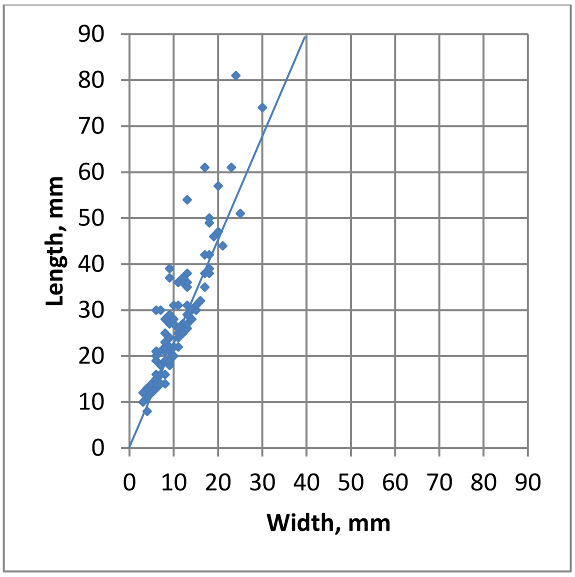
	Quantity		Per cent	
	Flakes	*Blades*	*Flakes*	*Blades*
Soft percussion	153	255	33	81
Hard percussion	163	22	35	7
Indeterminate platform technique	47	6	10	2
Platform collapse	84	30	18	9
Bipolar technique	16	2	4	1
TOTAL	**463**	**315**	**100**	**100**

Fig. 4.1 shows the length:width of all intact blades and microblades from Zone 4, with blades/microblades having average dimensions of 27 x 11 x 4mm. In Aberdeenshire this is consistent with a date within the framework of the Late Mesolithic to the earliest part of the Early Neolithic (cf. Ballin 2013a; 2016a). As mentioned in connection with the discussion of the blades from Site 3B (this volume), it should be borne in mind, that Mesolithic blades and microblades are delicate objects which break easily, and that intact pieces probably represent a site's more robust pieces (Ballin 2004b). On this background, it is suggested that the original blades produced within Zone 4 were generally somewhat longer, narrower and thinner than indicated by the average dimensions above.

The line running through the diagram defines the metric border between flakes and blades, and it is obvious (as indicated by the cluster's truncated nature) that, in Zone 4, metric blades and flakes formed a continuum, as was also the case at this project's Site 3B (this volume), and at the Early Neolithic site Garthdee Road in Aberdeen (Ballin 2016a). The truncated nature of Fig. 4.1 is due to the fact that flakes were not measured during the cataloguing of the lithic finds from the project (see methodology, above).

In Fig. 4.1, the blades from Zone 4 form a dense cluster below L=40mm,very much like the blades from Zone 5. It is thought that these blades may be the Late Mesolithic target microblades and narrow-blades. In connection with the discussion of the blades from Zone 5 and those from Site 3B (this volume), it was suggested that the loose extension of this cluster between L=40-50mm may mainly be coarser blades from the initial part of the Late Mesolithic operational schema, produced in connection with core preparation and detachment of the very first blades from the conical blade cores. The much larger broad-blades in Fig. 4.1 between L=50-80mm are likely to be pre Mesolithic pieces (see Table 4.6, below).

Figs 4.1-2. The main dimensions of the blades from Zone 4 (Fig. 4.1) compared to the blades from Zone 5 (Fig. 4.2).



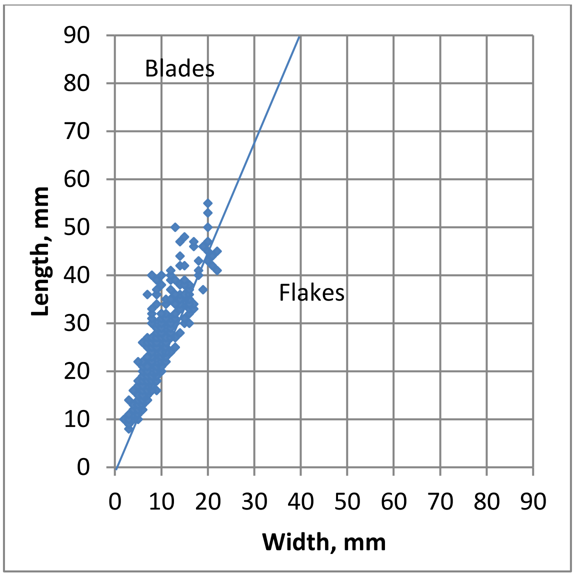
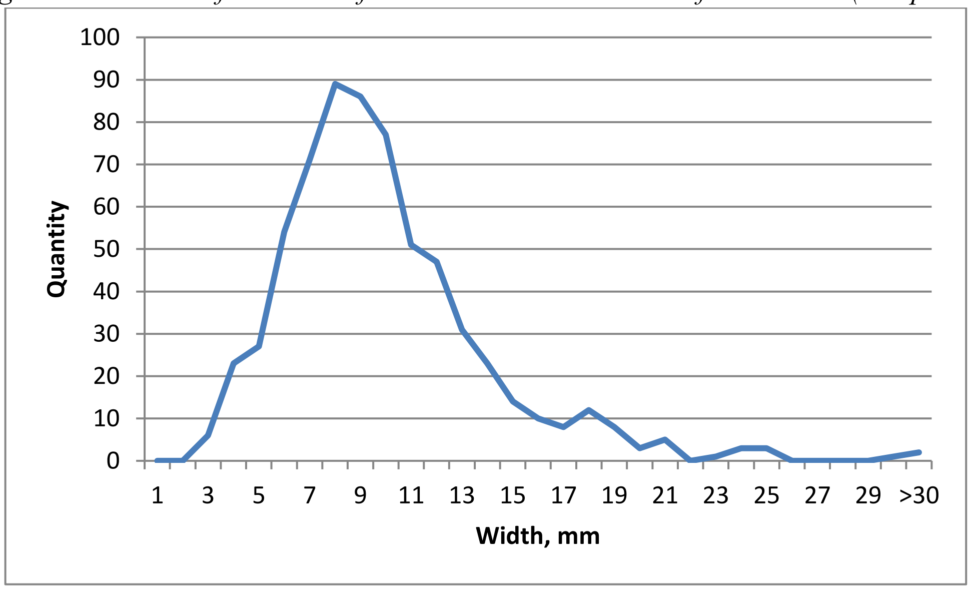


Fig. 4.3 shows the width of all Zone 4's intact blades and microblades. The diagram's curve is almost perfectly bell-shaped, with a peak at W=8-9mm, suggesting that the area's Late Mesolithic blades may have been produced and/or deposited within a very narrow chronological horizon, such as a segment of the Late Mesolithic period. Some of the minor peaks or 'dimples' in the right side of the curve may represent larger specimens produced at the beginning of the site's operational schema (see technology section) but, as mentioned above (Figs 4.1-2), some of the largest blades are almost certainly Late Upper Palaeolithic pieces. Some of the largest blade fragments have widths of 30-40mm, and it is estimated (Table 4.6) that some of those may have been 120-150mm long.

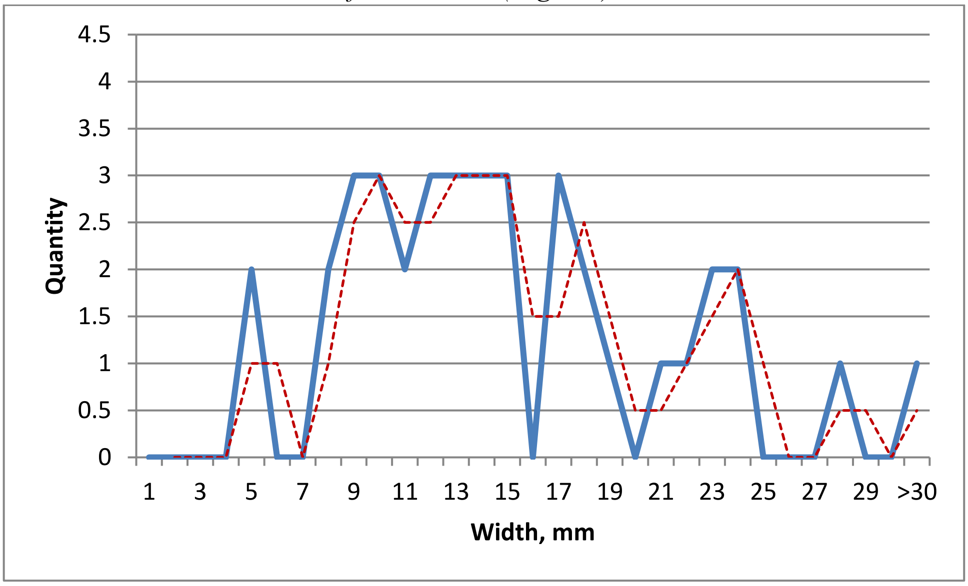
Fig. 4.3. The width of all unmodified blades and microblades from Zone 4 (655 pieces).

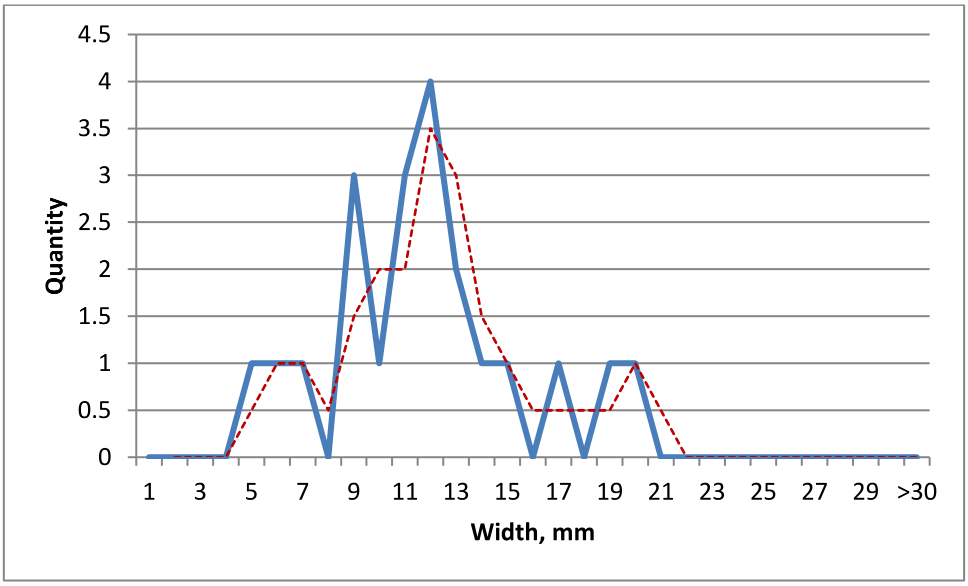


The 45 preparation flakes include 37 crested pieces and eight platform rejuvenation flakes. Nine of the crests are flakes, whereas 25 are broad-blades, and three are microblades (Fig. 4.4).

Fig. 4.5 shows the width of the crested pieces from Zone 5, demonstrating how much smaller and more delicate those pieces are, supporting the suggestion that the sub-assemblage from this area has a Late Upper Palaeolithic component, as well as the suggestion that core preparation was much more common in connection with Late Upper Palaeolithic reduction than with Late Mesolithic reduction (see the Zone 4 technology and dating sections, below). The largest intact crested piece (CAT 3187) measures 65 x 23 x 8mm (the largest fragmented crest [CAT 10110] 93 x 33 x 19mm), and the smallest (CAT 10188) 13 x 10 x 2mm. These blades were detached in equal measure by soft and hard percussion. The largest crested pieces are more likely to be cortical than the smaller ones, indicating that the Late Upper Palaeolithic crests may have been produced in connection with the initial core preparation, as well as core adjustment between the various blade series, whereas the Late Mesolithic crests may mostly have been manufactured in connection with core adjustment during blade production.

Figs 4.4-5. The width of all crested pieces from Zone 4 (Fig. 4.4), and comparison with the crests from Zone 5 (Fig. 4.5).





The smallest platform rejuvenation flake (CAT 10158) measures 9 x 19 x 2mm, whereas the largest (CAT 10139) measures 34 x 29 x 12mm, and all technologically definable pieces were detached by the application of hard percussion.

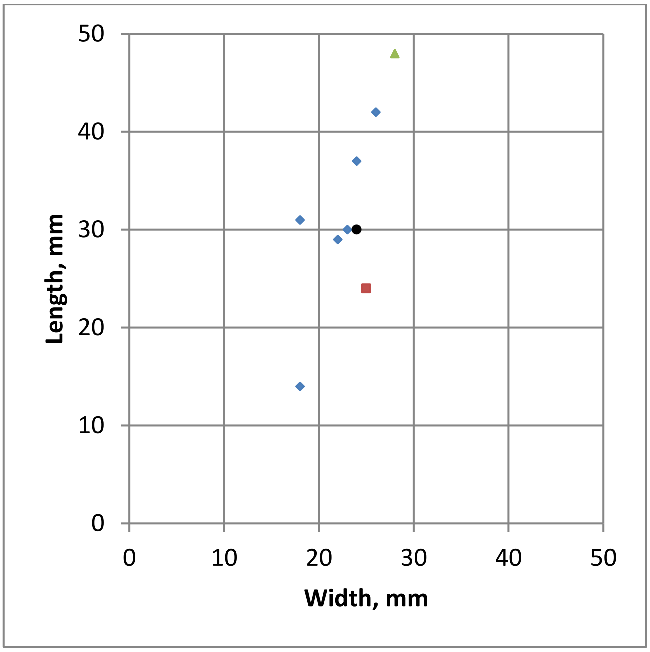
A total of 14 flakes and blades have been defined as having finely faceted platforms, a feature associated with the preparation of the platform-edges of blanks produced during two prehistoric periods, namely the Middle/Late Neolithic period (the Levallois-like approach; Ballin 2011a; Suddaby & Ballin 2010) and the Late Upper Palaeolithic period (in Scotland certainly the Hamburgian; Ballin *et al.* 2010). Originally, this group of artefacts was numerically larger, but by closer scrutiny, several of these pieces turned out to be platform rejuvenation flakes. It can not be ruled out that a proportion, even most, of the remaining group are also core tablets. One piece, however, appears to be a particular form of finely faceted with a small spur at the proximal end (CAT 5228). These pieces are referred to as *en eperon* flakes and blades, and they are generally a feature of a number of contemporary Late Upper Palaeolithic industries, such as the Hamburgian.

A total of 1,170 pieces have been exposed to fire, or 36% of the entire sub-assemblage. Most of this material is knapping debris, but 35 pieces are cores, microliths, microburins, and pieces with edge-retouch, showing that in prehistory not only the production of blanks and tools, but also the use of them, took place at domestic fireplaces (see distribution section). Practically all these pieces are Late Mesolithic cores and implements. Almost all (132 of 138) indeterminate pieces are burnt and probably represent flakes and blades which could not be defined more precisely due to the fire-induced loss of their ventral faces.

Cores

A total of 10 cores were recovered from Zone 4: six conical single-platform cores, two plain single-platform cores, one opposed-platform core, and one discoidal core. The cores were measured following the principles described in the methodology section.

Fig. 4.6. The dimensions of all intact cores: conical single-platform (blue); plain single-platform cores (red); opposed-platform cores (green); and discoidal cores (black).



Single-platform cores: The single-platform cores from Zone 4 (Table 4.1) are separated into 'proper' conical cores (six pieces) and less regular ones (two pieces). In Fig. 4.6, the conical cores (apart from 14mm long 'outsider' CAT 10135) form a cluster of pieces with lengths between *c*. 30-40mm, whereas the plain single-platform cores are shorter (only one piece is intact). The five 'standard' conical cores have average dimensions of 34 x 23 x 21mm, whereas the completely exhausted conical core CAT 10135 measures 14 x 18 x 9mm. The intact plain single-platform core (CAT 10076) measures 24 x 25 x 13mm, defining it as quite flat.

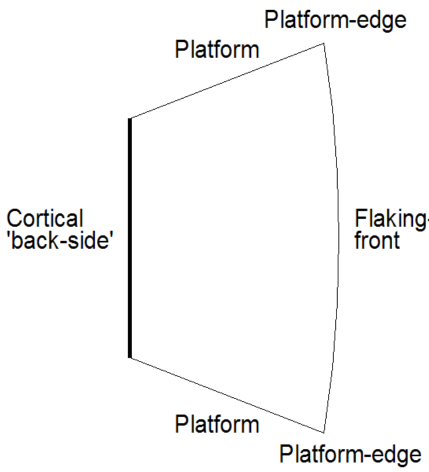
Apart from conical core CAT 10064, which has a faceted platform, all single-platform cores have a plain platform, and they all have a neatly trimmed platform-edge. All the single-platform cores have some cortex, but three cores (CAT 10076, 10084, 10088) have retained so much cortex that they were described as having a cortical 'back-side'. The character of the platforms suggests that they were not prepared but formed when a raw pebble was split into two core rough-outs, as demonstrated through refitting of cores platform-to-platform on Site 3B (this volume). It is thought that cresting may not generally have been used in connection with the initial preparation of the Late Mesolithic single-platform cores (see discussion in connection with the presentation of the cores from Site 2D Zone 5 and Site 3B; this volume), but that cresting was used during blank production to adjust the shape of the cores. CAT 10064, for example, has a neat 'second-generation' crest running along one side of its flaking-front, which is characterized by regular microblade scars. Some of the single-platform cores were abandoned when they either developed deep hinge- or step-fractures (eg, CAT 10064, 10084) or when a blade overpassed and removed the core's apex (eg, CAT 10076).

Interestingly all but one (CAT 10064) of the single-platform cores are heavily burnt. Two were found by the fireplace identified in Grid BM 27 (see distribution section), whereas the remainder were scattered across the site (ie, *near* but not *in* the hearths), probably indicating that these relatively large pieces were kicked around in connection with later visits to the area, although the morphological and size-wise homogeneity of the Late Mesolithic material (eg, the blades; above) indicates that these visits took place within a relatively narrow time-frame. In connection with the pieces being burnt, expanding, and cracking, CAT 10078 split into two parts, a platform end and an apex, which were successfully conjoined.

Opposed-platform cores: Only one opposed-platform core was recovered from Zone 4 – and from Site 2D in general – namely CAT 10059. This piece is assumed to be a Late Upper Palaeolithic object (discussed below), and although it is relatively small (48 x 28 x 27mm) compared to the large crests and opposed-platform blades recovered from the area (see Table 4.6), it is of a type usually associated with the well-known north-west European industries of this period, and it is the largest core retrieved from Zone 4 (Fig. 4.6).

This core has a cortical 'back-side', and like for example Hamburgian opposed-platform cores from Denmark and northern Germany (eg, Madsen 1992, Fig. 81.B; Weber 2012, Fig. 32), its two platforms are sloping, with platform-edge angles of *c*. 65° (Fig. 4.7). The two platforms are plain, and the platforms' ripples show that both platforms have had core tablets removed by strikes to the flaking-front. The two platform-edges display regular trimming, combined with abrasion. The flaking-front is characterized by parallel scars of blades struck from both platforms.

Fig. 4.7. Section of CAT 10059.



Discoidal cores: One discoidal core (CAT 10098) was found during the excavation of Zone 5, and this piece is a slightly idiosyncratic, probably expedient piece. It measures 30 x 24 x 16mm, and it is probably based on a primary flake, from the ventral face of which small flakes were struck.

Tools

The 73 tools from Zone 4 (Table 4.5) include a small number of separate implement categories, such as 24 microliths and microlith-related implements (33%), 34 microburins (34%), five points or likely points (7%), five scrapers (7%), three truncated pieces (4%), and 11 pieces with edge-retouch (15%).

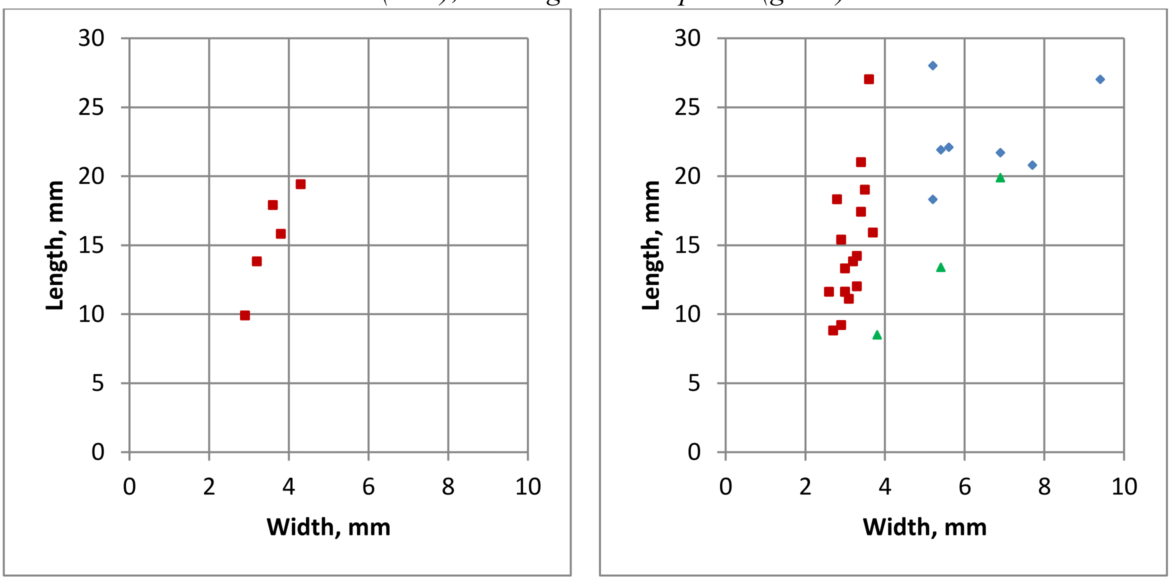
Table 4.5. Generalized list of the tools from Zone 4.

	n	*%*
Microliths	9	12

Frags of microliths/backed bladelets	13	18
Backed/truncated bladelets	2	3
Microburins	25	34
Points	5	7
Scrapers	5	7
Truncations	3	4
Pieces w edge-retouch	11	15
TOTAL TOOLS	**73**	**100**

Microliths and 'microlith-related implements': This category embraces a number of formal types, including one obliquely blunted point, seven scalene triangles, two backed bladelets, 13 fragments, and one so-called Krukowski 'microburins' (which is more likely to be a microlith, or the fragment of a microlith, than a microburin; see below).

Figs 4.8-9. Fig. 4.8) The main dimensions of the scalene triangles from Zone 4. Fig. 4.9) The scalene triangles, crescents and edge-blunted pieces from Zone 5 (this volume); scalene triangles (red); crescents (blue); and edge-blunted pieces (green)..



Obliquely blunted points: Only one obliquely blunted point was recovered (CAT 10466), and measuring 17.3 x 10.8 x 4.3mm it is considerably larger than for example the pieces from Zone 5 (av. dim.: 13.8 x 5.2 x 1.5mm). At its base it retains part of its original platform remnant, and at the distal end it has an oblique truncation orientated towards its LHS, associated with the remains of a sharp microburin facet. Its modification is relatively crude and slightly denticulated. CAT 10466 is burnt, and it was recovered from Grid BM 27, the centre of the main concentration's hearth (as identified by the distribution of burnt flint; below).

Scalene triangles: The only formal microlith type present is the scalene triangle. No crescents or edge-blunted pieces were retrieved from the area. As shown in Figs 4.8-9, the size of the triangular microliths from Zone 4 corresponds roughly to that of the triangular microliths from Zone 5. Five of the seven scalene triangles are intact, and they measure on average 15.4 x 3.6 x 1.8mm, varying in length between 9.9mm and 14.4mm. Like the specimens from Zone

5, these pieces are slightly narrower than the ones from the numerically much larger assemblage from Nethermills Farm at Banchory, Aberdeenshire (Ballin 2013a). Only five scalene triangles from Site 3B are intact. In all cases, the shortest retouched side is proximal, and all scalene triangles have their two retouched short legs orientated towards the left.

Backed bladelets: The group of modified bladelets from Zone 4 only includes backed specimens (CAT 10465, 10478); no truncated bladelets were found. They are generally defined by having retained their bulbar ends. Both backed bladelets have retouch along their LHS. They are both proximal fragments, and their width varies between 4.1mm and 4.4mm.

Fragments of microliths and microlith-related implements: These edge-modified fragments were subdivided into two groups, namely 1) fragments of microliths, and 2) fragments of microliths or backed bladelets. *Proximal* fragments which had clearly had their bulbar ends removed, but which could not be formally defined as belonging to one or the other specific microlith type, were referred to the former category, whereas *medial* and *distal* fragments, which would not allow the character of their proximal ends to be defined, were referred to the latter category. Overall, six fragments of microliths were recovered, and seven fragments of microliths or backed bladelets. The pieces included in these two categories have an average width of 5.0mm; two-thirds of these fragments have a retouched left lateral side, and one-third a retouched right lateral side.

Krukowski 'microburins' (Krukowski 1914): For definition and discussion of this type, see the methodology section. It is recommended to refer to the group as 'Krukowski pieces' rather than 'Krukowski microburins', as it is highly likely that the group includes few or no actual microburins. Only one such piece was recovered from Zone 4 (CAT 10504). It has a fully retouched LHS, and a surviving microburin facet at the proximal end, and it has a width of 4.5mm. This piece may – due to its roughly scalene triangular outline – have been used as a scalene triangle without further modification of its sharp *piquant triédre*.

Microburins: A total of 25 microburins were recovered from the area. They include 18 proximal variants, three distal ones, and four are medial (proximal:distal ratio 86:14). In connection with the analysis of the microburins from Site 3B it was shown that the proximal variants are somewhat broader than the distal forms, which is a function of the generally tapering shape of most blades/microblades. Due to the relatively low number of distal microburins from Zone 4, it was not possible to replicate this trend diagrammatically.

The average width of the 25 microburins is 7.8mm. A total of 23 pieces (or 92%) had their notch in the LHS, and the remainder in the RHS. As many as 17 pieces (or 68%) were broken successfully, forming the required sharp microburin facet, whereas the remainder simply snapped straight across. It is thought that the presence of left and right-side notches relate to the presence in prehistory of left-handed and right-handed people (cf. Andersen's [1982] discussion of right- and left-handedness amongst people in the Danish Maglemosian).

Fig. 4.10. The width of all microliths and microlith-related implements, incl. frags (blue), and all microburins (red). Due to the low numbers (24 microliths and microlith-related implements and 34 microburins), the original curves fluctuated considerably. The diagram's curves are the trendlines (moving average) of the original curves, which made the lines less wavy and more easily interpretable.

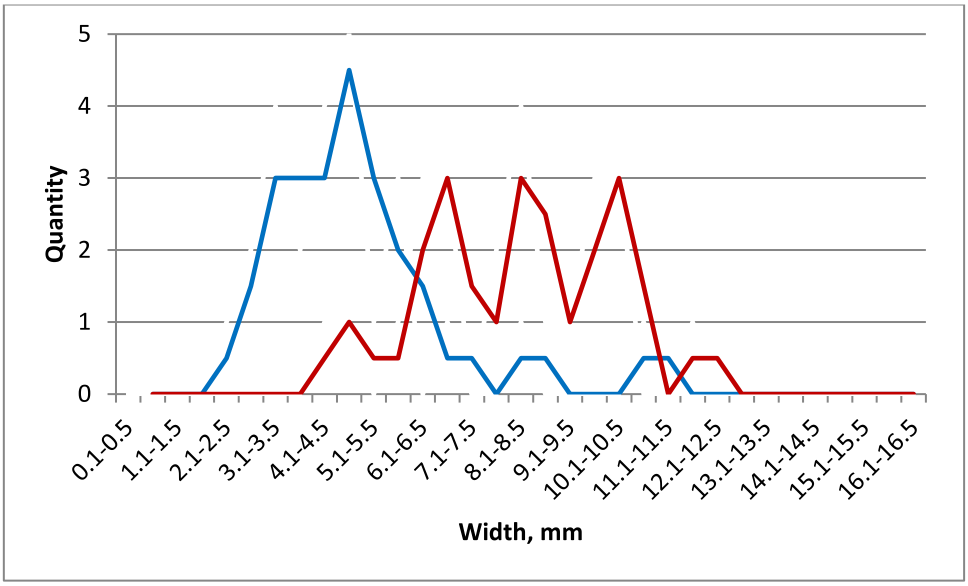
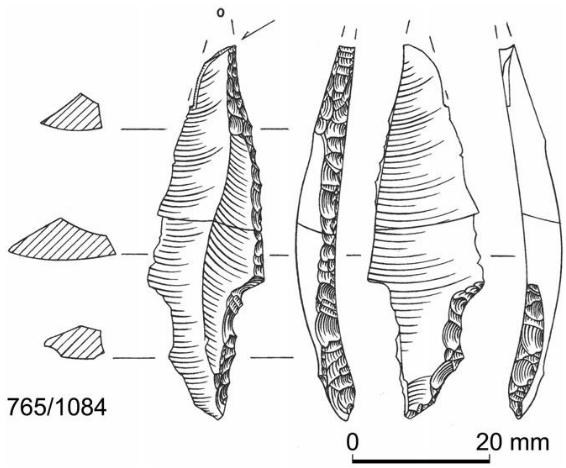


Fig. 4.10 shows the width of all microliths and microlith-related implements compared to the width of all microburins. Generally, the microliths tend to be approximately half as wide as the microburins, demonstrating how much of one lateral side was removed in connection with the modification of the microliths, whereas the width of the microburins correspond approximately to the width of the original microblade blanks selected for microlith production (above).

Points and likely points: This category includes five pieces which may be Late Upper Palaeolithic points, or fragments thereof. They have been defined in the following fashion: one fragment of a tanged or angle-backed point (CAT 10265), one idiosyncratic point (CAT 10456), two backed blades (CAT 10289, 10567), and one double-truncated piece (CAT 10236).

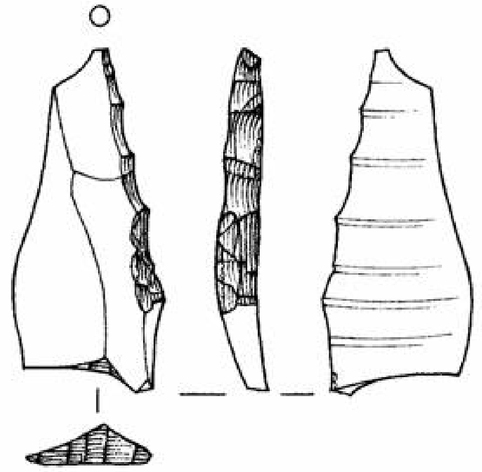
CAT 10265 is the outermost tip of a blade-based point, and it measures 15.5 x 8.0 x 2.2mm. The tip is distal, and the retouch straight. The angle of the retouch against the opposed lateral side is considerably more acute than what would usually be expected from a simple truncated piece, and it corresponds better to the tip of an Upper Palaeolithic tanged point (Fig. 4.11), although it can not be ruled out that this fragment broke off an angle-backed point. Similar fragments are present in the Hamburgian Howburn assemblage from South Lanarkshire (Ballin *et al.* 2010; forthcoming). The retouch was carried out *sur enclume* ('on an anvil'), which is a typical feature of Late Upper Palaeolithic points, and found less commonly in connection with microliths. During *sur enclume* modification of an edge, small chips were detached from the lateral edge by strikes to both faces.

Fig. 4.11. Howburn point w acutely-angled tip retouch similar to that of CAT 10265 (drwn by Hazel Martingell).



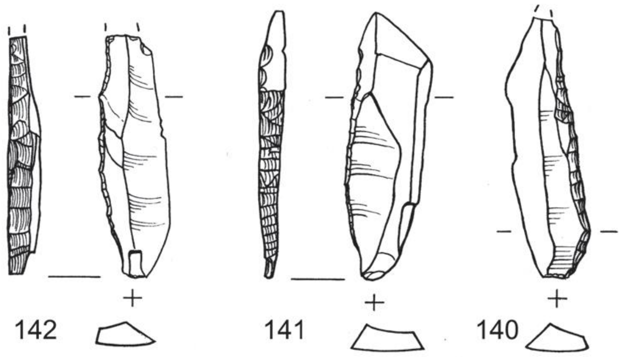
CAT 10456 is a roughly triangular point, with a distal tip and a straight base. Its left lateral side is almost fully covered by retouch, which is straight. It measures 28.6 x 10.8 x 3.2mm. It is quite possible that this type of point represents the repair of a tanged point, like the piece from Howburn illustrated in Fig. 4.12, where the broken-off tip of a tanged point was transformed into a triangular point. As the shape of this and similar pieces do not fit any of the well-known standard point types from the north-west European Late Upper Palaeolithic, it was characterized as 'idiosyncratic'. The modification of CAT 10456 was also carried out *sur enclume*.

Fig. 4.12. 'Idiosyncratic' point from Howburn, South Lanarkshire (drawn by Marion O'Neil).



CAT 10289 and CAT 10507 are both backed blades, they are both missing the distal end, and they are both considerably larger than the Late Mesolithic backed bladelets described above. The former measures 20.1 x 8.6 x 3.0mm, and the latter 27.1 x 9.4 x 3.7mm. Both have robust straight retouch along the entire LHS, and the modification of CAT 10567 was carried out *sur enclume*. The best comparative material for these two pieces is the assemblage from the assumed Late Upper Palaeolithic *Federmesser-Gruppen* site of Kilmelfort Cave near Oban (Fig. 4.13), which includes a relatively large number of backed blades and backed points (Saville & Ballin 2009, Table 3; Illus 5).

Fig. 4.13. Kilmelfort Cave backed points/blades (drawn by Marion O'Neil).



CAT 10236 is a slightly unusual double-truncated blade, measuring 36 x 16 x 4mm. The size and notably high quality of the blade blank indicates a non-Mesolithic date, and it is possible that this piece may be a form of angle-backed point or insert for a composite cutting implement. The two truncations are straight to slightly oblique, giving the piece a weakly developed trapezoid shape, corresponding to some Creswellian pieces (Jacobi 2004). Although double-truncated pieces like this are uncommon in British Neolithic contexts (eg, Butler 2005; Saville 2006), it is possible that it may be a later cutting tool or sickle insert, and the use-wear of the piece should be tested. Although diagnostic Neolithic flint is uncommon on Site 2D, some pieces are present, and a post Mesolithic date can not be ruled out.

Scrapers: The five scrapers form a heterogeneous, but interesting, group. CAT 10507 is a large (70 x 34 x 15mm) blade-scraper based on a crested piece, and it has a convex, acute scraper-edge at its distal end. The size defines this object as almost certainly a Late Upper Palaeolithic piece, as does the acute scraper-edge. This type of working-edge is rare or absent on post Palaeolithic scrapers, although some are known from later Neolithic contexts (Ballin 2011b). However, they are quite common at Howburn, which was dated to the Hamburgian period (Ballin *et al.* 2010, Figs 8-9).

Three short end-scrapers differ considerably in terms of appearance. CAT 10214 is a large oval piece (45 x 31 x 8mm) with a steep convex working-edge. Its dorsal scars indicate that, although the tool blank is a flake, it was struck off a large blade-core and this implement is also likely to be of a Late Upper Palaeolithic date. CAT 10215 is a considerably shorter flake-based piece (29 x 27 x 7mm) with a straight, steep working-edge. Again, the dorsal scars indicate that it was detached from a large blade-core. However, due to the implement being fairly squat, this is not as certain as in the previous case. This scraper *may* be Late Upper Palaeolithic. CAT 10217 is a small expedient scraper (27 x 21 x 6mm) with a slightly convex, steep scraper-edge. It is based on a plain irregular waste flake.

The category also includes an expedient side-scraper on a relatively large crude waste flake (34 x 48 x 18mm). It has a straight, steep working-edge along its longest edge.

Truncated pieces: The tree truncated pieces include one piece with a straight truncation (CAT 10213), one with an oblique truncation (CAT 10235), and one with a curved truncation (CAT 11539). The former piece is an intact squat flake (18 x 20 x 7mm) with distal modification, and its RHS has use-wear, probably from being used as a knife. The other two pieces are the distal parts of broad blades (W = 12-13mm), and CAT 10235 has flat macroscopic use-wear of both lateral edges. Due to the fragmentation, it is not possible to determine whether these pieces are the remains of knives or points.

Pieces with edge-retouch: Eleven lithic artefacts display various forms of lateral modification. Five are based on flakes, and six on blades. These pieces differ considerably in shape and size (GD 14-91mm), and it is thought that this tool group includes artefacts, or fragments of artefacts, with different functions. However, one piece stands out, namely CAT 10291. This piece is a long secondary soft percussion blade, measuring 91 x 24 x 10mm. It has retouch at its proximal end, left lateral side, and at the distal end it has obvious flat use-wear from the use as a knife. The retouch is somewhat abraded, and it is possible that this is a polished-edge implement, like the pieces recovered from Zone 5 (this volume). As such, it testifies to the movement of people across Site 2D, between the various zones. As this long blade clearly belongs to the group of Late Upper Palaeolithic artefacts recovered from Site 2D, and mainly Zone 4, and as the Zone 5 polished-edge implements are thought to date to the Late Mesolithic, this also supports the idea of the Palaeolithic remains probably having been 'mined' by the later Mesolithic settlers in the area.

Technological summary

This technological summary is based on information presented in the debitage (tool blanks and waste), core and tool sections above. In connection with the presentation of the lithic artefacts from Zone 4, it was suggested that the area may have been visited a number of times during early prehistory, and it has been possible to define two main – and very different – technological approaches associated with Zone 4, namely 1) a general Late Mesolithic approach; and 2) a Late Upper Palaeolithic approach.

The Late Mesolithic approach: Although the distribution analysis (below) suggests possibly five visits to the site during the Late Mesolithic period (with each visit being focused on its own central hearth), the basic operational schema applied by all Mesolithic settlers within Zone 4 is fundamentally the same. This schema corresponds to the one defined in connection with the analysis of the finds from Site 3B. The fact that the widths of the blades (Fig. 4.3) form an almost perfect bell-shape (apart from some minor peaks towards Fig. 4.3's right margin, which are thought to be associated with the area's large Palaeolithic blades) suggests that the Mesolithic visits took place within a very narrow time-span.

It is possible to summarize the Late Mesolithic approach, or operational schema, in the following manner (cf. the discussion of the assemblages from Site 3B and Zone 5, this volume):

1. *Procurement*: The dimensions of the recovered microblades/narrow-blades and microblade cores, in conjunction with the presence of abraded cortex, suggest that pebbles were collected from North Sea beach walls approximately 12km away. In contrast to Site 3B, which was situated further away from a water-course, Site 2D was located close to the River Dee which would have made transport of raw flint easy. The size of the artefacts and the curvature of the outer surfaces of the cores suggests a general size of these nodules of *c*. 40-70mm.
2. *Opening*: At Site 3B, some cores were refitted platform-to-platform, indicating that rather than opening pebbles by detaching a primary so-called 'opening flake', pebbles were opened by simply splitting them across, thus forming two core rough-outs with ready-made plain striking platforms. This may also have been the approach followed by the Late Mesolithic visitors to Zone 4.

3. *Heat-treatment?*: At Site 3B, a number of factors indicated that raw flint pebbles may have been heat-treated. These indicators (burnt pebbles, blades and cores with shiny surfaces) are not present in the Zone 4 Late Mesolithic sub-assemblage, but it is not possible to rule out that heat-treatment of flint took place.
4. *Core preparation*: At Site 3B, the evidence suggested that, prior to initiation of blank production, the Late Mesolithic cores received little other core preparation than platform-edge trimming. In contrast to this scenario, the present sub-assemblage includes a notable number of crested pieces (38 pieces). However, these pieces tend to be quite large, and they probably relate to the zone's Late Upper Palaeolithic material. Some narrow crests probably relate to the Late Mesolithic visits to the area and appear to be crests created *during* the reduction process to adjust core shape between blade series rather than to prepare the early-stage cores *prior* to the initiation of this process. Seven platform rejuvenation flakes are generally quite large and, apart from one relatively small specimen, they have GDs of *c*. 30-40mm. These pieces probably also relate to the zone's Late Upper Palaeolithic settlers. The character of the mostly plain platforms of the Late Mesolithic conical cores supports the view (see Site 3B) that, during this period, platforms were in most cases not rejuvenated.
5. *Blank production*: The Late Mesolithic visitors to the area produced two forms of blanks, namely squat, mainly hard-hammer flakes (most of Zone 4's 1,051 pieces) and elongated regular soft-hammer (pressure-flaked) microblades/narrow-blades (most of Zone 4's 652 pieces). The flakes are probably mainly waste from the decortication of blade cores, although some blanks for, for example, scrapers may have been produced from simple flake cores, which were subsequently 'tossed' out of the site in connection with 'preventive site maintenance' (Binford 1983, 189). The surviving cores are predominantly neat conical single-platform cores from the focused production of microblades and narrow-blades (widths *c*. 5-13mm), most likely for the manufacture of microliths.
6. *Tool production*: The tools from the area include four main groups, namely microliths and microlith-related implements (24 pieces, supplemented by 34 microburins), points (five pieces), scrapers (five pieces), and truncated pieces or knives (three pieces). However, the points and most of the scrapers are probably Late Upper Palaeolithic pieces, and apart from possibly one or two of the scrapers and truncated pieces, the Late Mesolithic production in Zone 4 appears to have focused almost entirely on the manufacture of microliths. The microliths are all based on regular soft-hammer microblades or narrow-blades. As indicated by the approximate numerical parity between microliths and microburins (24:34), most microliths were manufactured by the application of microburin technique, although some may have been produced either by simply snapping off the proximal end or by retouching obliquely through the bulbar area (approaches demonstrated at Site 3B and in Site 2D's Zone 5). In this zone, the microliths are dominated notably by scalene forms, supplemenetd by a small number of obliquely blunted pieces, Krukowski pieces, and backed bladelets. Due to the mixture of Late Mesolithic and Late Upper Palaeolithic material, it is not possible to determine whether different types of blanks were preferred for different types of non-microlithic tools during the Late Mesolithic visits to the area.

Table 4.6. Selected likely Late Upper Palaeolithic pieces from Zone 4 and other parts of Site 2D.

The Late Upper Palaeolithic approach: A Late Upper Palaeolithic presence at Site 2D, focusing on Zone 4 (but with individual artefacts also having been recovered from other parts of the site), is suggested by finds associated with an operational schema differing *fundamentally* from that associated with the operational schemas of traditional Late Mesolithic settlers in eastern Scotland (eg, the one above, and the ones defined in connection with the assemblages from Zone 5 and Site 3B). The lithic evidence from Zone 4, supplemented by finds from other zones, suggests an approach, or operational schema, for the Late Upper Palaeolithic visitors to Site 2D as follows:

1. *Procurement*: In Table 4.6, the most obviously pre-Mesolithic artefacts from Site 2D are listed. The finds include several other likely, but less certain, artefacts from this period, which are not included in this table. Table 4.6 includes information on the size of intact objects, as well as the estimated size of broken pieces, and it is thought that some of these artefacts may have had lengths of between 120-150mm. As this operational schema includes serial detachment of core tablets and crests, many of the original nodules are likely to have been larger than this. However, it is certain that several of the raw flint nodules procured would have been up to, and possibly larger than, 150mm. Flint pebbles presently available along the North Sea coast, and (according to the evidence from many Mesolithic sites from the region; eg, assemblages from the present project as well as from Nethermills Farm; Ballin 2013a) those available at any time after the formation of the North Sea would mostly have been in the order of 40-70mm. It is therefore likely that the flint procured by Zone 4's Palaeolithic settlers was procured from sources no longer available, such as outcrops on Doggerland (Ballin 2016d; Ballin & Bjerck 2016; Brooks *et al.* 2011; Sturt *et al.* 2013). It is known that, today, flint corrresponding in type and quality to the first-class flint mined or collected in prehistoric Yorkshire or East Anglia is available from sources in the North Sea (Harker 2002)
2. *Opening*: As the target blanks of this industry were long broad-blades, rather than microblades, core rough-outs were not created by splitting small pebbles into two, but by removing a primary opening flake from large nodules (see for example rejuvenation flake CAT 10120). This allowed sizeable opposed-platform core rough-outs to be formed, and subsequently very long and broad blades to be produced.
3. *Core preparation*: The recovery of several partially cortical crests (eg, CAT 10102) suggests that cresting was used in connection with the initial formation of the core rough-outs, with some of the cortex-free crests (eg, CAT 10103) probably having been detached as part of the adjustment of the cores' shape during the actual blank production. Although this is unlikely to be an absolute rule, first-generation crests (from the formation of the core rough-outs) are in many cases bilateral (that is, with small flakes having been detached to either side of the crest), whereas second-generation crests (from the adjustment of core-shape during blank production) tend to be unilateral (that is, with small flakes having been detached to one side of an existing dorsal arris left by previous blade detachments). There is also a trend towards many of the Late Upper Palaeolithic crests being located very close to one lateral side, rather than at the centre of the dorsal face (eg, CAT 10118). Crest were frequently detached serially: if the detachment of one crest resulted in the production of an irregular blade, or if the resulting core shape was not satisfactory, other crests were immediately formed below the first one, and then detached (eg, dorsal-

ventrally conjoining crests CAT 10117 and 10118; although they refit, there is space between them for a third crest).

During blade production, both opposed platforms were regularly adjusted (both platforms of opposed-platform core CAT 10059 have been rejuvenated), and several refit complexes testify to the serial detachment of core tablets. CAT 10129 and CAT 10157 do not fit exactly, but the patterns of the cortex of one core-side are so distinct that these two pieces must have been detached from the same parent core. The missing flake between the two would almost certainly have been a third core tablet. In this case, three core tablets were detached, one after the other, without any blades having been detached between the removal of what the knapper may have perceived as unsatisfactory platforms. CAT 10104, 10182 and 10184 from Zone 3 is another complex of refitting core tablets. In this case, a first core tablet was detached, then a few blades were produced, a second core tablet was then detached, with the later platform-edge having moved a few millimetres back, and then this process was repeated a third time.

4. *Blank production*: The Late Upper Palaeolithic visitors to the site focused on the production of, compared to the microblades of the Late Mesolithic settlers, exceptionally long, broad and sturdy blades (length up to 150mm; width in many cases between 20-40mm; Table 4.6) by the application of mainly soft percussion, although some of the largest (particularly crested) blades were detached by hard percussion (eg, crested blade-scraper CAT 10507). Some flakes would have been produced as part of the cores' preparation (decortication, and cresting), but it is uncertain which of the site's flakes were made by the Late Upper Palaeolithic visitors, rather than by the Late Mesolithic ones. Due to the likely 'strip-mining' of the original Palaeolithic concentration by later flint-using settlers (see distribution section), pre-Mesolithic pieces were scattered from Zone 4 and across Site 2D, and it is impossible to quantify the original Palaeolithic assemblage. Table 4.6 only lists what the analyst perceived to be *formally or technologically certain* pre-Mesolithic objects.

   Several intact blades (eg, CAT 899, 3186, 8395, 10020), and blade ends (eg, CAT 3090, 3100, 6592, 11371), define the cores responsible for the manufacture of these large blades as opposed-platform cores, as they have well-defined secondary platform-edges at their distal ends. The platform-edges are generally well-trimmed and occasionally also abraded. Some of the crested pieces also display dorsal blade-scars detached from opposed directions (eg, CAT 10102, 10110, 10183 and 10121). The relative dimension of the frequently elongated core tablets suggests that the Late Upper Palaeolithic opposed-platform cores may have looked very much like the cores described by Madsen (1992, Fig. 81B) as typical Hamburgian cores, with a main flaking-front, and two opposed, sloping, elongated platforms (also see Weber 2012, Fig. 32). Although only one dual-platform cores was recovered from Zone 4 (CAT 10059), this relatively small core corresponds morphologically to the cores described by Madsen. This, However, does not necessarily mean that this industry is Hamburgian, as similar cores may be found in other north-west European Late Upper Palaeolithic industries (eg the Ahrensburgian; Vermeersch 2015). The absence in Zone 4 of more cores of this sort may be due to 'tossing' (Binford 1983, 189), which would remove large pieces of debris from the camp surface, or they may, more likely, have been cannibalized by the later Mesolithic settlers to whom large pieces of Doggerland flint would have been precious.

5. *Tool production*: A number of implements and implement fragments are defined by their size and morphology as most likely non-Mesolithic, and a Palaeolithic date is more likely than a later one. These tools include points (five pieces), scrapers (two are almost certainly pre-Mesolithic, and another is likely to belong to this group), truncated pieces or knives (two may be Palaeolithic). The points include some backed pieces, and some of the fragments may be from tanged forms. One of the scrapers has an acute working-edge, which is a typical Late Upper Palaeolithic feature. It is difficult to say whether other large Palaeolithic tools may have been present, as these pieces could have been collected by later Mesolithic visitors and recycled.

The Late Mesolithic and the Late Upper Palaeolithic operational schemas are summarised and compared in Table 4.7.

Table 4.7. Comparison of the Late Upper Palaeolithic and Late Mesolithic operational schemas responsible for the lithic sub-assemblage from Zone 4.

		Late Upper Palaeolithic	*Late Mesolithic*
Procurement	*Material*	Procurement of flint nodules with GDs of up to, and possibly beyond, 150mm.	Procurement of flint pebbles with GDs of *c*. 40-70mm.
	Provenance	Most likely outcrops on Doggerland.	Most likely North Sea beach walls along a coastline roughly corresponding to that of the present day.
Preferred core type		Large opposed-platform macroblade cores.	Small conical microblade cores.
Opening		The character of the core tablets (only one opp-platf core has been recovered) suggests that nodules were opened by detaching a primary opening flake.	Platform-to-platform refitting of cores (Site 3B) suggests that pebbles were generally split into two rough-outs with immediately available plain striking platforms.
Heat treatment			Only clearly indicated at Site 3B
Core preparation	*Prior to production*	Extensive cresting (eg. CAT 10110) and trimming.	No cresting, but extensive platform-edge trimming.
	During production	Serial cresting (eg, refit CAT 10117-8) and platform rejuvenation (eg, refit CAT 10129, 10157, and refit CAT 10104, 10182 and 10184).	Little or no platform rejuvenation, but adjustment of core shape by cresting.
Blank production	*Target blanks*	Large macroblades with lengths of up to 120mm, and widths of 20-40mm.	Microblades and narrow-blades with intended widths of *c*. 5-11mm.
	Percussion technique	Soft percussion.	Soft percussion, probably generally pressure-flaking.

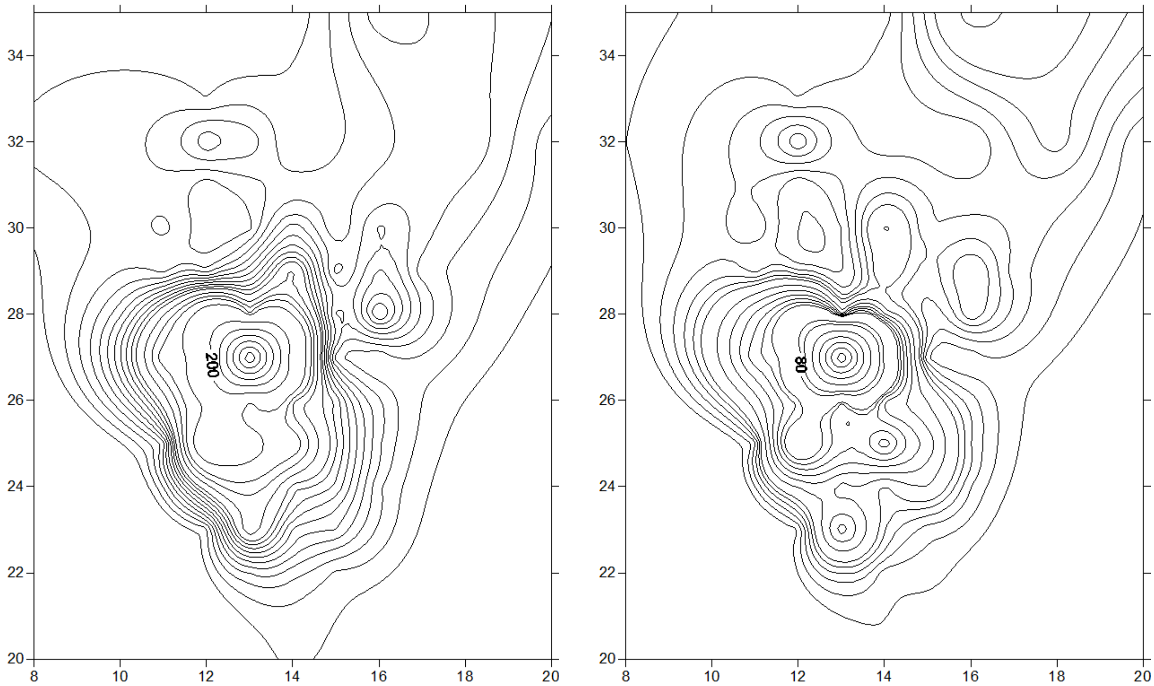
Tool production	*Main tool forms*	Large blade-scrapers and oval scrapers and fragments of points have been recovered from Site 2D. Crested blades and large blades were used as knives without modification.	Predominantly microliths, but some small piercers, scrapers, and truncated pieces (knives) have also been recovered. A large assemblage of polished-edge implements were retrieved from Zone 5.
Core abandonment		Uncertain, as only one small opp-platf core was recovered. The large UP cores may either have been 'tossed' out of the site (Binford 1983), exported out of the site when the settlers left, or scavenged by LM settlers 'strip-mining' the UP site. Bipolar technique not applied.	The conical cores were generally abandoned when they were deemed useless due to the development of deep hinge- or step fractures, or overpassed blades. Extremely limited application of bipolar technique - examples of this technique may relate to a small number of later visits to the site.

Distribution, features and on-site activities

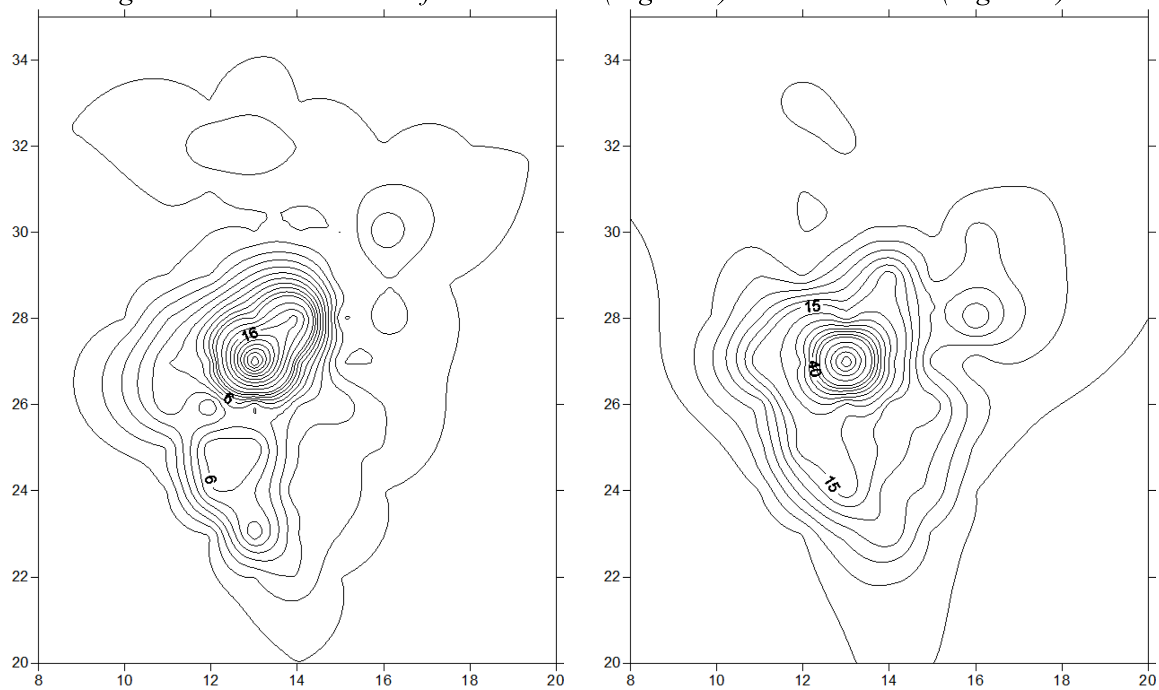
In an attempt to 'dissect' Zone 4 into its likely chronological components (visits), as well as to shed light on intra-zonal activities, a number of distribution maps were produced. The distribution of categories involving large numbers of finds (all lithics; chips; broad and microblades; and burnt pieces; Figs 5.9-12 and 5.17) was shown by the application of contour-mapping, and that of categories involving relatively small numbers of finds (cores; preparation flakes; microliths; microburins; and likely Late Upper Palaeolithic elements; Figs 5.13-16) through 'dot-mapping', where a number in each grid indicates how many pieces were found there. In addition, a number of '3D' surface maps were produced to express the distribution of the former categories in a more visual manner (Figs 5.18-22).

Some of the contour maps (eg, Fig. 4.15) display a relatively complex pattern along the line Y=30, but this is probably largely due to some grids in this area not having been excavated, and it has little to do with prehistoric behaviour.

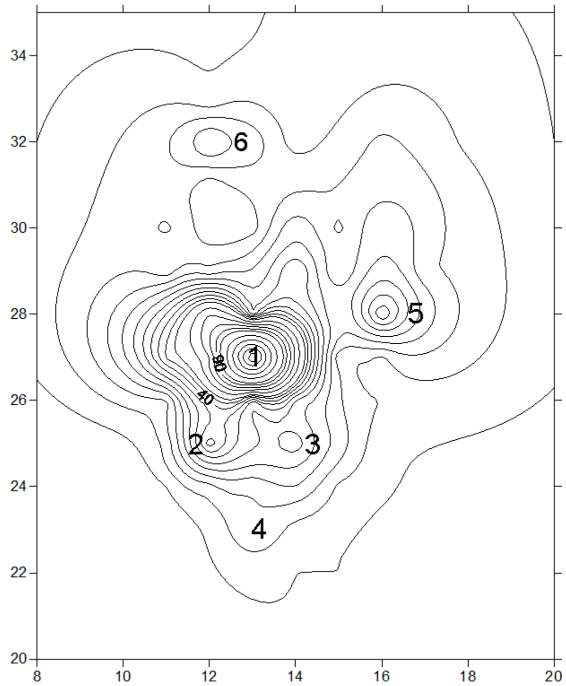
Figs 4.14-15. Distribution of all lithics (Fig. 4.14) and chips (Fig. 4.15).



Figs 4.16-17. Distribution of broad-blades (Fig. 4.16) and microblades (Fig. 4.17).



Figs 4.18. Distribution of burnt pieces – the numbers indicates where hearths may have been located. The position of some hearths is more clearly indicated by the distribution of the chips, which are thought to represent the knapping floors immediately next to the hearths (Fig. 4.15).



As Zone 4 includes a number of concentrations, with one being numerically dominant (containing approximately two-thirds of the zone's lithics) and the others involving relatively low numbers of finds, a fixed contour interval would have resulted in the main concentration obscuring all other concentrations. It was therefore decided to make the contour intervals smaller at the low end (to bring out the smaller concentrations) and larger at the high end (to prevent the main concentration appearing as a black smudge). This explains the apparent presence in some of the contour maps of a 'ledge' at the mid-level, where sets of small and large contour intervals meet. For a general discussion of the approach applied in this section, see Ballin (2013b) and Binford (1983).

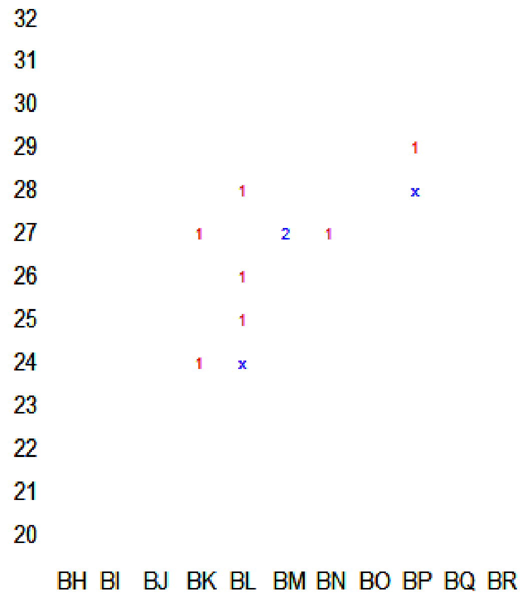
Figs 4.14-18 (all lithics; chips; broad- and micro-blades; as well as burnt pieces) show that Zone 4 has six centres or focal points (Concentrations 1-6): 1) BM 27 (the 'main' concentration); 2) BL 25; 3) BN 25; 4) BM 23; 5) BP 28; and 6) BL 32. They were probably all associated with a central domestic hearth, although only the hearths of Concentrations 1, 2 and 5 are clearly indicated by burnt flint (Fig. 4.18). The likely presence of a hearth in Concentrations 3, 4 and 6 is supported by the surface map Fig. 4.28.

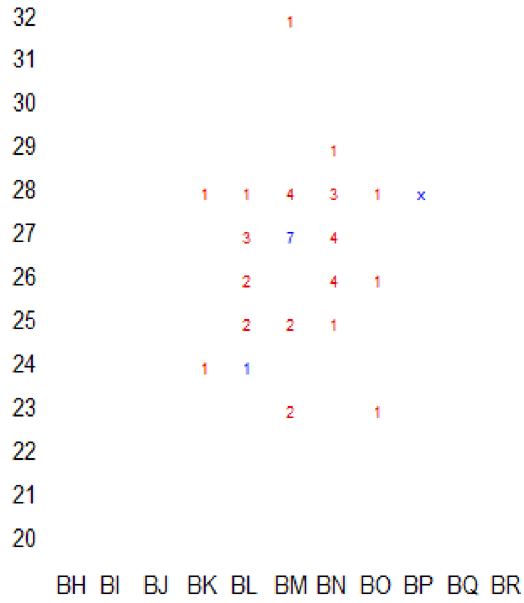
The position of the six concentrations is most clearly shown by the distribution of the chips (≤ 10mm) (Fig. 4.15). These pieces represent what Binford (1983, 153) referred to as the drop zone of finds too small to be a problem (in prehistoric time) to the general traffic across the site, and which were therefore generally left where they fell (ie, they were not exposed to preventive or *post hoc* site maintenance; ibid.). They show the position of a number of knapping floors, which tend to be located immediately next to the location's fireplaces (cf. Ballin 1998).

The distribution of the blades (Figs 4.16-17) is interesting, as the broad-blades (L ≥ 2W) and the microblades (W < 2W) appear to have slightly different distribution patterns. Concentration 1 clearly includes broad as well as microblades; Concentration 2 appears to be dominated by broad-blades; and Concentration 5 by microblades. It is possible that Concentration 2, with its broad blades, was the centre of the Late Upper Palaeolithic settlement in the area, and that the presence of many broad blades and other Palaeolithic pieces in Concentration 1

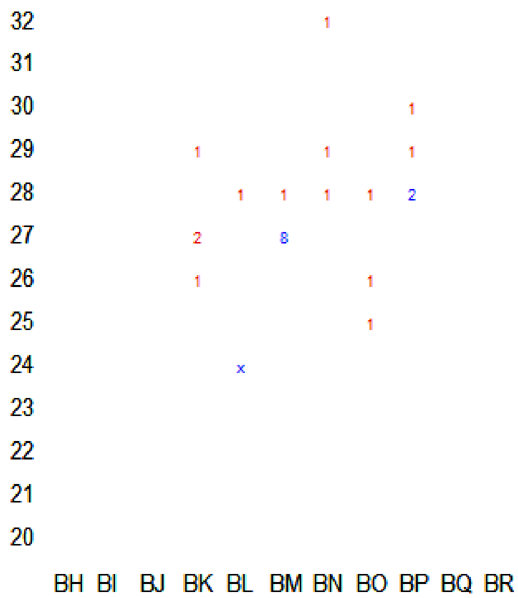
(Fig. 4.23) is due to that concentration's Late Mesolithic settlers mining Concentration 2 for all larger pieces, whereas Concentration 5, with its microblades, seems to be entirely Late Mesolithic.

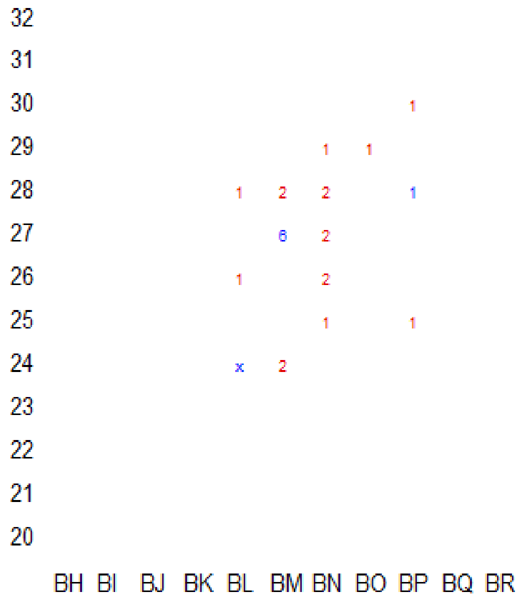
Figs 4.19-20. Distribution of cores (Fig. 4.19) and preparation flakes (Fig. 4.20). In Figs 4.19-23, a blue number or – when a grid did not contain any pieces of the category in question – a blue cross indicates the presence of a perceived hearth.





Figs 4.21-22. Distribution of microliths (Fig. 4.21) and microburins (Fig. 4.22).





As mentioned in connection with the presentation of Zone 4's cores, most of these are burnt. However, only two pieces were recovered at the centre of a perceived hearth (BM 27), whereas most of the burnt cores were found scattered across the area (Fig. 4.19). This suggests that either one or more hearths were deliberately manipulated (either cleared out or reconstructed), or later visitors to the area have kicked these objects around. The preparation flakes (crested pieces and platform rejuvenation flakes) are mainly found around concentrations 1 and 2 (Fig. 4.20). Most of these are large, and it is thought that many of them are pre-Mesolithic. It is possible that some of the pieces around Concentration 2 represent Palaeolithic 'tossing' (Binford 1983, 153), whereas the mostly large crests and core tablets found around the Concentration 1 fireplace may be scavenged pieces used by the Late Mesolithic settlers responsible for this concentration.

The microliths of Zone 4 (Fig. 4.21) are found within the hearth areas of Concentrations 1 (eight pieces) and 5 (two pieces), as well as scattered around those two concentrations. The pieces from the fireplaces indicate that microliths were produced near the fire, whereas the pieces further away from the hearths may relate to various other activities involving these pieces, including hafting, caching, etc. The microburins (Fig. 4.22), which are simply waste products from the microlith production, have a tighter distribution, with these pieces either having been found within the fireplaces of Concentrations 1 (six pieces) and 5 (one piece), or within a circle surrounding the hearth of Concentration 1, probably all representing 'dropping' in the Binfordian sense. This tighter distribution supports the suggested link between microlith production and the fireplaces around which the knapper(s) would have been seated (eg, Ballin 2013b). The area around the hearth is also where hafting and 're-tooling' would have taken place (ibid; Keeley 1982).

Fig. 4.23. Distribution of likely Late Upper Palaeolithic elements across Zone 4.

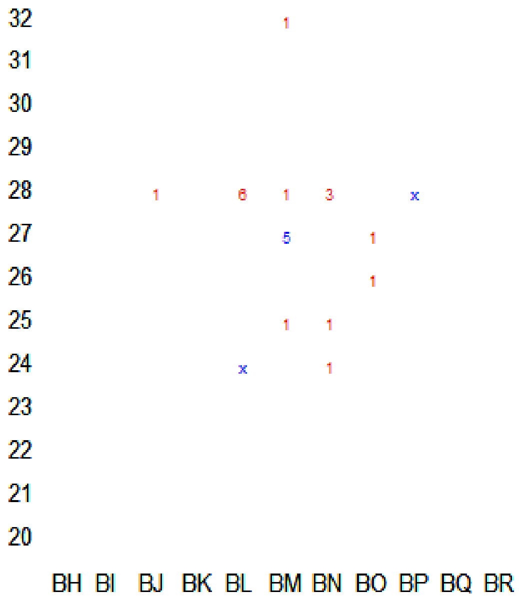
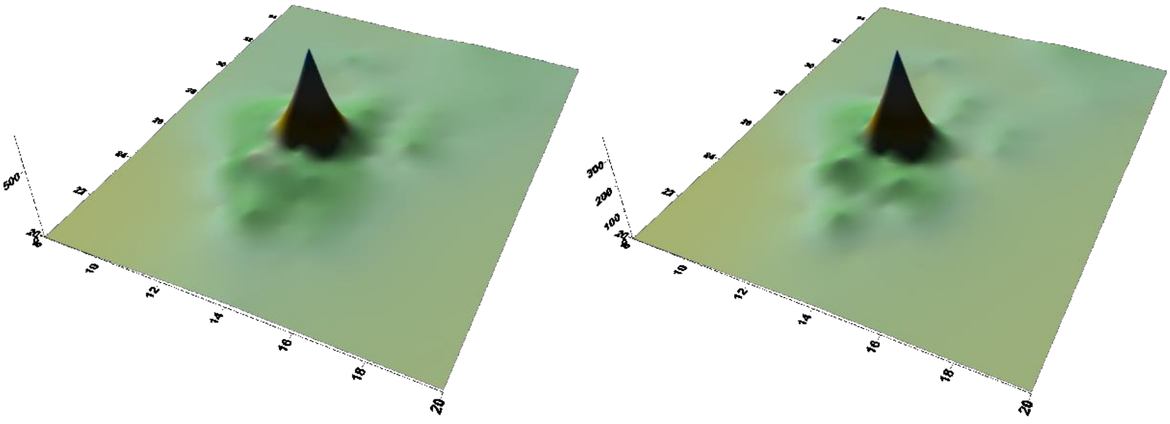


Fig. 4.23 shows the distribution of the likely Late Upper Palaeolithic objects listed in Table 4.6. Some pieces were recovered from the centre of the hearth grid of Concentration 1 (BM 27), whereas most are found around this concentration and towards Concentration 2. The distribution of these pieces probably reveals little, as most of these pieces are likely to have been affected by the activities of later settlers in the area, with some of them probably having been actively 'harvested' and removed by Mesolithic people due to their content of still usable flint raw material. The likely mining of the original Late Upper Palaeolithic camp (possibly Concentration 2) is also suggested by the distribution of likely Palaeolithic pieces across other parts

of Site 2D (Table 4.6), with most having been recovered from the neighbouring Zones 3 and 5.

Figs 4.24-25. 3D surface maps. Distribution of all lithic (Fig. 4.24) and chips (Fig. 4.25).



Figs 4.26-27. 3D surface maps. Distribution of broad-blades (Fig. 4.26) and narrow-blades (Fig. 4.27).

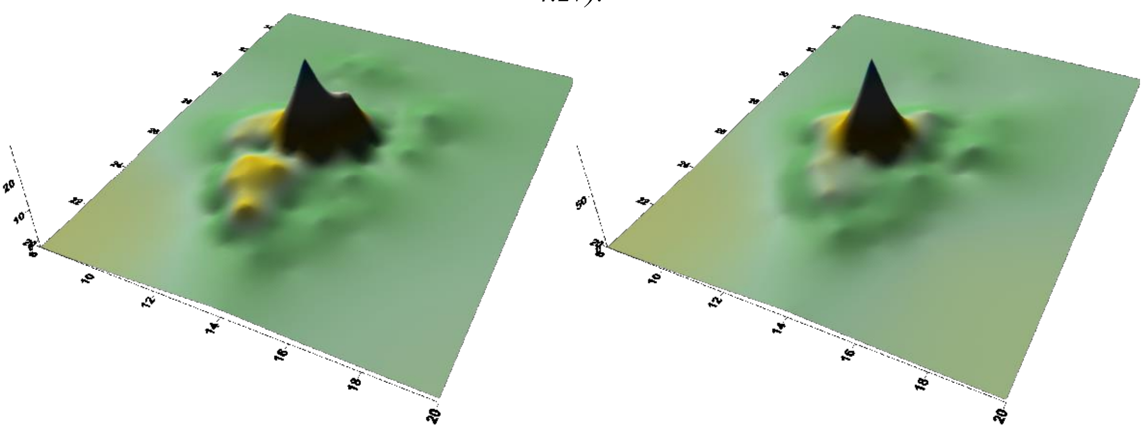
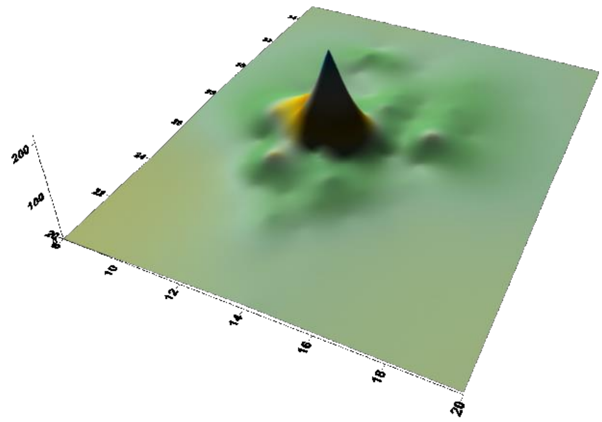


Fig. 4.28. 3D surface maps. Distribution of burnt flint.



Two postholes (1569 and 1571) contained some knapping debris which may have entered the features with the backfill. It has not been possible to associate the postholes with any structure, and the various concentrations of Zone 4 may mainly represent open-air sites. Pit 1882 is thought to date to the post-medieval period, and it only contained one flint flake. The distribution of the various artefact categories (including the possible interference between the remains of different visits to the area, possible scavenging, etc.) does not help in terms of determining whether the concentrations mainly represent open-air sites or whether a (flimsy?) structure could have been present at any time.

Dating

As mentioned above, Zone 4 seems to have been visited on a number of occasions through early prehistory. The distribution of the lithic artefacts across the area suggests that it may have been visited six or or more times (Figs 4.15-28), with most of the finds dating to the Late Mesolithic period and some to the Late Upper Palaeolithic. No radiocarbon dates were obtained for this area. The lithic assemblage includes several diagnostic elements, such as raw material (type of flint), core and tool types, metrics, and technological attributes (operational schemas).

Raw material: As mentioned in connection with the definition of the site's operational schemas (above), the settlers of Zone 4 seem to have procured two different types of flint, namely flint in the form of very large nodules (many probably larger than GD 150mm) and small flint pebbles (with GDs of 40-70mm). Both types of flint are of good quality (that is, they have good flaking properties), but they must have been procured from different sources. Where the smaller pebbles would have been available from North Sea beach walls throughout the Mesolithic and post Mesolithic times, the larger nodules must have been procured from sources further afield, and the nearest sources of good quality flint in the form of large nodules would probably have been on Doggerland (Ballin 2016d; Ballin & Bjerck 2016; Brooks *et al.* 2011; Sturt *et al.* 2013). This suggests a date for the operational schema based on this type of flint of the Late Upper Palaeolithic period.

Core and tool types: The distribution of microblades (Fig. 4.17), conical cores (Fig. 4.19) and microliths/microburins (Figs 4.21-22) across the site suggests that most of the scatters may be the result of activity in the Late Mesolithic period. It is possible that the higher ratio of broad blades in Concentration 2, as well as the absence of microliths here, is an indication that this may be the original Late Upper Palaeolithic camp.

The area's conical cores are associated with the production of narrow blades and as such they are likely to date to the Late Mesolithic/Early Neolithic framework (cf. Ballin 2013a; 2016a), but as strictly diagnostic Early Neolithic pieces are absent from the zone, they probably relate to the area's Late Mesolithic knapping and microlith production. One opposed-platform core (CAT 10059) is smaller than one would have expected on the basis of the size of the broad blades from opposed-platform cores recovered from the area, but in morphological and technological terms it corresponds precisely to the cores described by Bo Madsen in his analysis of later Hamburgian flintwork (1992, Fig. 81; also see Weber 2012, Fig. 32). However, related cores have been found in other Late Upper Palaeolithic contexts (eg, Vermeersch 2015), and at the present time this core should only be perceived as indication of an unspecified Late Upper Palaeolithic presence in Zone 4, that is, predating *c*. 10,000 cal BC.

In contrast to Zone 5, there is no spatial subdivision into areas dominated by either scalene triangles or crescents, but it is still uncertain whether these two types of microliths indicate different dates or different functions within the Late Mesolithic (see discussions in the chapters relating to Zone 5 and Site 3B). The solitary obliquely blunted point (CAT 10466) is relatively broad (W = 10.8mm), but due to this being the only piece of its kind in Zone 4 it is difficult to determine whether it represents a brief Early Mesolithic visit to the site (most British obliquely blunted points date to this period; eg, Butler 2005, 96), or whether it could be later, like the narrow obliquely blunted pieces from Zone 5 (this volume). CAT 10466 was recovered from the hearth grid of Concentration 1 (BM 27). The dominating scalene microliths are all narrow pieces.

The sub-assemblage from Zone 4 includes a number of pieces which have been characterized as likely Late Upper Palaeolithic points, or fragments thereof. They include one fragment of a tanged or angle-backed point (CAT 10265), one idiosyncratic point (CAT 10456), two backed blades (CAT 10289, 10567), and one double-truncated piece (CAT 10236). Although none of these pieces can be attributed with certainty to any specific part of the Late Upper Palaeolithic period, their general size, shape and associated technological attributes suggest a pre-Mesolithic date.

CAT 20165, for example, is similar to tip fragments from Howburn, broken off late Hamburgian Havelte points (Ballin *et al.* 2010, Fig. 6). Although the piece from Zone 4 is smaller than the tip fragment shown in Fig. 4.11, it has the same general angle against the opposed lateral side, the same thickness, and both pieces were produced by the use of *sur enclume* technique. CAT 10456 corresponds to another piece recovered from Howburn (Fig. 4.12). It is a roughly triangular point with a straight base and, like the Howburn piece, CAT 10456 may be a re-used/re-modified tip fragment from a broken tanged point. The two backed blades from Zone 4, CAT 10289 and 10567, find their best parallels in the assemblage from the *Federmesser-Gruppen* site Kilmelfort Cave, near Oban (Saville & Ballin 2009), although some backed pieces were also recovered from Howburn (Ballin *et al.* forthcoming). The double-truncated piece is unusual, and it has preliminarily been interpreted as a potential Upper Palaeolithic point (see for example Jacobi 2004), although it can not be ruled out that the piece is post Mesolithic. However, the general absence of diagnostic Neolithic pieces within Zone 4 speaks against this.

Two large scrapers (CAT 10214 and 10507) are also likely to date to the Late Upper Palaeolithic period. The former is an oval flake scraper (L = 45mm), and the latter a blade-scraper (L = 70mm), and the dorsal scars indicate that both blanks were struck off a large blade core (see technological attributes, below). In addition, the working-edge of the blade-scraper, which is based on a crested piece, is distinctly acute, which is a feature associated with pre Mesolithic scrapers (Ballin *et al.* 2010, Figs 8-9).

Technological attributes: Most of the lithic material retrieved from the various concentrations in Zone 4 clearly represents a microblade industry. This industry first and foremost aimed to produce blanks for microliths by the application of soft percussion, and the majority of the non-microlithic tools appear to be pre-Mesolithic. The cores of this industry are almost exclusively conical single-platform cores, which received little preparation other than trimming. It is not possible on the basis of the technological attributes, or the operational schema associated with the microblade production, to date this industry more precisely than to the Late Mesolithic/Early Neolithic continuum (Table 4.8; Ballin 2014a), although other available evidence (such as the microliths/microburins) narrows this date down to the Late Mesolithic period.

Where the technological information relating to the Mesolithic industry only has a supporting role, with the main Mesolithic dating evidence being typological (ie, the presence of microliths and microburins), the dating of Zone 4's Late Upper Palaeolithic component follows an entirely different principle, with the typological evidence being weak (fragments and recycled fragments of points, backed pieces of low diagnosticity) and the technological evidence strong.

Occasionally, individual technological attributes may indicate a date, such as the presence of finely faceted platform remnants (including *en eperon* flakes and blades). This particular feature is generally associated with either Middle/Late Neolithic industries (Ballin 2011a; Suddaby & Ballin 2010) or Late Upper Palaeolithic industries (in Scotland, *en eperon* pieces are exclusively associated with the Hamburgian; Ballin *et al.* 2010). However, it is possible that most of the 14 finely faceted pieces recovered from Zone 4 are in fact core tablets, including the solitary *en eperon* flake CAT 5228, as several originally defined finely faceted pieces on closer scrutiny, and following dorsal-ventral refitting of several of these, turned out to be core tablets.

The establishment of entire operational schemas is a much more secure approach to technological dating, and in Scotland it is possible to distinguish between a number of different operational schemas, each focusing on the production of one or more specific types of blanks, and each associated with a certain set of waste products (eg, preparation flakes and cores). Table 4.8 does not include a Late Upper Palaeolithic techno-complex as no pre-Mesolithic assemblages or individual finds were known when this table was produced.

Table 4.8. The techno-complexes of East of Scotland and their diagnostic lithic elements (Ballin 2008a; 2008b; 2013a; Ballin 2016a; Suddaby & Ballin 2010). Produced in connection with an investigation of lithics from museums in Moray (Ballin 2014a).

Techno-complex	*Period*	*Raw material*	*Target blanks*	*Percussion technique*	*Diagnostic microliths/arrowheads*	*Sites*
1	Early Mesolithic	Local red/brown flint	Broad blades	Soft	Broad microliths	Nethermills, Banchory
2	Late Mesolithic	Local red/brown flint	Microblades	Soft	Narrow microliths	Nethermills, Banchory
	Early Neolithic	Local red/brown flint	Microblades/ broad blades	Soft	Leaf-shaped points	Garthdee Road, Aberdeen
3	Middle Neolithic	Exotic light-grey and local red/brown flint – frequently half-and-half	Broad blades	Hard (Levallois-like)	Chisel-shaped points	Stoneyhill, Peterhead
	Late Neolithic	Exotic dark-grey and local red/brown flint – frequently half-and-half	Broad blades	Hard (Levallois-like)	Oblique points	Midmill, Kintore
4	Early Bronze Age	Local red/brown flint	Flakes	Bipolar	Barbed-and-tanged points	Kingfisher Est., Aberdeen

The finds from Site 2D, and in particular those from Zone 4, have allowed a detailed operational schema to be defined which does *not* fit into Table 4.8 (see technology section above, in particular Table 4.7). The responsible industry focused on the production of sizeable blades from opposed-platform cores, and the flint for the industry's impressively large cores (as defined by the size of the blades and the crested pieces – only one relatively small opposed-platform core was retrieved) must have been procured from well outside the area of present-day Scotland, probably from sources on Doggerland (Ballin 2016d; Ballin & Bjerck 2016; Brooks *et al.* 2011; Sturt *et al.* 2013).

This operational schema includes considerably more vigorous core preparation than that associated with for example Late Mesolithic/Early Neolithic microblade/narrow-blade production from small conical cores, leaving large crested blades and core rejuvenation flakes. Some of these crested pieces are so large that fragments of these pieces could have been used as raw material for, for example, Late Mesolithic conical cores. In fact, the opposed-platform blades and crested blades from Zone 4 are so big that the German term *Riesenklingen* ['giant blades'] seems appropriate; these 'giant blades' are usually associated with north-west European blades from the Late Upper Palaeolithic period, in particular the Ahrensburgian (Taute 1968), but as indicated by the finds from Howburn in South Lanarkshire (Ballin *et al.* 2010), many Hamburgian blades are also quite large.

This operational schema seems to correspond closely to that defined by Bo Madsen (1992; Fig. 81; also see Weber 2012, Fig. 32) for the Hamburgian settlers at Jels in southern Jutland, Denmark, and it is therefore suggested that the opposed-platform core industry identified at Zone 4 dates to the Late Upper Palaeolithic period. Due to the lack of *certain* Palaeolithic diagnostic implement forms in this area, and due to the fact that other opposed-platform core industries are known from north-west Europe (cf. Vermeersch 2015), it is not yet beyond reasonable doubt that the pre Mesolithic finds from Site 2D could date to other parts of the Late Upper Palaeolithic than the Hamburgian. The distribution of material from this industry across Site 2D supports the suggested 'strip-mining' of Zone 4's original pre-Mesolithic remains by later Mesolithic settlers scavenging for easily accessible flint.

Associated radiocarbon dates: Unfortunately, Zone 4 is the only zone from which no C14-dates were obtained.

Summary and discussion – Zone 4

As shown by the lithic evidence and its distribution, Zone 4 was visited at least once during an unspecified part of the Late Upper Palaeolithic period, as well as several times during the Late Mesolithic. It is thought that the original Palaeolithic remains may have been scavenged by later settlers in the area, explaining why pieces relating to this industry have been recovered from particularly Zone 4's Concentration 1, as well as from the neighbouring Zones 3 and 5, with some potentially Palaeolithic pieces having been noticed amongst the finds from areas even further away from Zone 4. No radiocarbon-dates are available from this zone.

The lithic remains form six concentrations, and the distribution patterns, as well as the almost complete absence of structural evidence (only a small number of post- or stakeholes were noted), suggest that these concentrations may represent individual hunter-gatherer open-air sites, rather than visits involving sophisticated structures (eg, Howburn and Echline Fields; Waddington 2007; Robertson *et al.* 2013) or light shelters (eg, ABNL-3B and Fife Ness; this volume; Wickham-Jones & Dalland 1998). It is possible that the difference between the numbers of artefacts recovered from each concentration, as well as the density of the burnt flint, indicates visits to the zone of varying duration, or that the concentrations may represent the remains left by different sets of activities.

In general, the Late Mesolithic concentrations are dominated by waste from the production of microblades and microliths/microburins, and most non-microlithic implements may be Palaeolithic. The Late Upper Palaeolithic settlers appear to have focused on the production of large blades from opposed-platform cores, and some tools and tool fragments suggest that these blanks may have been intended for points, which may have formed tips and/or edges in composite hunting gear.

The Late Mesolithic finds from Zone 4 adds to the information obtained through the project's other sites from this period (not least the single-occupation camp Site 3B; this volume), which all appear to be short-term hunting camps focusing on the production of microblades and microblade-based microliths, supplemented by small numbers of other possibly subsistence-related implements (mainly scrapers and truncated pieces/knives).

However, the main achievements of the analysis of the lithic assemblage from Zone 4 relate to the pre-Mesolithic sub-assemblage. The identification of these finds as dating to the Late Upper Palaeolithic period adds to the small group of presently known pre-Mesolithic sites in Scotland, including Howburn (Hamburgian; Ballin *et al.* 2010), Kilmelfort Cave (*Federmesser-Gruppen*; Saville & Ballin 2009) and Rubha-Port an t-Seilich on Skye (Ahrensburgian; Mithen *et al.* 2015). At the present time it is not possible to determine whether the pre-Mesolithic finds from Zone 4 date to one or the other part of the Late Upper Palaeolithic, but these finds clearly date to a time prior to 10,000 cal BC (cf. Saville 2004).

More importantly, though, is the development – through the investigation of the Zone 4 assemblage – of a technology-based approach for the identification of Scottish assemblages as pre-Mesolithic. The logical first step in the search for the oldest Scottish hunter-gatherer camps was the identification of individual diagnostic implements, such as arrowheads/points, but as not all assemblages (from any prehistoric period) include diagnostic tools, it is necessary to be able to identify other diagnostic elements, such as technological ones.

Although individual technological attributes may be valuable (such as the details defining certain blanks as *en eperon* blades), the most certain way to date an assemblage to a specific period is by assigning it to a specific techno-complex, through detailed, step-by-step characterization of its operational schema. Important elements of this approach is the determination of the industry's target blanks (flakes, blades, microblades), including estimation of their general shapes and sizes (eg, average length, width, thickness, and length:width ratio), and definition of the associated forms of core preparation/rejuvenation, and characterization of the by-products of this process (eg, decortication, cresting, platform-edge-trimming/-abrasion, faceting of the platform, platform rejuvenation and production of second-generation crests, detachment of core flaking-fronts, etc.).

It is this analyst's view that the analysis of further early prehistoric assemblages will allow this approach to be refined.

ZONE 5

Introduction

Approximately 5,700 lithic finds from Zone 5 were recovered from gridded squares, with less than 200 deriving from a line of four pits in the southern half of the area (Table 5.7). One radiocarbon-dated (SUERC-68102) Early Neolithic pit north of the actual lithic scatter contained no lithic finds. The lithic artefacts make up six concentrations, each of which is thought to have had its own central hearth and therefore probably represents an individual visit to the area. The southern Concentration 4 has been cut straight through by the border of the excavation trench. Approximately two-thirds of the finds were retrieved from Concentration 1.

The typo-technological composition of the lithic sub-assemblage from Zone 5 suggests that the finds may almost exclusively date to the Late Mesolithic period (supported by a radiocarbon date from the zone's southern half; SUERC 68101), supplemented by a Late Upper Palaeolithic element (over-spill from Zone 4?) and one identifiable Early Neolithic object (serrated knife CAT 10237).

During the initial phases of the post excavation work, it was noted that the finds from Concentration 1 included a large number of abraded pieces ('polished-edge implements'). In an attempt to shed light on the date and function of this unusual group of tools, the polished-edge implements were characterized in particular detail in terms of their typological and technological attributes, as well as their distribution. In general, all lithic artefacts from Zone 5 were exposed to typo-technological characterization and spatial analysis in the hope that this would increase the understanding of the zone's internal chronology and on-site behaviour.

General overview

This group of finds embraces 5,891 lithic artefacts. They are listed in Table 5.1. In total, 92.6% of this assemblage is debitage, whereas 0.4% is cores and 7% tools.

Table 5.1. General artefact list – Zone 5.

Debitage	
Chips	2,285
Flakes	1,779
Blades	653
Microblades	513
Indeterminate pieces	199
Crested pieces	21
Platform rejuvenation flakes	4
Total debitage	*5,454*
Cores	
Split pebbles	1
Single-platform cores - conical	12
Single-platform cores - plain	2
Bipolar cores	4
Core fragments	3
Total cores	*22*
Tools	
Microlith preforms	1
Obliquely blunted points	5
Scalene triangles	38
Crescents	12
Edge-blunted pieces	3
Idiosyncratic microliths	1
Frags of microliths	7
Frags of microliths or backed bladelets	27
Backed bladelets	3
Truncated bladelet	2
Microburins	117
Krukowski 'microburins'	5
Discoidal scrapers	1
Short end-scrapers	6

Blade-scrapers	1
Double-scrapers	1
Scraper-edge fragments	1
Straight truncations	3
Oblique truncations	4
Serrated pieces	1
Polished-edge implements	157
Pieces w edge-retouch	19
Total tools	*415*
TOTAL	**5,891**

Debitage

In total, 5,454 pieces of debitage were recovered from Zone 5 (Table 5.2). The debitage includes 2,285 chips, 1,779 flakes, 653 blades, 513 microblades, 199 indeterminate pieces, and 25 preparation flakes (21 crested pieces and four platform rejuvenation flakes). In Ballin (1999), the author demonstrated that the chip ratio of sieved assemblages usually varies between *c.* 30% and 55%, and the present chip ratio is within this framework. A high chip ratio usually indicates that primary production took place at a location.

Table 5.2. Relative composition of the debitage.

	n	*%*
Chips	2,285	42
Flakes	1,779	33
Blades	653	12
Microblades	513	9
Indeterminate pieces	199	3
Preparation flakes	25	1
Total debitage	*5,454*	*100*

The blanks (Table 5.2) are dominated by flakes (33%), but blades and microblades are also common (21%). The main aim of the zone's primary production is thought to have been the manufacture of microblades and narrow-blades for the production of microliths, as well as cutting implements, with flakes mainly being waste from the shaping of the blade cores. These waste flakes occasionally found use as blanks for scrapers and other robust tool forms. The flake:blade ratio is 60:40.

Table 5.3. Reduction sequence of the flakes and blades.

	Quantity		**Per cent**	
	Flakes	*Blades*	*Flakes*	*Blades*
Primary pieces	182	4	10.2	0.4
Secondary pieces	675	167	38.0	14.3
Tertiary pieces	922	995	51.8	85.3
TOTAL	**1,779**	**1,166**	**100.0**	**100.0**

The different nature of the blades and the flakes (target blanks and mainly waste) is demonstrated by Tables 5.3 and 5.4. The flakes include many primary and secondary pieces (almost 50% of them are cortical), whereas the blades are mostly tertiary (*c*. 85% inner pieces). In addition, the flakes and blades were produced by the application of different technological approaches, where many flakes (41%) were produced by the application of hard percussion, whereas most blades (83%) were produced by the application of soft percussion (the use of either a punch or a pressure-flaker; cf. Inizan *et al.* 1992, 63; Sørensen 2006, 57).

The fact that the flakes are mostly waste from the decortication of nodules, whereas the blades are the intended products of the reduction process, should have resulted in two more distinct technological groups (Table 5.4). The fact that the difference between the two groups is not more distinct (such as the fact that 34% of the flakes were produced by the application of soft percussion), may largely be due to prehistoric 'production errors', with some intended blades turning out shorter than planned. Most soft percussion flakes from Zone 5 have regular, parallel dorsal arrises and parallel lateral sides, and they could be defined as failed blade blanks.

Table 5.4. Applied percussion techniques: definable unmodified flakes and blades.

	Quantity		Per cent	
	Flakes	*Blades*	*Flakes*	*Blades*
Soft percussion	330	576	34	83
Hard percussion	385	41	41	6
Indeterminate platform technique	80	11	8	1
Platform collapse	134	60	14	9
Bipolar technique	32	5	3	1
TOTAL	**961**	**693**	**100**	**100**

Fig. 5.1 shows the length:width of all intact blades and microblades from Zone 5, with blades/microblades having average dimensions of 25 x 10 x 3mm. In Aberdeenshire, this is consistent with a date within the framework of the Late Mesolithic to the earliest part of the Early Neolithic (cf. Ballin 2013a; 2016a). As mentioned in connection with the discussion of the blades from Site 3B (this volume), it should be borne in mind, that Mesolithic blades and microblades are delicate objects which break easily, and that intact pieces probably represent a site's more robust pieces (Ballin 2004b). On this background, it is suggested that the original blades produced within Zone 5 were generally somewhat longer, narrower and thinner than indicated by the average dimensions above.

The line running through the diagram defines the metric border between flakes and blades, and it is obvious (as indicated by the cluster's truncated nature) that, in Zone B, metric blades and flakes formed a continuum, as was also the case at this project's Site 3B (this volume), and at the Early Neolithic site Garthdee Road in Aberdeen (Ballin 2016a). The truncated nature of Fig. 5.1 is due to the fact that flakes were not measured during the cataloguing of the lithic finds from the project (see methodology, above). The blades in Fig. 5.1 form a coherent cluster, but a small group of blades longer than 40mm (visible in Fig. 5.2 as a small 'dimple' at width *c*. 20mm) may either represent blades from the initial preparation of the cores (see discussion in connection with Site 3B, this volume), or earlier or later visits to the area.

Fig. 5.1. The main dimensions of the blades from Zone 5.

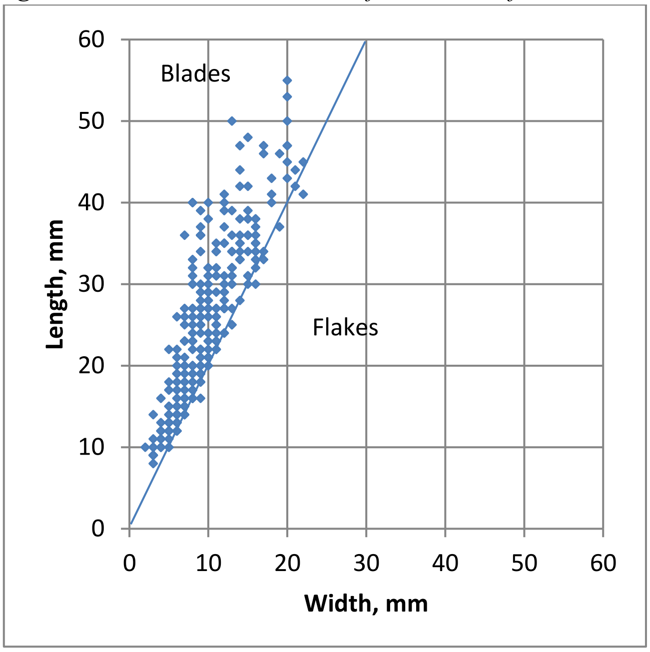
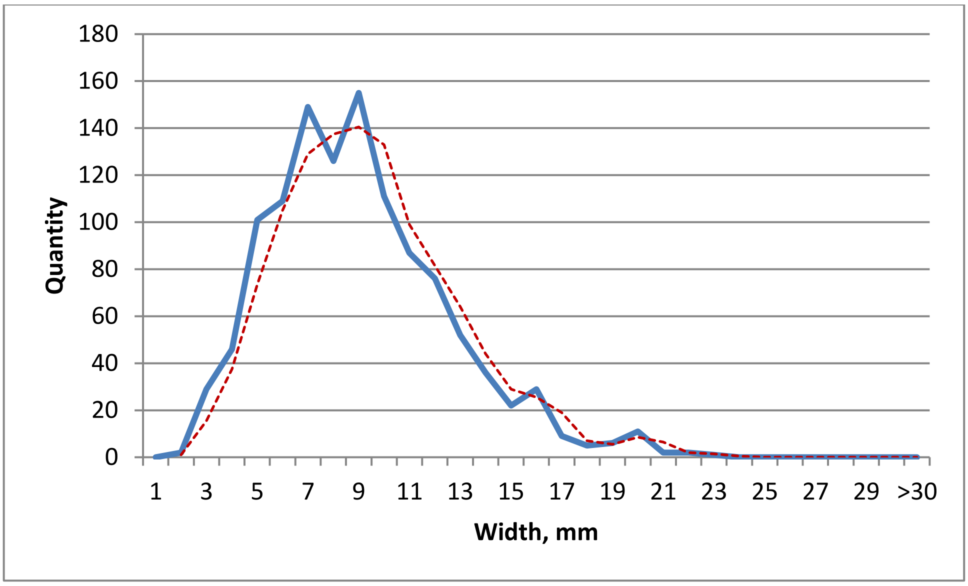


Fig. 5.2 shows the width of all Zone 5's intact blades and microblades. The diagram's curve has two peaks immediately next to each other, almost forming a statistically 'normal' distribution. The curve's adjusting trendline forms a perfectly bell-shaped figure. This suggests that, even if the area was visited more than once, most of the blades are likely to have been produced and/or deposited during one relatively narrow chronological horizon, such as a segment of the Late Mesolithic period. The fact that the cores, microliths and microburins also form two size groups (see below), supports the indication of more than one visit to the zone. The scalene triangles and the crescents form two spatial groups, with narrow scalene triangles towards the north and broader crescents towards the south, and this trend is repeated by the microblades: the microblades towards the north have an average width of 8.8mm and those towards the south 9.5mm.

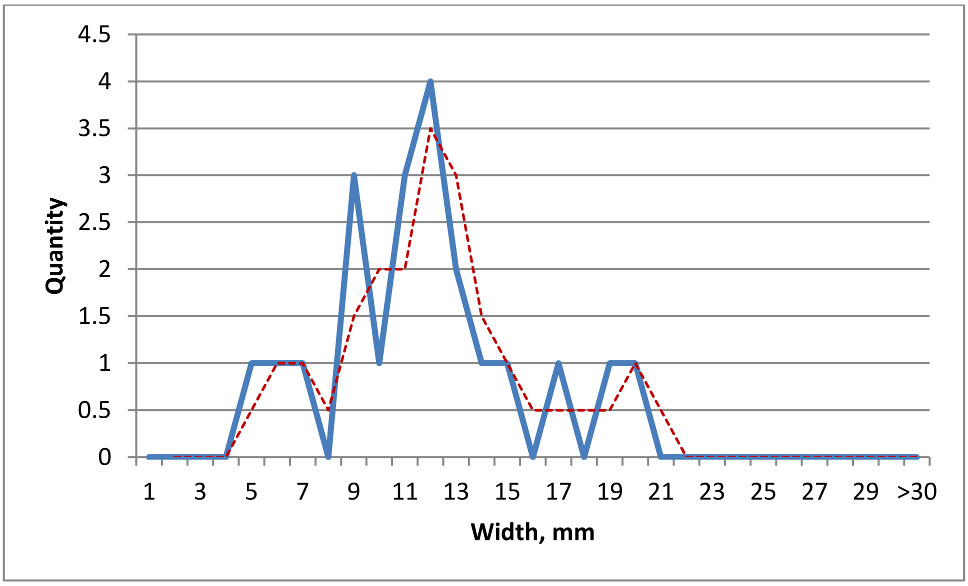
Two small 'dimples' in the right side of the curve may represent either larger specimens produced at the beginning of the site's operational schema (see technology section), or they may represent blades produced in connection with short visits to the area before or after the main visit(s) to the location (see distribution section).

Fig. 5.2. The width of all unmodified blades and microblades from Zone 5 (blue). A trendline (moving trendline) has been inserted (red) (1,166 pieces).



The 25 preparation flakes include 21 crested pieces and four platform rejuvenation flakes. Apart from two elongated flakes, all crested pieces are blades or microblades. The width of those is shown in Fig. 5.3, and although crested pieces should generally be larger than the blade blanks produced at later points in the operational schema, some of these pieces are so large (compare with Fig. 5.2) that they could be suspected of being Late Upper Palaeolithic crests associated with the Late Upper Palaeolithic concentration in Zone 4 (see elsewhere in this volume). The largest intact crested piece (CAT 10205) measures 49 x 11 x 5mm, and the smallest (CAT 10209) 10 x 5 x 3mm. These blades were detached by the application of soft percussion.

Fig. 5.3. The width of all crested pieces from Zone 5. A trendline (moving trendline) has been inserted.



Apart from one relatively delicate soft percussion specimen (CAT 10208; 8 x 20 x 3mm), all platform rejuvenation flakes are fairly large hard percussion specimens (av. dim.: 44 x 26 x

10mm). Two pieces (CAT 10129 and 10157) from the western periphery of the Zone 5 scatter are clearly from the same core, and from the rejuvenation of the same platform, but they do not conjoin – a third core tablet (which would have fit in between those two pieces) was not recovered. CAT 10129 and 10157 are from a core of such dimensions that it must be defined as most likely pre Mesolithic and these two platform rejuvenation flakes are likely to date to the Late Upper Palaeolithic period (see general discussion of Late Upper Palaeolithic material from Site 2D in connection with the presentation of the finds from Zone 4).

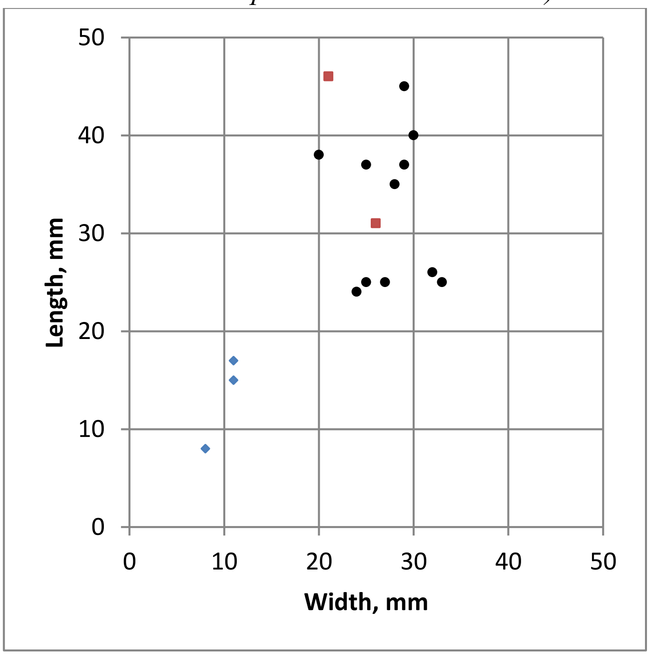
A total of 888 pieces have been exposed to fire, or 15% of the entire sub-assemblage. Most of this material is knapping debris, but 49 pieces are cores, microliths, microburins, scrapers and polished-edge implements, showing that in prehistory not only the production of blanks and tools, but also the use of them, took place at domestic fireplaces (see distribution section). Three-quarters of 199 indeterminate pieces display fire-crazing, and in most cases flake and blade fragments were made 'indeterminate' through exposure to fire, which would cause their ventral face, or both faces, to be detached.

Cores

A total of 35 cores were recovered from Zone 5: one split pebble, 12 conical single-platform cores, two plain single-platform cores, four bipolar cores, and three core fragments. The cores were measured following the principles described in the methodology section.

Split pebbles: Only one split pebble was recovered from Zone 5 (CAT 11537), measuring 23 x 27 x 15mm. First, it was attempted to split the piece lengthwise by striking one pointed end of the pebble, but as this was unsuccessful, it was simply struck at the centre of one broadside, splitting the piece across. This action was probably taken to produce a striking platform for a small conical core.

Fig. 5.4. The dimensions of all intact cores: conical single-platform (black); plain single-platform cores (red); and bipolar cores (blue). CAT 10162 has been inserted with its original length (ie, refitted with overpassed blade CAT 10163)



Single-platform cores: In Table 5.1, the single-platform cores are separated into 'proper' conical cores and slightly less regular ones. The former category includes 12 specimens, which in Fig. 5.4 form two clusters. One group has an average length of *c*. 25mm, and the other a length of more than 35mm. This trend, in conjunction with the separation of microliths and microburins into narrow and broad pieces (below), suggests that the two peaks in Fig. 5.2 at blade widths 7mm and 9mm may indicate a minimum of two visits to the site within the Late Mesolithic period, and the production of blades and microliths of two size categories from differently sized conical cores. The smaller conical cores have average dimensions of 25 x 27 x 23mm, and the larger ones of 39 x 29 x 24mm.

All the conical cores have plain platforms, indicating that platform rejuvenation was not a common occurrence. If platforms were regularly rejuvenated, the detachment of the odd partial core tablet would have equipped some of the cores with a faceted platform. It is possible that these striking-platforms were formed when pebbles were split across to form two cores, as demonstrated through refitting of two cores on Site 3B, platform against platform (see elsewhere in this volume). All the conical cores have carefully trimmed platform-edges, and seven cores have cortical 'back-sides'.

Many of the conical cores recovered from Site 2D in general were abandoned due to the development of deep hinge or step fractures. However, core CAT 10162 was discarded when a blade overpassed and removed its apex, as shown by the refitting of this piece with overpassed blade CAT 10163, connecting grids BS 41 and BW 35 which are *c*. 7m apart (see Fig. 5.17; distribution section). This production 'accident' shortened the core from 38mm to 25mm.

The two plain single-platform cores differ considerably. CAT 10063 is a fairly regular piece, closely related to the conical cores. However, it has two flaking-fronts, one at either end of an elongated platform, and it is therefore technically a handle-core (for definitions, see Ballin forthcoming a). It measures 31 x 26 x 38mm. The other plain single-platform core is a somewhat idiosyncratic piece, where a thick flake was transformed into a slightly twisted core. It measures 46 x 21 x 18mm.

Bipolar cores: Four of Site 2D's six bipolar cores are from Zone 5. One is the broken-off terminal of a core (CAT 10187), whereas the other three are intact (CAT 10086, 10258, 10593). The bipolar cores are all minuscule objects, and the intact specimens measure on average 13 x 10 x 5mm. Two are unifacial and two are bifacial, and where three of the cores have one reduction axis (one set of opposed terminals), CAT 10086 has two axes. The latter is a highly unusual piece in the sense that it was certainly reduced on an anvil, and from two perpendicular directions, but it is unusually small (8 x 8 x 2mm). Spatially, these four pieces form a group, all having been recovered from a small area immediately south of Concentration 1's hearth (BY 40-41; see distribution section).

Core fragments: Three indeterminate core fragments were retrieved during the excavation (CAT 10142, 10195-6). The two larger pieces (CAT 10195-6; GD 37-38mm) are from cores which disintegrated due to internal impurities, whereas CAT 10142 (GD 15mm) is a section of a platform-edge which broke off due to the exposure to fire.

Tools

The 415 tools from Zone 5 (Table 5.5) include a small number of separate implement categories, such as 104 microliths and microlith-related implements (25%), 117 microburins (28%), 10 scrapers (2%), seven truncated pieces (2%), one serrated piece (0.2%), 157 polished-edge implements (38%), and 19 pieces with edge-retouch (5%). Without the unusual polished-edge implements, which are partly defined by retouch (which was then in most cases abraded by use) and partly by use-wear, the tools from Zone 5 are composed as shown in Table 5.5. Disregarding the polished-edge implements, microlithic pieces (microliths + microburins) make up 85% of the tools.

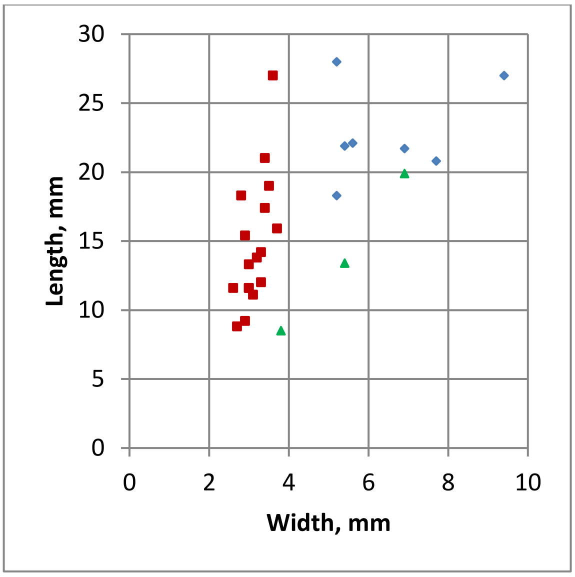
Table 5.5. Generalized list of the tools from Zone 5, less polished-edge implements (see Table 5.1).

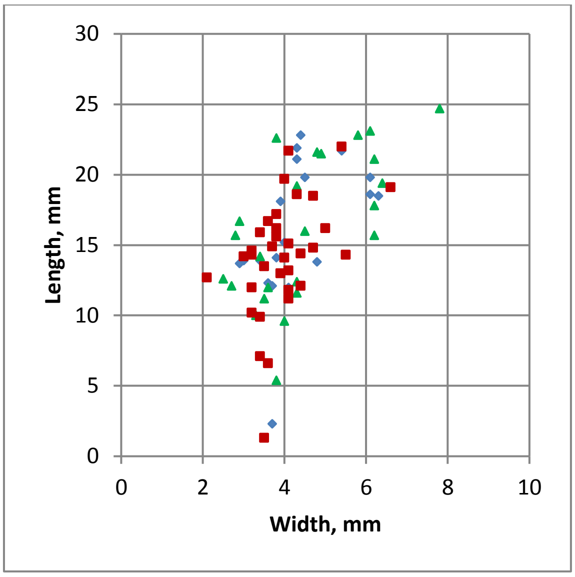
	n	*%*
Microliths	65	25
Frags of microliths/backed bladelets	34	13
Backed/truncated bladelets	5	2
Microburins	117	45
Scrapers	10	4
Truncations	7	3
Serrations	1	1
Pieces w edge-retouch	19	7
TOTAL TOOLS	**258**	**100**

Microliths and 'microlith-related implements': This category embraces a number of formal types, including one microlith preform, five obliquely blunted points, 38 scalene triangles, 12 crescents, three edge-blunted microliths, one idiosyncratic microlith, five backed and truncated bladelets, 34 fragments, and five so-called Krukowski 'microburins' (which are more likely to be microliths, or fragments of microliths, than microburins; see below).

Microlith preforms: As discussed in connection with the presentation of the microlithic material from Site 3B, microliths were traditionally produced in two ways, namely 1) by producing a lateral notch and then breaking the microblade blank in the notch to create a microlith preform; or 2) by producing a usually shouldered linear retouch along one lateral side and then breaking the microblade blank towards the (most commonly) proximal end of the piece (referred to as the *lamelles a cran* approach). In Mesolithic north-west Europe, including Scotland, the former approach dominated notably, and CAT 10376 is a preform of this type. This microblade has a microburin notch in its LHS, and it measures 16.5 x 8.7 x 2.6mm.

Figs 5.5-6. Fig. 5.5) The main dimensions of selected (intact) microliths from Zone 5; scalene triangles (red); crescents (blue); and edge-blunted pieces (green). Fig. 5.6) The scalene triangles, crescents and edge-blunted pieces from Nethermills Farm, Aberdeenshire (Ballin 2013a).





Obliquely blunted points: The sub-assemblage from Zone 5 includes five obliquely blunted points (CAT 10453, 10534, 10543, 11555, 11557), four of which are intact (av. dim.: 13.8 x 5.2 x 1.5mm). They are generally *c.* 10-13mm long, but CAT 10534 is 21mm long. They all have retouch of their LHS, but CAT 10534 also has basal retouch, and CAT 11555 has additional fine retouch of the RHS. In two cases (CAT 10543, 11555), the original proximal microburin facet is still visible. Obliquely blunted points are usually associated with Early Mesolithic assemblages (eg, Morton and An Corran; Coles 1971; Saville *et al.* 2012), but as demonstrated by the various sub-assemblages from Site 2D, they also form part of many later Mesolithic assemblages, although in considerably fewer numbers than in earlier assemblages.

Scalene triangles: The obliquely blunted points, scalene triangles, crescents and edge-blunted microliths are all defined by their blank forms and dimensions as later Mesolithic pieces, and their main dimensions are shown in Fig. 5.5. Interestingly, the pieces from Zone 5 are separated into three distinct size groups, whereas this is not the case at Nethermills Farm on the Dee (Fig. 5.6). Seventeen of the 38 scalene triangles are intact, and they measure on average 14.8 x 3.1 x 1.3mm, varying in length between 8.8mm and 27.0mm. This makes them approximately as long as the main group of scalene pieces from Nethermills Farm (Ballin 2013a), but slightly narrower (Fig. 5.6). Only five scalene triangles from Site 3B are intact.

Generally, the shortest retouched side is proximal, but in six cases this side is distal (CAT 10459, 10529, 10540, 10555, 10558, 10581). Consequently, 35 pieces (or 92%) have their two retouched short legs orientated towards the left, and three towards the right. Four of the scalene triangles have ancillary retouch of their longest side (CAT 10449, 10529, 10561, 10566) and in three cases (CAT 10493, 10519, 10548) the original *piquant triédre* is identifiable, although in slightly modified form. In three cases (CAT 10497, 10548, 10558) microburin technique was *not* applied, and one leg of the triangle was produced by retouching diagonally through the bulbar area. CAT 11564 has no blunting along the triangle's longest leg, only along its shortest leg.

Crescents: As some edge-blunted microliths do have slightly convex lateral modifications, it was decided to define the crescents as microliths with *highly* regular curvatures, where it is obvious that the knapper *deliberately* aimed at producing this geometric shape (ie, that we are talking about a mental template, rather than random morphology). The sub-assemblage includes 12 crescentic microliths, which are generally quite regular. Seven intact crescents measure on average 22.8 x 6.5 x 2.4mm (Fig. 5.5), varying in length between 18.3mm and 28.0mm. As a group, they are considerably longer and almost twice as broad as the scalene triangles. Two-thirds of the crescents have their LHS blunted, and one-third their RHS. Four pieces (CAT 10500-1, 10458, 10484) have ancillary retouch of the cutting-edge. CAT 10484 testifies to the use of microburin technique, as part of the original *piquant triédre* is still identifiable. CAT 10496, on the other hand, was produced without the application of this technique, and a tiny proportion of the platform remnant survives at the proximal end.

Edge-blunted microliths: Only three edge-blunted pieces were recovered from Zone 5. They are generally characterized by having one fully blunted lateral side, but where this retouch did not transform the blanks into geometric forms, and this retouch may be straight, slightly curved or undulating. The three edge-blunted microliths are all intact, and they measure on average 13.9 x 5.4 x 1.4mm (Fig. 5.5), varying in length between 8.5mm and 19.9mm. They all have their retouched lateral side towards the left.

Idiosyncratic microliths: CAT 10495 is a unique piece, based on the medial-distal end of a small blade. Its proximal end was removed by microburin technique, and it has an oblique, concave proximal truncation which curves and continues into the undulating retouch of the microlith's LHS. It measures 24.3 x 8.9 x 3mm.

Backed and truncated bladelets: This formal group includes three backed bladelets (CAT 10523, 10550, 10561) and two bladelets with distal truncations (CAT 10486, 11563). They are generally defined by having retained their bulbar ends. The former are all proximal fragments, and they either have retouch along their LHS or their RHS. Their width varies between 2.5mm and 5.8mm. The latter two pieces both have oblique distal truncations. CAT 11563 is intact, and it measures 11.5 x 4.8 x 1.1mm.

Fragments of microliths and microlith-related implements: These edge-modified fragments were subdivided into two groups, namely 1) fragments of microliths, and 2) fragments of microliths or backed bladelets. *Proximal* fragments which had clearly had their bulbar ends removed, but which could not be formally defined as belonging to one or the other specific microlith type, were referred to the former category, whereas *medial* and *distal* fragments, which would not allow the character of their proximal ends to be defined, were referred to the latter category. In total, seven fragments of microliths were recovered, and 27 fragments of microliths or backed bladelets. The pieces included in these two categories have an average width of 4.5mm; 29 of these fragments have a retouched left lateral side, and five have a retouched right lateral side.

Krukowski 'microburins' (Krukowski 1914): For definition and discussion of this type, see the methodology section. It is recommended to refer to the group as 'Krukowski pieces' rather than 'Krukowski microburins', as it is highly likely that the group includes few or no actual microburins.

In terms of the five Krukowski pieces from Zone 5, they all have a fully retouched LHS, and a surviving microburin facet at the proximal end, and their widths vary between 3.1-6.4mm. It can not be ruled out that some of these pieces are broken microliths, or pieces which broke during production, but the fact that they tend to have a roughly scalene triangular outline, suggests that they may mostly be scalene triangles which were used without further modification of their sharp *piquant triédre*.

Microburins: A total of 117 microburins were recovered from the area. They include 96 proximal variants, 10 distal ones, and 11 are medial. The proximal:distal ratio is therefore 91:09. In connection with the analysis of the microburins from Site 3B it was shown that the proximal variants are somewhat broader than the distal forms, which is a function of the generally tapering shape of most blades/microblades. Due to the relatively low number of distal microburins it was not possible to replicate this trend diagrammatically.

The average width of the 117 microburins is 7.0mm. A total of 107 pieces (or 92%) had their notch in the LHS, and the remainder in the RHS. As many as 63 pieces (or 54%) were broken successfully, forming the required sharp microburin facet, whereas 54 snapped. Only CAT 10411 is a *lamelle a cran* microburin. It is thought that the presence of left and right-side notches relate to the presence in prehistory of left-handed and right-handed people (cf. Andersen's [1982] discussion of right- and left-handedness amongst people in the Danish Maglemosian).

Fig. 5.7. The width of all microliths and microlith-related implements, incl. frags (blue), and all microburins (red; see below).

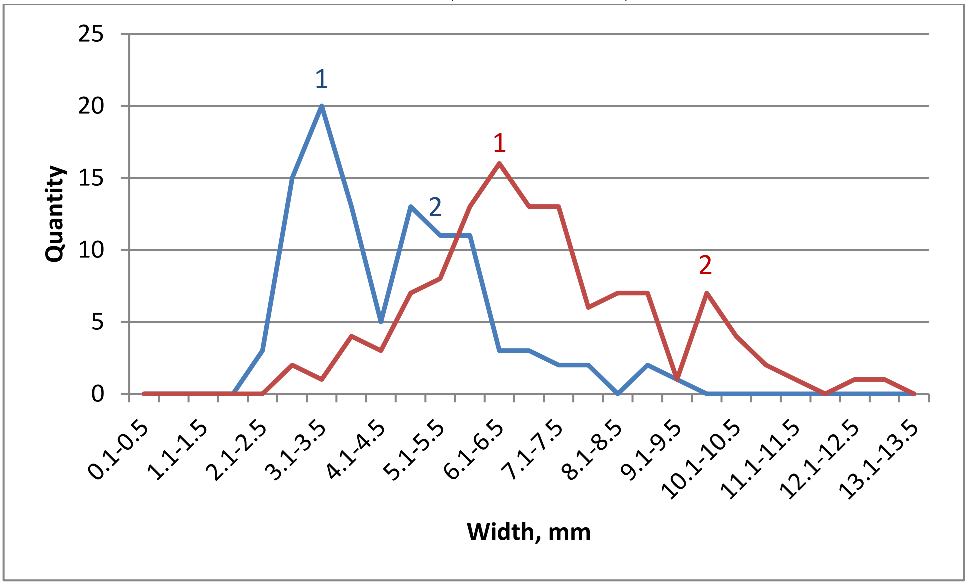


Fig. 5.7 shows the width of all microliths and microlith-related implements compared to the width of all microburins. Generally, the microliths tend to be approximately half as wide as the microburins, demonstrating how much of one lateral side was removed in connection with the modification of the microliths, whereas the width of the microburins correspond approximately to the width of the original microblade blanks (above). Interestingly, the microliths, as well as the microburins, include two distinct size categories, supporting the suggestion put above that Zone 5 may have been visited at least twice during the Late Mesolithic period.

Scrapers: Ten scrapers were recovered from Zone 5, including one discoidal scraper (CAT 10228), six short end-scrapers (CAT 10218-9, 20222-3, 10225, 10589), one blade-scraper (CAT 10221), one double-scraper (CAT 10220), and one scraper-edge fragment (CAT 10224).

CAT 10228 is a minuscule, button-sized discoidal scraper with retouch along most of its circumference. This piece was exposed to fire, and shed its dorsal face, but it has been possible to conjoin the two fragments. The refitted piece measures 16 x 15 x 3mm. Although buttonand thumbnail-scrapers are generally associated with Early Bronze Age industries, this implement is not as neat and well-executed as the later pieces, and its execution corresponds to what would be expected from Mesolithic scrapers.

The short end-scrapers form a highly heterogeneous category of probably expedient pieces. They generally have steep working-edges, but these scraper-edges include pieces with convex, as well as straight delineations, in addition to pieces with distal and proximal working-edges. CAT 10219 has a peculiar retouched spur at the proximal end, but this part does not seem to have been used. The largest of the end-scrapers (CAT 10225) measures 36 x 32 x 9mm, whereas the smallest (CAT 10223) measures 19 x 13 x 6mm.

CAT 10221 is the distal fragment of a burnt blade-scraper which, due to its exposure to fire, shed its dorsal face. The scraper-edge is slightly convex to straight and steep, and the surviving fragment measures 22 x 18 x 4mm. CAT 10220 is a burnt double-scraper based on a crested flake or blade. It has a convex steep scraper-edge at the distal end, and at the proximal end only a corner survives of a second, opposed working-edge. This piece measures 22 x 18 x 8mm. It was not possible to define scraper-edge fragment CAT 10224 (GD = 10mm) more specifically.

Truncated pieces: This category includes seven blades or elongated flakes with distal truncations. Four pieces (CAT 10240, 10256, 10270, 10283) were defined as having oblique truncations, and three (CAT 10238-9, 10580) as having straight truncations. However, apart from CAT 10240, which has a regular well-executed oblique distal truncation, all other truncations are somewhat 'flimsy', probably representing the minimal modification needed to protect the user's finger during use. Almost all truncated pieces display flat use-wear along one lateral edge, suggesting that these implements were used as knives. CAT 10240 forms a ventral-dorsal refit with flake CAT 1493. The flake CAT 1493 also has flat use-wear from cutting, showing that this piece was used as an informal knife. Three truncated pieces (CAT 10239, 10270, 10283) are approximately intact, measuring on average 27 x 12 x 4mm.

Serrated pieces: Only one serrated piece was recovered from Zone 5 (CAT 10237). This implement is based on a blade, and it has lost its distal end. The surviving segment of the piece measures 27 x 10 x 2mm. CAT 10237 has approximately five teeth per cm, and the serration is generally quite worn. Serrated pieces, or microdenticulates, are mostly associated with Early and later Neolithic sites (eg, Saville 2006; Suddaby & Ballin 2011), and it is possible that this piece is an intrusive element in an otherwise mainly Late Mesolithic sub-assemblage. One radiocarbon-date (SUERC-68102) from Pit 1879 (which contained no flint) a few meters north-west of the main Zone 5 scatter returned a date of 3944-3713 cal BC, or the Early Neolithic period. Although CAT 10237 was recovered from the central part of the main scatter, it is possible that this piece should be associated with the Neolithic activity around Pit 1879, and that this pit may form part of the Early Neolithic activities which took place at the base of the slope and further towards the east, around Zone 6.

Polished-edge implements: The name of this category was chosen due to similarities between these heavily used pieces from Zone 5 and a particular group of tools commonly recovered from Scottish later Neolithic sites (Ballin 2011b, 27, Figs 19-20). However, where the later Neolithic pieces have been used to an extent, and in a manner, which has provided them with almost mirror-like polish, the pieces from the present site are more coarsely abraded, rather than polished, and it is in many cases possible to see in light magnification (8X) that the used edges have striations running at a perpendicular angle to the edge. The later Neolithic implements, as well as many of the ones from Zone 5, have clearly rounded edges, although a large number of pieces from Zone 5 also display well-developed edge-facets (eg, CAT 10665), as well as rounded and faceted tips (used pointed ends and corners).

Table 5.6. Characterization of the 157 polished-edge implements from Zone 5. In total, these pieces have 306 used 'parts' (either tips or edges).

	Number				Per cent			
	Location	*Edge prep.*	*Tip/edge*	*Degree*	*Location*	*Edge prep.*	*Tip/edge*	*Degree*
Proximal	44				14			
Left lateral	91				30			
Right lateral	81				27			
Distal	89				29			
Dorsal	1				trace			
Unmodified		99				32		
Modified		156				51		
Edge of platf remnant		24				8		
Break facet		27				9		
Tip			44				15	
Edge			260				85	
Platform surface			1				trace	
Uncertain			1				trace	
Barely notable				120				39
Light				159				52
Heavy				27				9
TOTAL	**306**	**306**	**306**	**306**	**100**	**100**	**100**	**100**

In an attempt to characterize the use of these unusual pieces more precisely, Table 5.6 was produced. It shows the location of the use, edge preparation, whether an edge or a pointed part was used, and the degree of use. In total, 306 used 'parts' were identified on the 157 polished-edge implements.

The left and right lateral edges were, as would be expected, used to an equal extent. The distal end was also commonly used. If the distal end was broad, its edges would be used, and if it was pointed or had protruding corners, these parts were used. The proximal end was used less commonly, but the edges and protruding parts of this end were also occasionally employed.

Table 5.6 also shows that more than half of the used tool parts were modified by steep edge-retouch prior to use, with approximately one-third being unmodified pieces. In 8% of the cases, platform remnant edges were used, and in 9% of the cases, the used edges are break facets. The employment of break facets suggests that some of these pieces are recycled abandoned blanks or tools, which is supported by the fact that probably 12 pieces are reused end- or side-scrapers (CAT 10639, 10645, 10695-6, 10743 are particularly obvious). However, the fact that most used parts have a retouched base indicates that in many cases edges or points were modified to make them usable in connection with some specialized task. Although the used parts are mostly edges (85%), a notable proportion of these parts are tips, or pointed/protruding parts.

The assessment of the degree of use is based on the analyst's subjective impression. A total of 39% of the pieces have barely notable, but macroscopically visible, use-wear; as many as 52% have light use-wear; and 9% of the implements are characterized by heavy use-wear. If all edges and pointed parts of all lithic artefacts from Zone 5 were inspected by the consistent use of a microscope, this tool category would almost certainly expand exponentially.

In addition, four pieces have lateral use-wear from cutting (CAT 10605, 10643, 10704, 10721), and CAT 10650 seems to have a degree of gloss, possibly indicating the processing of vegetable matter.

In summary, the area's polished-edge implements were used to rub, scrape, or smooth some as yet unknown materials in a number of different ways (the use of edges as well as tips). They appear to have been used either slightly less, or in a slightly different way, than the well-known later Neolithic pieces (Ballin 2011b), as they did not develop the mirror-like polished surfaces of these objects. The abraded surfaces of the edges find parallels in a group of flint artefacts from Kom el-Hisn, a site dating to the Old Kingdom of Ancient Egypt (Winiarska-Kabacinska 2015, Appendix Fig. 1). These pieces were described broadly as having been used for the 'smoothing of non-organic materials'. In an attempt to specify the suggested use of these pieces, the analyst contacted Dr Winiarska-Kabacinska (email of 13.06.2016) who kindly narrowed the processed objects down to '… hard materials […] like stone (non-organic) rather than bone, antler or wood'. However, this is to a degree countered by the above-mentioned use-wear from cutting and the possible presence of gloss which suggest the processing of organic materials (although these uses could be secondary to the main use of the pieces). It is expected that Dr Hardy's use-wear analysis may shed light on this issue.

General technological analysis of the implements shows that 1) they are mostly based on dense, opaque, monochrome or marbled grey flint; 2) they include five crested pieces (CAT 10618, 10633, 10721, 10745, 10754); 3) they are partly based on thick flakes/flake fragments and whole or broken blades/microblades (flake:blade ratio 63:37); 4) most of the blades are broad-blades (blade:microblade ratio 93:7; average width 13mm); and 5) most of the blades are hard percussion specimens (hard:soft percussion ratio of definable pieces 59:41).

In terms of form and use, the assemblage of polished-edge implements come across as a homogeneous category, and the fact that the vast majority of them were recovered from one well-defined cluster (Figs 5.18, 5.23) centred on grids BX/BY 41 (84% of all polished-edge implements), indicates that they were made, used and deposited by the same person or group of persons within a very narrow time span (one or a few days?), and that this well-defined scatter represents one event focusing on the execution of one specific task. (see Hardy, this volume).

In terms of dating this event, the use of relatively large, predominantly hard percussion blades indicates a date in the later Neolithic, suggesting that this group of objects may indeed be contemporary with the later Neolithic polished-edge implements from, for example, sites near Overhowden Henge in the Borders (Ballin 2011b), but the general distribution of artefacts across Zone 5 suggests a different scenario. The distribution of chips, blades and burnt pieces (Figs 5.10-12) indicates the presence of at least six concentrations and hearths, with the most notable one being centred on grids BX/BY 41. This concentration also includes many micro-blades, microliths (almost exclusively scalene triangles) and microburins, and it is highly likely that the polished-edge implements are contemporary with these pieces, and therefore date to the Late Mesolithic period.

The analyst considered whether the dominance of robust blade blanks over microblades might be a result of the Late Mesolithic settlers 'mining' Zone 4's Late Upper Palaeolithic material (see Zone 4, this volume), but the technological attributes of the Upper Palaeolithic blades from Zone 4 and those of the polished-edge implement blanks suggest the application of two significantly different operational schemas: the Late Upper Palaeolithic blades from Zone 4 were generally produced by the reduction of very large opposed-platform cores, whereas the frequently notable curvature of the polished-edge implement blades (eg, CAT 10633, 10711) testify to these pieces generally having been struck off conical single-platform cores.

As the area's distribution patterns indicate that the polished-edge implements may date to the Late Mesolithic period, the composition of the polished-edge implement blanks may be explained in three ways: 1) As shown in connection with the analysis of the assemblage from Site 3B (this volume), blades from the initial preparation of the blade cores tend to be larger and more robust (and including more hard-hammer pieces) than the later actual blade blanks, and the blanks of the polished-edge implements may predominantly be waste from the preparation of cores (supported by the presence of several crested pieces and the fact that *c*. 40% of the category is cortical); 2) the polished-edge implement blanks may be robust blanks for heavy-duty use produced specifically for the occasion (supported by the general robustness of the flake and blade blanks); or 3) a combination of these two production/selection processes.

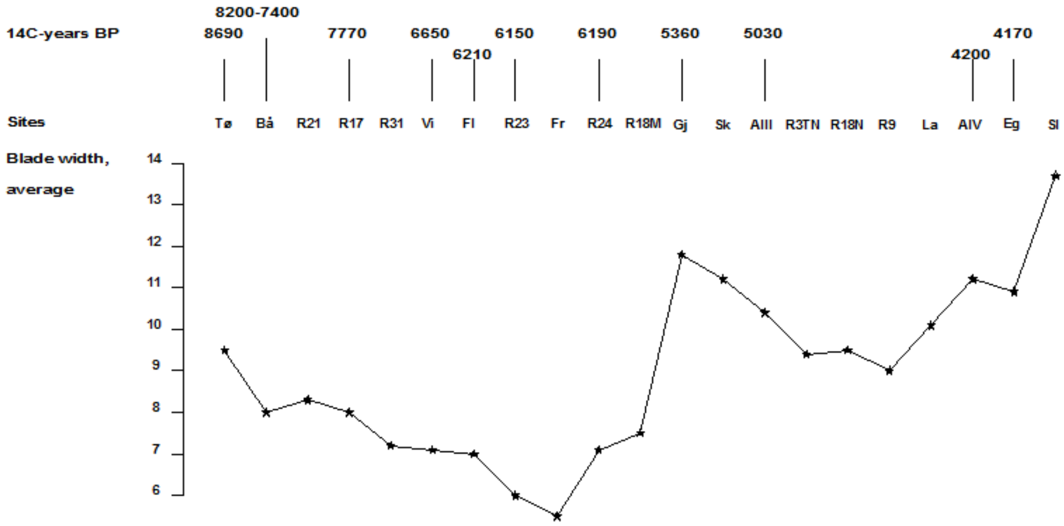
Pieces with edge-retouch: Nineteen lithic artefacts display various forms of lateral modification. Sixteen are based on flakes, two are blades, and one is a microblade. These pieces differ considerably in shape and size (GD 9-52mm), and it is thought that this tool group includes artefacts, or fragments of artefacts, with different functions.

Technological summary

This technological summary is based on information presented in the debitage (tool blanks and waste), core and tool sections above. It has been possible to identify a number of different technological approaches within the Zone 5 assemblage, namely 1) a general Late Mesolithic approach; 2) a Late Upper Palaeolithic approach; and 3) an approach linked specifically to the polished-edge implements.

The Late Mesolithic approach: Although the distribution analysis (below) suggests a minimum of five visits to the site during the Late Mesolithic period (with each visit being focused on its own central hearth), the basic operational schema applied by all Mesolithic settlers within Zone 5 is fundamentally the same. This schema corresponds to the one defined in connection with the analysis of the finds from Zone 4 and Site 3B. The only technological difference between material left by the different groups of Mesolithic settlers is the fact that – as indicated by the microblades, the conical cores, the microliths and the microburins – the main tool blanks differed in size over time. A similar trend (Fig. 5.8) has been noticed in connection with research into the blades and microblades produced through for example Danish and Norwegian Early Prehistory (Ballin 2004, Fig. 22.4), indicating that, within a region characterized by uniform raw material availability, average blade width may be a diagnostic value.

Fig. 5.8. The development of average blade width through the Mesolithic and Neolithic periods of southern Norway (Ballin 2004, Fig. 22.4).



By and large, the Late Mesolithic approach followed to produce most of the assemblage from Zone 5 corresponds to the one defined in connection with the discussion of the Zone 4 assemblage and the assemblage from Site 3B (this volume). Four tiny bipolar cores (GDs 8-17mm) appear out of place and do not seem to form part of the Late Mesolithic operational schema, but they were found within the main lithic concentration of Zone 5 and are therefore likely to represent some form of *ad hoc* lithic production during the Mesolithic.

The Late Upper Palaeolithic approach: In Zone 5, these pieces were not associated with a specific fireplace or other focal point, and these artefacts were probably brought in either as a result of Late Upper Palaeolithic activities focused on Zone 4 taking place away from the immediate surroundings of a hearth in that zone, or due to scavenging of Zone 4 by Late Mesolithic settlers from Zone 5. These pieces include broad blades, and large crested pieces and core tablets. For a detailed discussion of the Late Upper Palaeolithic approach, see the presentation of the finds from Zone 4 (this volume).

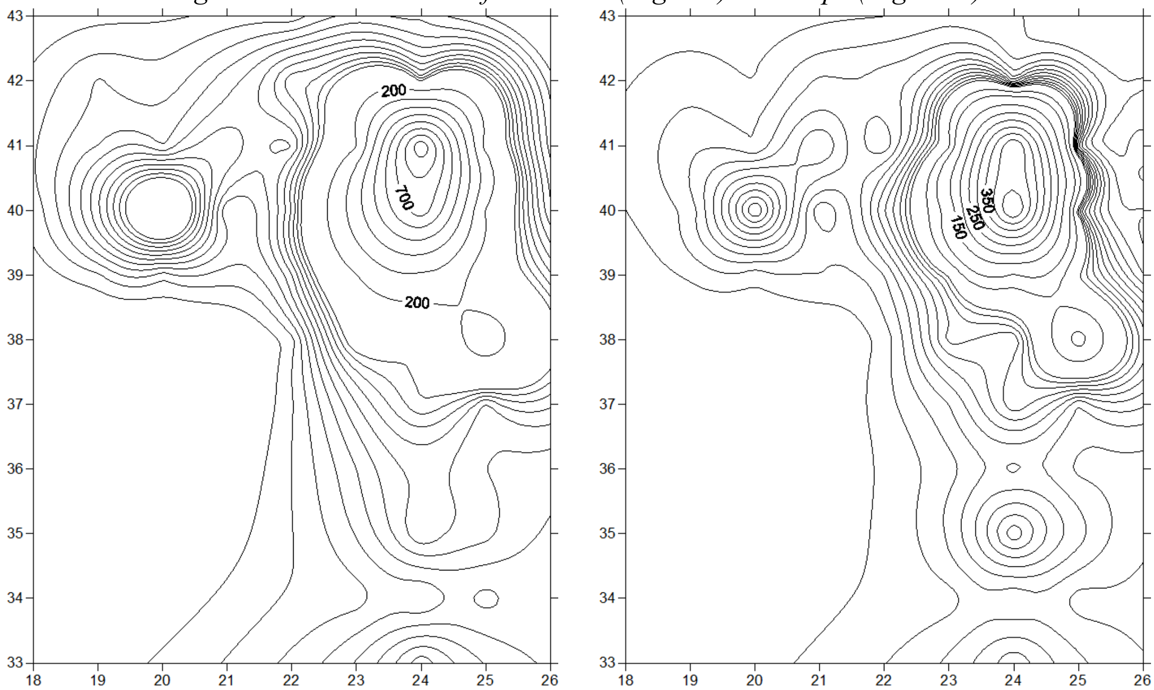
The approach associated with the polished-edge implements: This approach was dealt with in detail in connection with the presentation of these pieces (above). The blanks are mostly based on dense, opaque, monochrome or marbled grey flint; they include five crested pieces; they are partly based on thick flakes/flake fragments and blades/microblades (flake:blade ratio 63:37); most of the blades are broad-blades (blade:microblade ratio 93:7; average width 13mm); and most of the blades are hard percussion specimens (hard:soft percussion ratio of definable pieces 59:41). The fact that practically all of these pieces were recovered from the area's main concentration, centred on Grids BX/BY 41, and associated with scalene triangles suggests that they may be Late Mesolithic objects, despite the fact that they are more robust than one would expect from blanks dating to this period.

The curvature of some of the blades indicates that these pieces were struck off conical single-platform cores, rather than representing scavenged material from the Late Upper Palaeolithic Zone 4 concentration, which is based on opposed-platform technique. Above, it was suggested that these pieces may either be blanks from the initial and general core preparation taking place in Zone 5, or they may be robust blanks for heavy-duty use produced for one specific task (see Hardy; this volume).

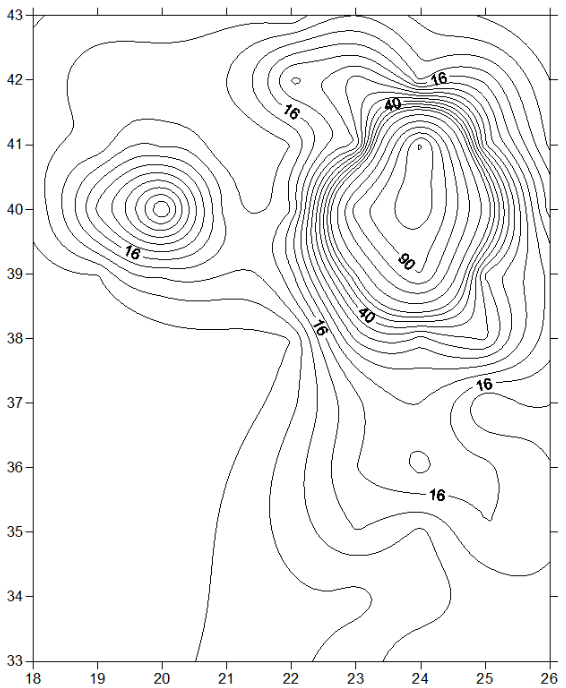
Distribution, features and on-site activities

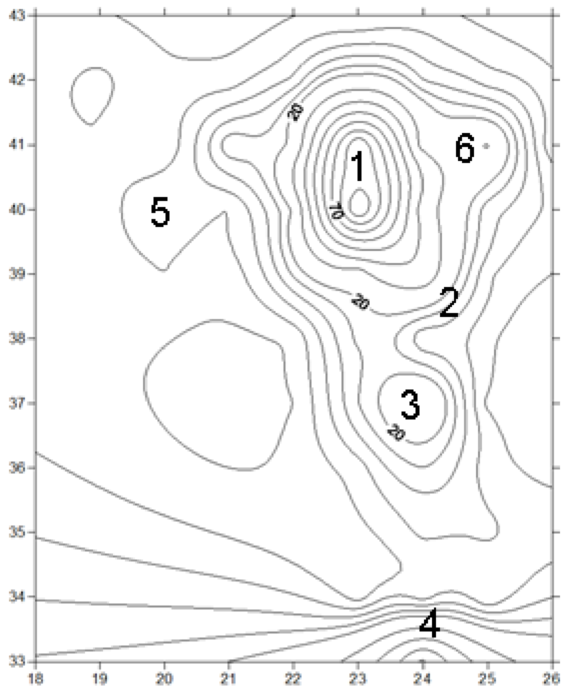
In an attempt to 'dissect' Zone 5 into its likely chronological components (visits), as well as to shed light on intra-zonal activities, a number of distribution maps were produced. The distribution of categories involving large numbers of finds (all lithics; chips; blades; burnt pieces; and polished-edge implements; Figs 5.9-12 and 5.18) was shown by the application of contour-mapping, and that of categories involving relatively small numbers of finds (cores; preparation flakes; microliths; and microburins; Figs 5.13-16) through 'dot-mapping', where a number in each grid indicates how many pieces were found there. In addition, a number of '3D' surface maps were produced to express the distribution of the numerous categories in a more visual manner (Figs 5.19-23).

Figs 5.9-10. Distribution of all lithics (Fig. 5.9) and chips (Fig. 5.10).



Figs 5.11-12. Distribution of blades (Fig. 5.11) and burnt pieces (Fig. 5.12) – the numbers indicates where hearths may have been located. The position of some hearths is more clearly indicated by the distribution of the chips, which are thought to represent the knapping floors immediately next to the hearths (Fig. 5.10).



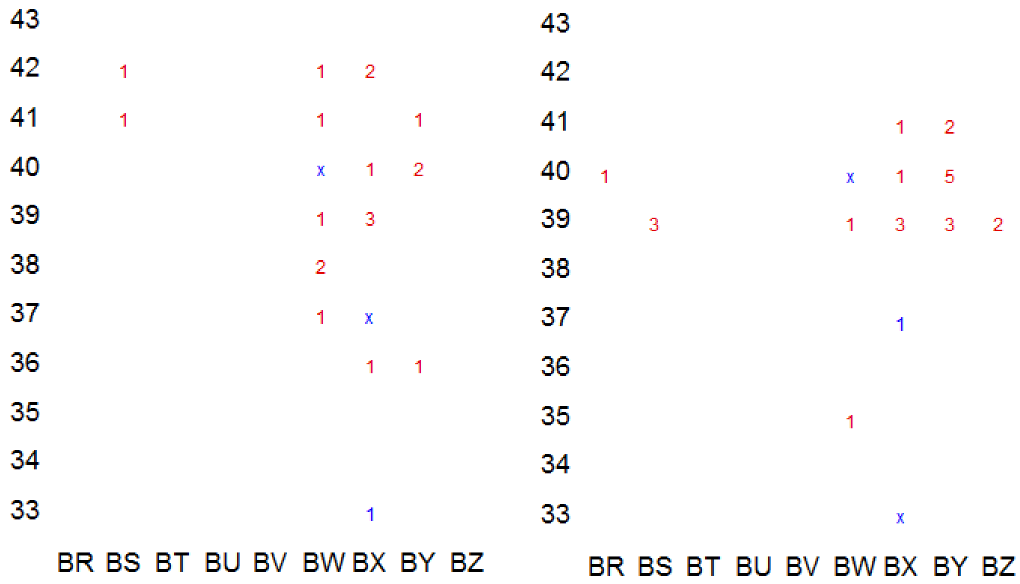


As Zone 5 includes a number of clusters, with Concentration 1 being numerically dominant (including approximately two-thirds of the zone's lithics) and the others containing relatively low numbers of finds, a fixed contour interval would have resulted in the main concentration obscuring all other concentrations. It was therefore decided to make the contour intervals smaller at the low end (to bring out the smaller concentrations) and larger at the high end (to prevent the main concentration appearing as a black smudge). This explains the apparent presence in some of the contour maps of a 'ledge' at the mid-level, where sets of small and large contour intervals meet. For a general discussion of the approach applied in this section, see Ballin (2013b) and Binford (1983).

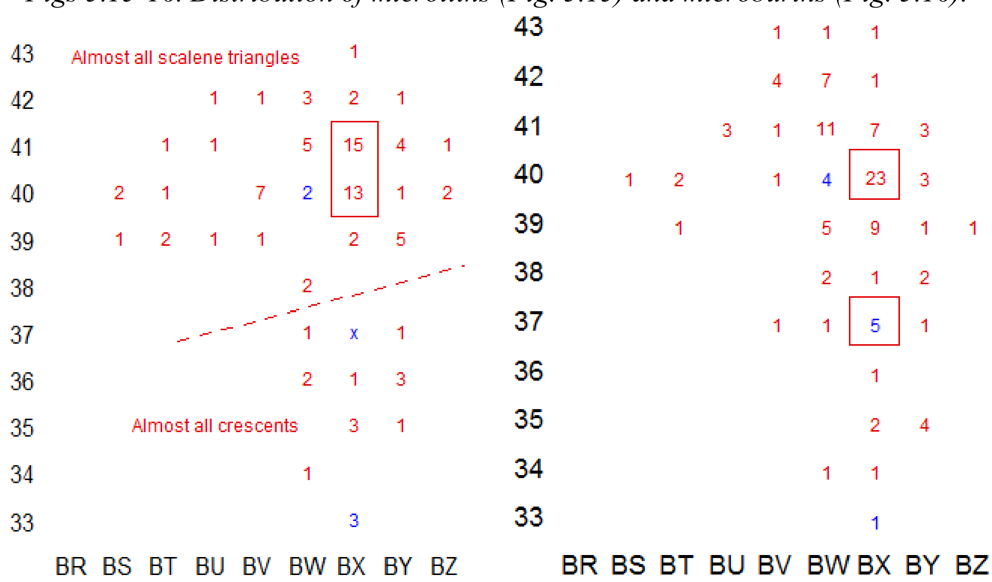
As shown in Figs 5.9-12 (all lithics; chips; blades; and burnt pieces), Zone 5 has six centres or focal points (Concentrations 1-6): 1) BW/BX 40/41 (the 'main' concentration); 2) BX/BY 38/39; 3) BX 37; 4) BX 33 (cut by the southern limit of the trench); 5) BT/BU 40; and 6) BY 41. They were probably all associated with a central (domestic) hearth, although only the hearths of Concentrations 1, 3 and 4 stand out (Fig. 5.12). The likely presence of a hearth in Concentration 2 is indicated more clearly in the surface map Fig. 5.22, which even indicates a possible sixth concentration at Grid BY 41, which has been almost entirely obscured by the neighbouring main concentration.

The position of the five concentrations is most clearly shown by the distribution of the chips (≤ 10mm) (Fig. 5.10). These pieces represent what Binford (1983, 153) referred to as the drop zone of finds too small to be a problem (in prehistoric time) to the general traffic across the site, and which were therefore generally left where they fell (ie, they were not exposed to preventive or *post hoc* site maintenance; ibid.). They show the position of a number of knapping floors, which tend to be located immediately next to the location's fireplaces (cf. Ballin 1998). This is also where most of the blades were found (Fig. 5.11), as the intact and fragmented mainly Late Mesolithic microblades and narrow-blades are sufficiently small to be included in the drop zone, rather than to be exposed to preventive maintenance (and become part of a toss zone; ibid.) or *post hoc* maintenance (and be removed to an actual midden) (Binford 1983, 189).

Figs 5.13-14. Distribution of cores (Fig. 5.13) and preparation flakes (Fig. 5.14). In Figs 5.13-16, a blue number or – when a grid did not contain any pieces of the category in question – a blue cross indicates the presence of a perceived hearth.

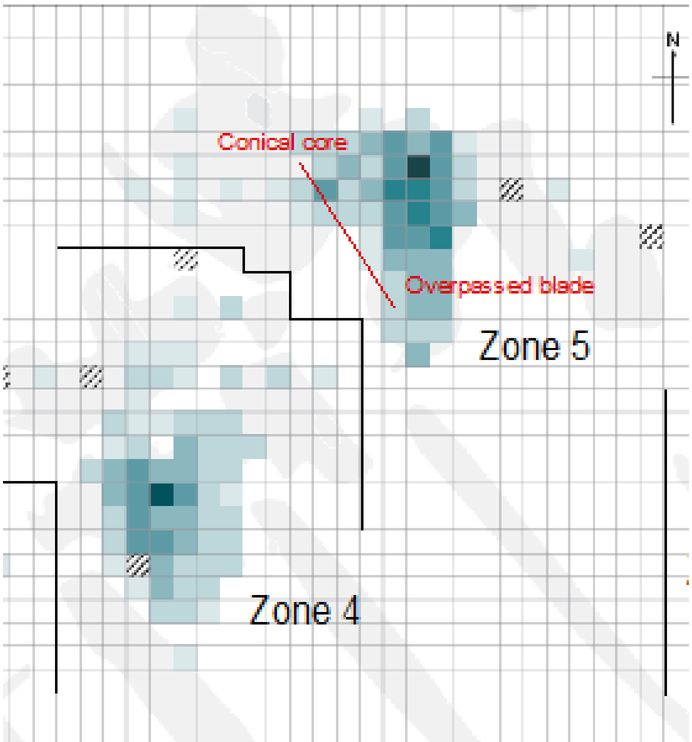


Figs 5.15-16. Distribution of microliths (Fig. 5.15) and microburins (Fig. 5.16).



The cores and preparation flakes (Figs 5.13-14), which are relatively large objects, were probably considered potential problems to the traffic across the prehistoric site and 'tossed' out of the area nearest the hearth. Only Concentrations 1 and 3 contain enough cores and preparation flakes to show a pattern, and both indicate a toss zone around the concentration's fireplace. Core CAT 10162 was discarded when a blade overpassed and removed its apex, as shown by the refitting of this piece with overpassed blade CAT 10163, connecting grids BS 41 and BW 35 which are *c*. 7m apart. As the line connecting the two find spots is almost exactly parallel with the site's plough furrows (Fig. 5.17), the question is whether these refitting pieces were separated by modern activities (ploughing), or whether this separation represents actual prehistoric activity. Site 2D's distribution patterns are generally quite neat and there is no indication of major plough-induced disturbance to the zones. However, it can not be ruled out that individual pieces were moved by ploughing.

Fig. 5.17. Location of the conjoined conical core (CAT 10162) and the overpassed blade (CAT 10163).

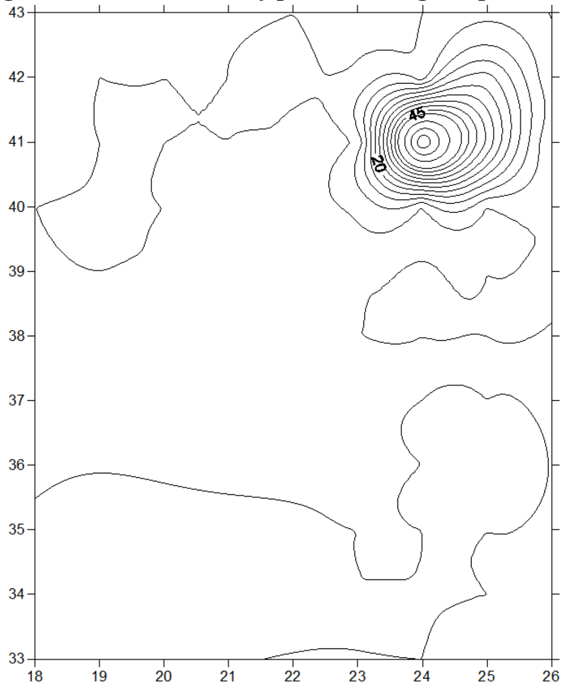


The microliths of Zone 5 were apparently produced immediately next to the hearths (Figs 5.12, 5.15-16), where the knappers would have been seated, and at Mesolithic sites microblades, microliths and microburins tend generally to be found together, overlapping the concentration of burnt flint (Cziesla 1990, 81). The area around the hearth is also where hafting and 're-tooling' would have taken place (ibid; Keeley 1982).

The most notable scatter of microliths is around the hearth in Concentration 1, with a general scattering of microliths across the zone indicating that microliths were also produced and used around the other hearths. The microburins define Concentrations 1 and 3 in particular, but, like the microliths, they also indicate that microliths were produced throughout the zone. Interestingly, the area appears to be divided into a northern (Concentrations 1-2 and 5-6) and a southern part (Concentrations 3-4), separated by a belt with relatively few microliths (Fig. 5.15). The northern part includes almost exclusively scalene triangles and the southern part almost exclusively crescents. Unfortunately, the northern part is not associated with any radiocarbon dates (an Early Neolithic date was obtained from Pit 1776 north of the scatter), but a pit at the periphery of the southern crescent-dominated segment of the zone (although being partly situated within the find-poor central belt) provided one date, namely 8222-7965 cal BC (SUERC 68101). A string of radiocarbon-dates from Fife Ness (Wickham-Jones & Dalland

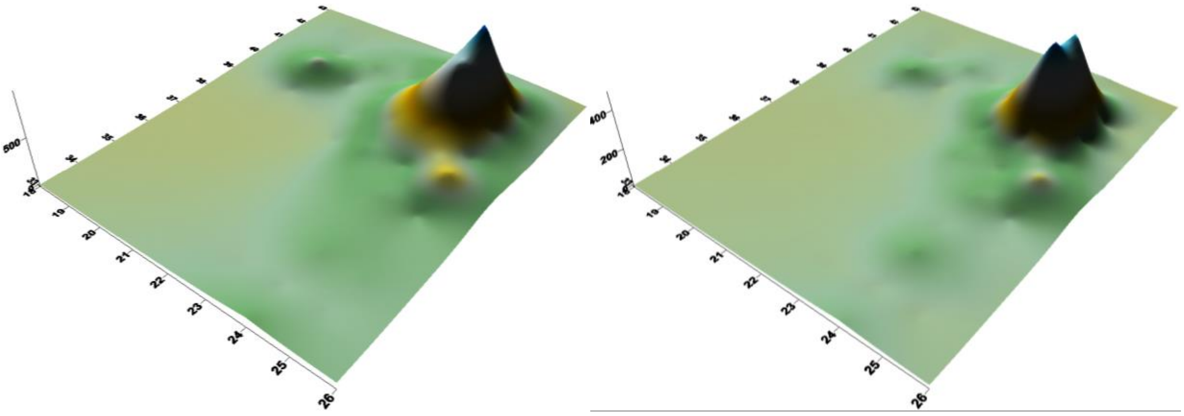
1998, 6) suggested a date for this crescent-dominated assemblage of *c*. 7600-7400 cal BC, or roughly 5-600 years later.

Fig. 5.18. Distribution of polished-edge implements.



Figs 5.18 and 5.23 jointly show that the zone's unusual polished-edge implements represent a single event, associated with the processing of presently unknown materials. As the, in spatial terms, tight concentration of these pieces coincide quite precisely with Concentration 1's other artefacts, including many scalene triangles, this event is likely to have taken place in connection with one, and only one, of the visits to the area in the Late Mesolithic period.

Figs 5.19-20. 3D surface maps. Distribution of all lithic (Fig. 5.19) and chips (Fig. 5.20).



Figs 5.21-22. 3D surface maps. Distribution of blades (Fig. 5.21) and burnt flint (Fig. 5.22).

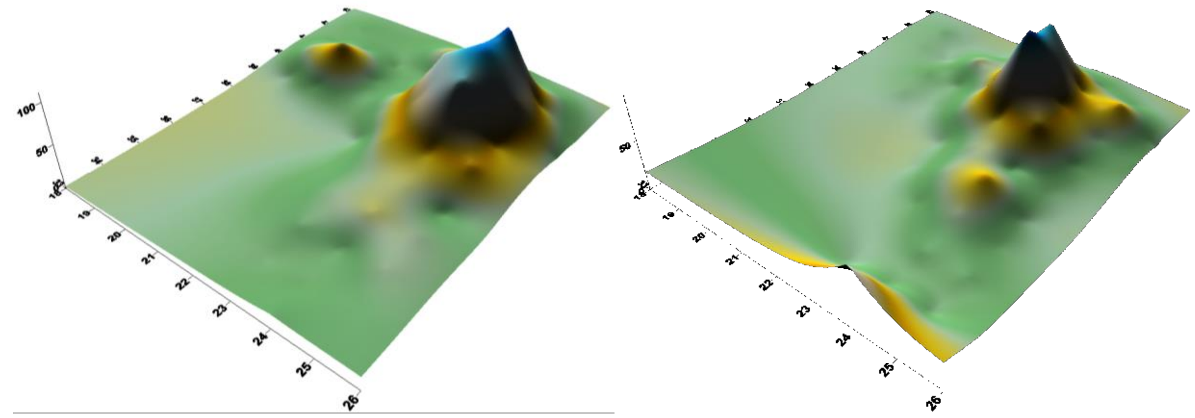
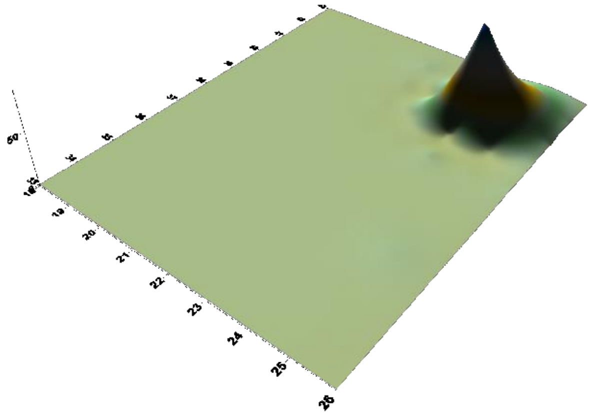


Fig. 5.23. 3D surface maps. Distribution of polished-edge implements.



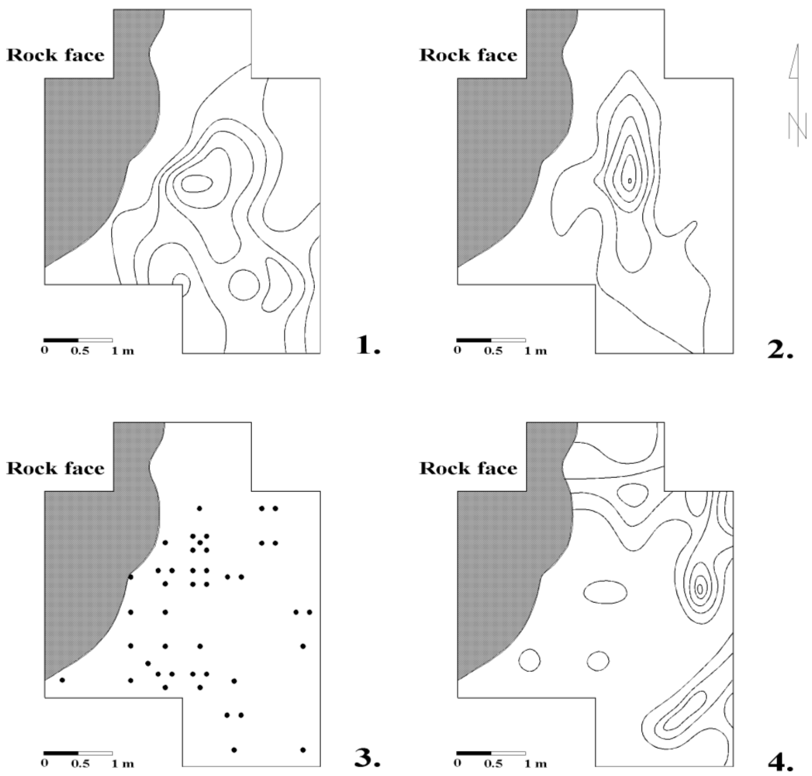
Four intercutting pits in Zone 5 may or may not be structural, but the absence of other features in the area – apart from Pit 1879 north of the scatter (which contained no flint) and Hearth 1211 – suggests that the fireplaces defined by burnt flint may relate to open-air sites. This interpretation is supported by the distribution of the cores (Fig. 5.13), the spatial pattern of which indicates that 'tossing' took place. In terms of the intra-site spatial patterns, there is little directly relevant comparative material from Scotland to the investigation of Zone 5, as Scottish early prehistoric sites have traditionally been excavated in contexts rather than grids or, when excavated by grid units, many turned out to be palimpsests which could not be disentangled (eg, Nethermills Farm; Ballin 2013a).

It is tempting to compare the patterns above with those of recently discovered Mesolithic huts from Scotland (eg, Echline Fields on the Forth; Robertson *et al.* 2013) or northern England (eg, Howick, Northumberland; Waddington 2007), but the organization of space on open-air sites and inside dwellings may have followed quite different principles. On open-air sites, the spatial patterns are very much governed by 'drop and toss' (Binford 1983, 153), where order within the confined space of dwellings would have been more structured and include features like door dumps, actual middens, wall-defining debris, tongues of micro-waste in the entrance area, etc. (ibid., 176; also see the distribution patterns associated with the Early Bronze Age house at Dalmore on Lewis; Ballin 2002a; 2008c). However, some universal trends are present at sites of both types, such as the focus on the central hearth, around which most activities took place.

A further problem relating to the use in the present context of comparative material from dwellings is the fact that space within those structures may have varied depending on factors such as time of the year, the weather, etc. as demonstrated by distribution analyses of Norwegian hunter-gatherer houses (including those from the Norwegian Early Neolithic period which economically was an extension of that country's Mesolithic period; Ballin 2004b). The stone-built prehistoric house from Austvik IV, Hordaland county, has its main hearth in the entrance area (suggesting use during the summer?), surrounded by knapping debris, whereas many tools were found within the dwelling, either representing tool modification, tool use or caches (Kristoffersen 1990, 41).

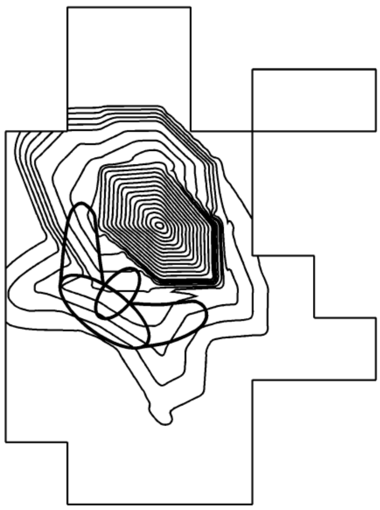
The general distribution patterns of small open-air hunter-gatherer sites were touched upon by the author in his analysis of the Middle Mesolithic site Lundevågen 31, Vest-Agder county, Norway (Ballin 2013b), and these trends are shown in Fig. 5.24. Lacking a built fireplace, the central hearth is defined by the distribution of burnt flint; the chips (Binford's drop zone) then defines the main knapping floor which is usually located immediately next to the hearth; slightly further away from the hearth one finds various activity areas, where the individual tool types were used; and furthest from the site's centre, is the heavy lithic waste, which defines the site's toss zone.

Fig. 5.24. Lundevågen 31. Distribution of 1) burnt flint, 2) chips, 3) tools, and 4) average weight per lithic per grid unit (Ballin & Lass Jensen 1995, 97, 99).



If a site is excavated by quarter of square metres (50x 50cm), it is occasionally possible to pick up even finer details, such as at Steinbustølen in the Norwegian High Mountains (Ballin 1998). In this case, the distribution (such as small distributional protuberances on either side of the perceived knapper) suggested that the best blades, as well as immediately produced implements, were collected next to the knapper, as well as in front of him (between his legs) (Fig. 5.25). Due to the excavation of Zone 5 by full square metres, it was not possible to reach this degree of detail in connection with the analysis of the present site. However, as shown above, it was possible to reach some general conclusions regarding the spatial patterning of Zone 5, despite the excavation by full square metres and the fact that the zone has most likely been visited on several occasions within the Late Mesolithic period (see dating section, below). The defined spatial trends generally correspond to those defined in connection with the analysis of Lundevågen 31, including the use of drop (eg, chips, microblade fragments and microburins) and toss (eg, cores and preparation flakes).

Fig. 5.25. Steinbustølen. Distribution of chips. The reason for the more idiosyncratic way of calculating the chip contours of Steinbustølen is the extremely dense central concentration of chips. If the same contour intervals had been applied throughout, neither protuberances nor the asymmetrical shape of the concentration would have been detectable.



The four inter-cutting pits (Pits 1211, 1776, 1837, and 1863) all contained flint – from four pieces (Pit 1837) to 137 pieces (Pit 1776) (Table 5.7). The presence of narrow microliths in three of the features (Pits 1211, 1776, and 1863) define them as Late Mesolithic, which was confirmed by a radiocarbon-date from Pit 1776 (8222-7965 cal BC; SUERC-68101). It is tempting to associate this date with the crescent-dominated southern concentration (Concentration 3), as the pit is at the periphery of this scatter, but the pit is also partly within the find-poor zone between the crescent-dominated and scalene triangle-dominated parts of Zone 5. As the pits contain not only crescents but also scalene triangles, it is possible that these features were dug after the formation of Zone 5's main scatters and that the visits to the area therefore generally pre-date the date suggested by SUERC-68101 (see dating section).

Table 5.7. Composition of the four assemblages from pits across Zone 5.

	Chips	*Flakes*	*Blades*	*Microblades*	*Indet. pieces*	*Crested pieces*	*Core frags*	*Scalene triangles*	*Crescents*	*Microlith frags*	*Scrapers*	*Total*
Pit 1211	6	4		1				1				12
Pit 1776	91	20	6	2	11		1	1		4	1	137
Pit 1837	1	2				1						4
Pit 1863	2	19	6	3	3				2			35
TOTAL	**100**	**45**	**12**	**6**	**14**	**1**	**1**	**2**	**2**	**4**	**1**	**188**

The composition of the four pit assemblages (Table 5.7), dominated by fine knapping debris (more than half of the finds is chips), suggests that this material may have entered the features with the backfill (see the discussion of the pits at the base of the slope) and that it does not represent deliberate deposition. It could therefore easily consist of waste left at the site in connection with several different visits to Zone 5.

Dating

As touched upon above, the location seems to have been visited on a number of occasions through early prehistory. The distribution of the lithic artefacts across the area suggests that it may have been visited at least six times (Figs 5.9-23), although almost exclusively in the Late Mesolithic (see Zone 5's radiocarbon dates, though). The lithic assemblage includes several diagnostic elements, such as core and tool types, metrics, technological attributes, as well as associated radiocarbon dates.

Core and tool types: The distribution of microblades (Fig. 5.11), conical cores (Fig. 5.13) and microliths/microburins (Figs 5.15-16) across the site suggests that all concentrations defined by burnt flint (and thereby by the presence of a hearth) may be Late Mesolithic. The area's conical cores are associated with the production of narrow blades and as such they are likely to date to the Late Mesolithic/Early Neolithic framework (cf. Ballin 2013a; 2016a), but as only the zone's solitary serrated piece could be associated with the Neolithic period, they probably relate to the area's Late Mesolithic knapping and microlith production. The microliths are almost exclusively micro-blade scalene triangles and crescents (Table 5.1), with the northern part of the zone being dominated by the former and the southern part by the latter. It is uncertain whether the preference for a particular type of microlith is diagnostic, relates to function, or simply is a matter of personal 'taste'.

As shown in Fig. 5.8, blade width is a diagnostic feature in many countries and regions, and in Britain this is the main reason for the subdivision of Mesolithic collections into broad-blade (early) and narrow-blade (late) assemblages. The fact that Zone 5's crescents are generally substantially broader than the area's scalene triangles (Fig. 5.5) may therefore signify a chronological difference. This is supported by the fact that the two types of microliths form two spatial groups – narrow scalene triangles towards the north and broader crescents towards the south – with the northern half of the site being characterized by narrower blades than the southern half (8.8mm vs 9.5mm).

In Britain, obliquely blunted points are traditionally associated with the Early Mesolithic (Butler 2005, 96), but some do occur in later contexts (see the characterization of the more than 500 microliths from Nethermills Farm; Ballin 2013a). The five pieces from Zone 5 are all microblade versions (av. width 5mm), and clearly date to the Late Mesolithic period.

Only the solitary serrated piece (CAT 10237) is an obvious later form, probably dating to the Early Neolithic period (Saville 2006). Serrated pieces, or microdenticulates, have been associated with either sawing (eg, wood, bone, antler) or cutting/sickling vegetable matter (Juel Jensen 1994, 59). On the continent, these pieces are particularly common in the Final Mesolithic period and through the Early Neolithic (ibid.). This piece may relate to the Early Neolithic radiocarbon date from Pit 1879 (below) and it may be linked to the Early Neolithic activities at the base of the slope north of Zone 5 and in Zone 6 towards the east.

The 157 polished-edge implements form a highly unusual group of tools, and although they are related to the polished-edge implements defined in connection with the author's discussion of Middle and Late Neolithic assemblages near Overhowden Henge (Ballin 2011b) they differ somewhat from these pieces – where the Neolithic pieces have mirror-like polish, the Zone 5 specimens display coarser abrasion and macroscopically visible striation. Their recovery from the area's main concentration, which is also defined by the presence of numerous scalene triangles and microburins, suggests that these pieces probably date to the Late Mesolithic. The fact that the robust blanks for these pieces seem to have been struck from conical cores rules out that they were scavenged from the Zone 4 Late Upper Palaeolithic concentration, and it was suggested above that they may either be blanks from the initial and general core preparation taking place in Zone 5, or they may be robust blanks for some heavy-duty task and produced specifically for this occasion.

Technological attributes: The bulk of the lithic material recovered from the various concentrations in Zone 5 clearly represents a microblade industry. This industry first and foremost aimed to produce blanks for microliths by the application of soft percussion. More robust tools, like scrapers were manufactured mainly on waste flakes from the preparation of the blade cores, although truncated pieces (knives) were predominantly made on the sturdy blades. The size and character of the zone's blades and conical cores are consistent with a date in the Late Mesolithic period.

As mentioned in the technological section, a number of broad blades, large crested pieces and core tablets probably relate to a Late Upper Palaeolithic presence at Site 2D, centred on Zone 4. These pieces were generally produced by the reduction of large opposed-platform cores, and they may either represent activities in Zone 5 by the Palaeolithic settlers of Zone 4, or they represent 'mining' of the Zone 4 Palaeolithic scatter by Zone 5 Mesolithic settlers. For more details on this aspect, see the discussion of Zone 4. As described above, the polished-edge implements, which are also thought to date to the Late Mesolithic, may have been produced on robust flakes and blades from the initial core preparation, or blanks produced specifically for these tools.

Associated radiocarbon dates: Only two radiocarbon dates relate to the prehistoric activities in Zone 5, namely SUERC-68101 and SUERC-68102. The former is based on a burnt hazel-nut shell, which was recovered from Pit 1776, returning a date of 8222-7965 cal BC, or the early part of the Late Mesolithic period. As Pit 1776 is situated immediately next to Concentration 3, it is tempting to associate this date with the visit during which the crescents were produced, but the fact that this pit is also within the zone separating Zone 5's northern (scalene triangles) and southern parts (crescents), and that it contains equal numbers of scalene triangles and crescents, suggests that it may have been dug after the visits producing the area's main concentrations, with the microliths in it simply having formed part of the backfill. Or in other words, the radiocarbon date may give a *terminus ante quem* date for most of the Mesolithic material of Zone 5, which would therefore have been deposited at the very beginning of the Late Mesolithic period around 8500 cal BC (Saville 2008).

The second radiocarbon date from the area is based on hazel charcoal from Pit 1879. This pit was located some metres north of the main distribution of lithic artefacts in Zone 5, and it contained no lithic artefacts. The date of 3944-3713 cal BC, or the early part of the Early Neolithic, may relate to the only lithic object within the area deemed to be a likely Neolithic piece, namely the serrated blade CAT 10237. The location of this pit between the Zone 5 lithic scatter and the pits at the base of the slope, in conjunction with the fact that the serrated piece is the only lithic artefact within Zone 5 typo-technologically identifiable as post Mesolithic, suggests that this piece and the pit may relate to the Neolithic activities at the base of the slope and further towards the east, and that the lithics of Zone 5 generally represent pre Neolithic activity.

Summary and discussion – Zone 5

As shown by the lithic evidence and its distribution, Zone 5 was visited on a number of occasions during the Late Mesolithic period. It is uncertain whether pieces relating to an earlier broad-blade industry represent Late Upper Palaeolithic activity within Zone 5, or whether they are objects 'mined' by the area's Mesolithic settlers from the Palaeolithic debris of Zone 4 (the focal point of Site 2D's Palaeolithic activity) and brought into Zone 5 as raw material or ready-made blanks.

A radiocarbon-date of 8222-7965 cal BC (SUERC-68101) dates Pit 1776, but its mixed content of scalene triangles and crescents indicates that it may post-date the zone's main concentrations which in terms of microliths are almost typologically exclusive and mainly contain either one or the other form. A date of 3944-3713 cal BC (SUERC-68102) was produced by a charcoal sample from Pit 1879, which was situated north of Zone 5's main lithic distribution, and which contained no lithic objects. It is uncertain whether this date relates to the only lithic piece from the area identifiable as a post Mesolithic piece (CAT 10237), but the fact that no other lithic objects seem to be of a Neolithic date, suggests that Zone 5 almost exclusively represents pre Neolithic activity. The typo-technological attributes of the lithic finds define them as almost entirely (with a *caveat* concerning the area's broad-blade element) Late Mesolithic.

The lithic debris forms six concentrations, and the distribution patterns suggest that these concentrations represent individual Mesolithic open-air sites, rather than visits involving sophisticated structures (eg, Howburn and Echline Fields; Waddington 2007; Robertson *et al.* 2013) or light shelters (eg, ABNL-3B and Fife Ness; this volume; Wickham-Jones & Dalland 1998). It is possible that the difference between the numbers of artefacts recovered from each concentration, as well as the density of the burnt flint, indicates visits to the zone of varying duration. It is also possible that the concentrations may represent the remains left by different sets of activities, although the only concentration standing out is Concentration 1. In general, the concentrations are dominated by waste from the production of microblades and microliths/microburins (supplemented by a few other tool forms like scrapers and truncated pieces), but Concentration 1 also yielded a sub-assemblage of unusual polished-edge implements.

In terms of future research, the finds recovered within Zone 5 present two main questions, namely 1) what is the relationship between the scalene triangles and crescents, and 2) what is the date and function of the polished-edge implements?

The distribution of scalene triangles and crescents across Zone 5 (Fig. 5.15), in conjunction with the fact that the crescents are generally approximately twice as broad as the scalene triangles (Fig. 5.5), suggest a potential chronological relationship between the two groups of microliths, with crescents possibly being earlier (broader) and scalene triangles later (narrower). This scenario is supported by the fact that the microblades from the two main parts of the zone (north and south) also form two size-groups, with microblades from the north (and associated with the narrow scalene triangles) being narrower (av. width 8.8mm), and those from the south (and associated with the broad crescents) being broader (av. width 9.5mm).

At Fife Ness, the microliths (as defined in the present paper) are almost all crescents, and in this case the authors suggested a functional explanation (Wickham-Jones & Dalland 1998, 15). Mostly, crescents and scalene triangles appear together (as at Gleann Mor on Islay; Finlayson & Mithen 1997), but in many cases the available sites are either obvious palimpsests (eg, Nethermills Farm; Ballin 2013a), or it is not entirely certain whether sites have single- or multi-occupation status. It is also quite possible that some pieces defined as crescents in old reports may be sloppily produced triangular microliths or edge-blunted pieces with a somewhat convex retouch.

The relationship between the different microlith forms is clearly in need of further attention, and future research of this issue should be based on small sites with distribution patterns which suggest that they represent one visit to the location only (eg, one hearth, one fan-shaped knapping floor etc.; see Fig. 5.24); this research ought to include full lithic analysis, including use-wear analysis, and radiocarbon-dates would be helpful.

The 157 polished-edge implements presently form a unique collection of tools, partly defined by modification and partly by use-wear. They are probably functionally related to the later Neolithic polished-edge implements discussed in Ballin (2011b), but in contrast to those pieces, the tools from Zone 5's Concentration 1 generally display rough abrasion, whereas the later Neolithic ones tend to display smooth mirror-like abrasion. In addition, the pieces from the present site are likely to date to the Late Mesolithic period. It is hoped that Hardy's use-wear analysis (this volume) may shed light on the function of the Zone 5 objects, and in the future the Neolithic polished-edge implements should be exposed to similar analysis and compared with the pieces from the present site. Will it for example be possible to link the two groups of formally related tools to different sets of activities (as indicated by slight differences in type of use-wear and appearance), for example relating to hunter-gatherer and farming economies?

ZONE 4/5

Introduction

The finds referred to 'Zone 4/5' are predominantly finds from the initial investigation of the site and which can only be defined as deriving from either Zone 4 or Zone 5. The assemblage is numerically small (242 pieces), and it does not include any typo-technological elements which would have influenced the perception of Zones 4 and 5, had it been possible to refer individual pieces to one or the other of these two zones.

The notable dominance of broad blades over narrow blades, as well as the presence of large crested pieces, may indicate the dominance of material from Zone 4 (a Late Upper Palaeolithic element) over material from Zone 5 (which is largely associated with a microblade industry), but the inclusion of one polished-edge implement suggests that the present sub-assemblage almost certainly also embraces material from Zone 5. The mixed chronological nature of this small sub-assemblage is supported by Fig. 4/5.1, which shows the widths of the blades and microblades recovered from this part of the site.

General overview

This group of finds embraces 242 lithic artefacts. They are listed in Table 4/5.1. In total, 94% of this assemblage is debitage, whereas 1% is cores and 5% tools.

Table 4/5.1. General artefact list – Zone 4/5.

Debitage	
Chips	12
Flakes	126
Blades	50
Microblades	11
Indeterminate pieces	22
Crested pieces	6
Platform rejuvenation flakes	1
Total debitage	*228*
Cores	
Single-platform cores - conical	2
Single-platform cores - plain	1
Total cores	*3*
Tools	
Scalene triangles	2
Microburins	2
Short end-scrapers	2
Polished-edge implements	1
Pieces w edge-retouch	3
Gunflints?	1
Total tools	*11*
TOTAL	**242**

Debitage

In total, 228 pieces of debitage were recovered from this zone (Table 4/5.2). The debitage includes 12 chips, 126 flakes, 51 blades, 11 microblades, 22 indeterminate pieces, and seven preparation flakes (six crested pieces and one core tablet). Compared to other early prehistoric assemblages from Scotland, the chip ratio is exceedingly small (*c*. 5%), probably reflecting the fact that most of these finds were retrieved at a stage of the investigation when sieving was not undertaken. As demonstrated in Ballin (1999), the chip ratio of sieved assemblages usually varies between *c.* 30% and 55%.

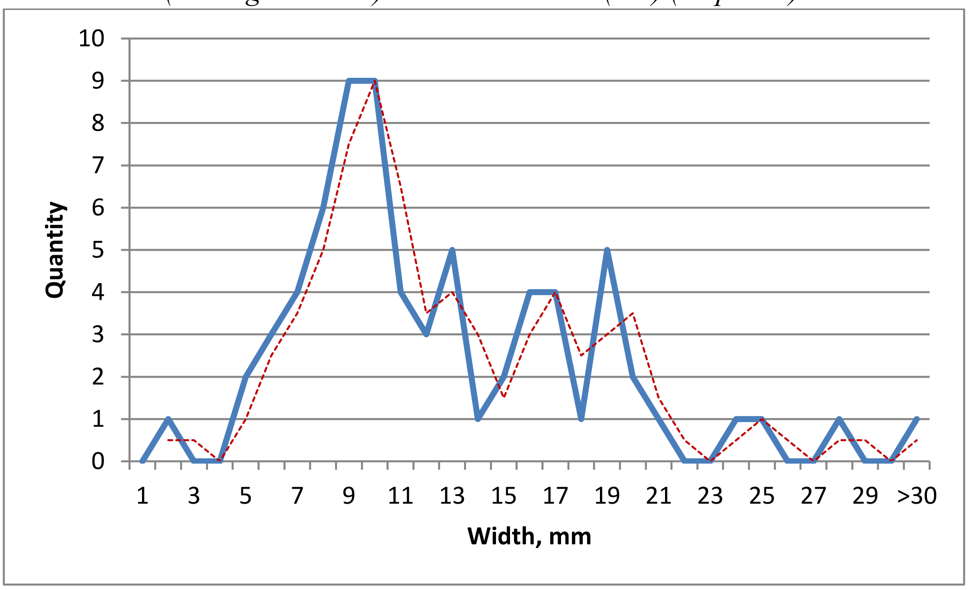
Table 4/5.2. Relative composition of the debitage.

	n	*%*
Chips	12	5
Flakes	126	55
Blades	50	22
Microblades	11	5
Indeterminate pieces	22	10
Preparation flakes	7	3
Total debitage	*228*	*100*

With 51 blades and only 11 microblades (ratio *c.* 82:18), this sub-assemblage is clearly dominated by broad blades (Table 4/5.2). This could to an extent be a function of recovery techniques, but it may also reflect inclusion of blades relating to the Late Upper Palaeolithic element of Zone 4, where the microblades are likely to indicate a Late Mesolithic presence.

The mixed nature of the finds from Zone 4/5 is further indicated by the width of the blades and microblades (Fig. 4/5.1). The widths of the blades produces a broad, multi-peaked and jagged curve, where the curve of a single-occupation site should be approximately bell-shaped and single-peaked (see dating section). The curve for Zone 4/5 could to an extent owe its appearance to the small numerical size of the blade category (61 pieces), but where the insertion of a moving trendline may occasionally remedy some statistical weaknesses, forming a slightly more regular curve, this is not the case in the present situation. As shown in Fig. 4/5.1, the moving trendline may at best be described as consisting of one main peak (microblades), supplemented by a series of peaks within the broad-blade part of the spectrum.

Fig. 4/5.1. The width of all unmodified blades and microblades from Zone 4/5 (blue). A trendline (moving trendline) has been inserted (red) (61 pieces).



Only seven preparation flakes were recovered from this zone, including six crested pieces (9929, 10113; 10118; 10121; 10124; 10132) and one core rejuvenation flake (10138). The crests are generally large, and two intact pieces (CAT 10118, 10121) have average dimensions of 65 x 25 x 13mm; one medial fragment of a large crested blade (CAT 9929) has a width of 31mm. The likelihood of these large crests being early is indicated not only by their size, but also by the fact that they fit the Late Upper Palaeolithic operational schema defined in connection with the discussion of the finds from Zone 4: 1) CAT 9929 and CAT 10121 are both from the preparation of large opposed-platform blade cores; 2) CAT 10124 has its crest not approximately at the centre of the dorsal face, but near one lateral edge; and 3) CAT 10118 conjoins with crest CAT 10117 (from Zone 3) in a ventral-dorsal fit, indicative of the preparation/rejuvenation of core-sides/platforms by the detachment of *series* of crests and core tablets, rather than these specimens being single preparation/rejuvenation pieces. Like several of the large crested blades from Zone 4, CAT 10113, 10121, and 10124 all have flat use-wear from use as unmodified knives.

The zone's solitary platform rejuvenation flake (CAT 10138) is large (43 x 33 x 12mm), and it appears to have been detached from one end of the elongated platform of a large blade core. This piece is probably also from a Late Upper Palaeolithic core.

Cores

In total, three cores were recovered from Zone 4/5, all of which are single-platform cores. The cores were measured following the principles described in the methodology section.

The appearance of the individual single-platform cores differs considerably: Two were described as conical, but where CAT 10072 is broad with acute edge-angles (42 x 33 x 35mm), CAT 10073 is approximately bullet-shaped with right-angled platform-edges (36 x 23 x 18mm). CAT 10075 is a small flat piece with a cortical 'back-side' (30 x 31 x 12mm). They all have plain, trimmed platforms.

Tools

The 11 tools (Table 4/5.1) include two scalene triangles, two microburins, two scrapers, one polished-edge implement, three pieces with edge-retouch, and one possible gunflint.

Two formal microliths are both *scalene triangles* (CAT 10577, 10578). The former is intact, and it measures 18.8 x 4.8 x 2.0mm. Like most standard scalene triangles, CAT 10578 has its shortest side at the proximal end, whereas CAT 10577 has it at the distal end. The latter is an unusual piece, as not only does it have its shortest side at the distal end – its bulbar end is still intact. Despite the presence of an intact bulb of percussion, the fact that the oblique distal edge of CAT 10577 was formed by the application of microburin technique defines this piece as a microlith. Both pieces have had their left lateral side blunted.

The two *microburins* (CAT 10355, 10356) are both proximal specimens with a notch in the LHS, and both successfully formed an oblique microburin facet or *piquant triédre* (see the report on the assemblage from Site 3B). They vary considerably in size, with widths of 4.4mm and 12.0mm, respectively.

Both *scrapers* are expedient pieces. CAT 10093 is a split pebble (48 x 44 x 23mm), which was provided with a regular, convex, steep scraper-edge along part of the newly decorticated face. It is quite likely that this pebble was split across to form two conical cores (the two halves of the original pebble; see section on Site ABNL 3B), but as the split resulted in a notably slanting 'platform', it was discarded and subsequently used as a blank for a robust scraper. CAT 10230 is the fragment of a primary flake (34 x 31 x 11mm), and it was given a convex, steep scraper-edge at one end. The modification is crude and inverse.

One distal fragment of a crested piece (CAT 10753; 27 x 23 x 8mm) has abrasion of the proximal break facet, linking it to the large collection of *polished-edge implements* in Zone 5. Three pieces and fragments with varying forms of *edge-retouch* are thought to be artefacts, or fragments of artefacts, with different functions. One of these (CAT 10264) is based on a hard percussion flake (42 x 26 x 11mm) detached from a fairly large pebble of bright red jasper. CAT 20243 is an edge-retouched and worn hard percussion flake (21 x 24 x 6mm) in a type of flint frequently associated with ballast flint and assemblages of modified ballast flint (eg, the Carmelite Friary, Aberdeen; Ballin 2001a), suggesting a fairly recent date. It has been characterized as a possible *gunflint*, but it does not fit any well-known formal categories of gunflints (Ballin 2012c). It is, however, quite likely that this is an early gunflint (cf. discussion of the gunflints from Dun Eistean, Lewis; ibid.), which was repaired, re-used, and subsequently recycled as a fire-flint. Use with a steel strike-a-light would explain the object's lateral concavities.

Summary and discussion – Zone 4/5

The composition of this sub-assemblage indicates that the finds from Zone 4/5 represent a number of different prehistoric periods, and some artefacts and categories correspond typo-technologically to finds from Zone 4 and some to finds from Zone 5.

The dominance of the blades of the sub-assemblage by quite large pieces links the Zone 4/5 finds to Zone 4 and the Late Upper Palaeolithic element of that sub-assemblage. The zone's very small microblades are most likely datable to the Late Mesolithic period. The crested pieces, as well as the solitary platform rejuvenation flake, are all fairly large and their size, as well as their general appearance suggest a Late Upper Palaeolithic date (see discussion in the Zone 4 section).

The narrow microliths and microburins are Late Mesolithic pieces, and at least one (CAT 10073) of the zone's conical cores is a typical microblade core created in connection with the production of blanks for microliths. The solitary polished-edge implement (CAT 10753) links this sub-assemblage to that of Zone 5.

ZONE 6

Introduction

The finds from Zone 6 (defined as 'east of Zone 5') were predominantly recovered from Structure 1917 or the immediate surroundings of this structure (158 pieces or 96%), with one flake deriving from Pit 1747 between Zone 5 and this structure, and six pieces of debitage from Pit 15 east of Structure 1917 (Table 6.1). All finds from the structure are from excavated features and contexts (spreads, pits and postholes). A number of lithic artefacts, including diagnostic Mesolithic pieces, were recovered from a deposit (hill-wash) covering the Early Neolithic contexts. These pieces are discussed as part of the sub-assemblage from Zone 0, which includes other unstratified, uncontexted and redeposited finds from Site 2D.

Pit 1747 and Pit 15 are not datable, nor are the finds recovered from them (plain debitage); however, a hearth (C1715) situated a few metres south of Pit 1747 provided a radiocarbon date of 5792-5661 cal BC, or the Late Mesolithic (SUERC-58189). Two radiocarbon dates from Structure 1917 are almost identical and suggest a date for the structure of the Early Neolithic (3961-3797 cal BC [SUERC-58194]; 3945-3714 cal BC [SUERC-68114]). This date is corroborated by the retrieval of a leaf-shaped arrowhead (CAT 10060) from Pit 1927 immediately outside the structure.

General overview

This group of finds embraces 165 lithic artefacts. They are listed in Table 6.1. In total, 99.4% of this assemblage is debitage, whereas 0.6% is tools. No cores were recovered.

Table 6.1. General artefact list – Zone 6.

Debitage	
Chips	94
Flakes	46
Blades	11
Microblades	9
Indeterminate pieces	3
Crested pieces	1
Total debitage	*164*
Tools	
Leaf-shaped arrowheads	1
Total tools	*1*
TOTAL	**165**

Debitage

In total, 164 pieces of debitage were recovered from this zone (Table 6.1). The debitage includes 94 chips (57%), 46 flakes (28%), 11 blades (7%), 9 microblades (5%), 3 indeterminate pieces (2%), and one crested piece (1%). In Ballin (1999), the author demonstrated that the chip ratio of sieved assemblages usually varies between *c.* 30% and 55%, and the present chip ratio is just beyond the upper end of this framework. A relatively high chip ratio usually indicates that primary production took place at a location.

Although the blades and microblades recovered from the zone (20 pieces) form a very small statistical population, the curve representing the widths of these pieces (Fig. 6.1) is surprisingly regular. Although the 'raw' curve displaying the dimensions of these pieces is dual-peaked, the 'dented' nature of the curve is based on ±1 piece around width 9mm, and the inserted trendline smoothes out the curve, resulting in a neat bell-shaped figure with a flat top at width 8-11mm. Microblades/narrow-blades of this size were produced by a number of Late Mesolithic and Early Neolithic industries. The blades from the roughly contemporary Early Neolithic site at Garthdee Road in Aberdeen (Ballin 2016a) form a similar curve, although these blades are slightly broader (Table 6.2). The Garthdee Road site was estimated by Marshall & Cook (2016, 12) to have been visited between 3850-3610 cal BC. It is possible that the small secondary peaks to the right of both main peaks may be blades produced in the early stages of the reduction process, for example in connection with the initial shaping of cores (see discussion in connection with the analysis of the blades from Site 3B; this volume).

Fig. 6.1. The width of all unmodified blades and microblades from Zone 6 (blue). A trendline (moving trendline) has been inserted (red) (20 pieces).

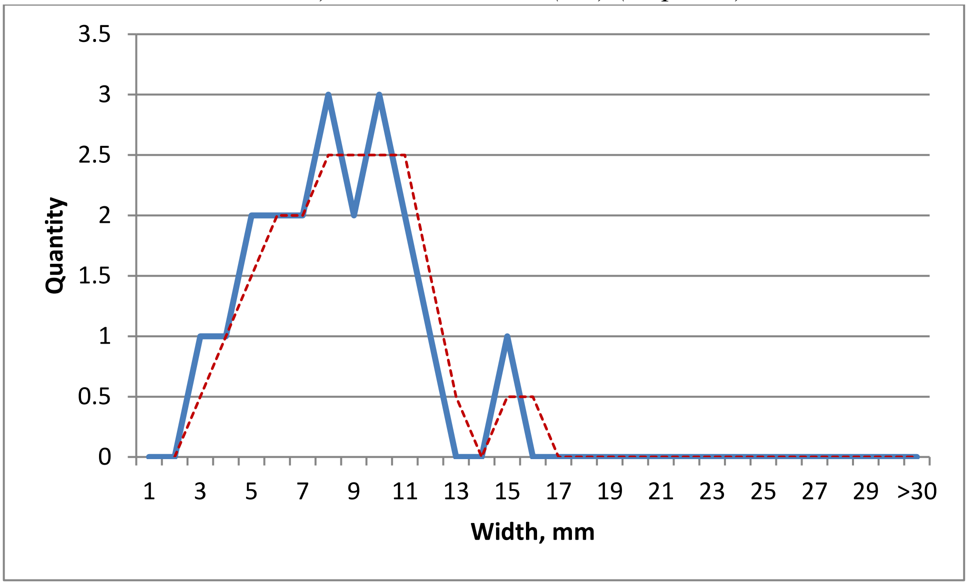
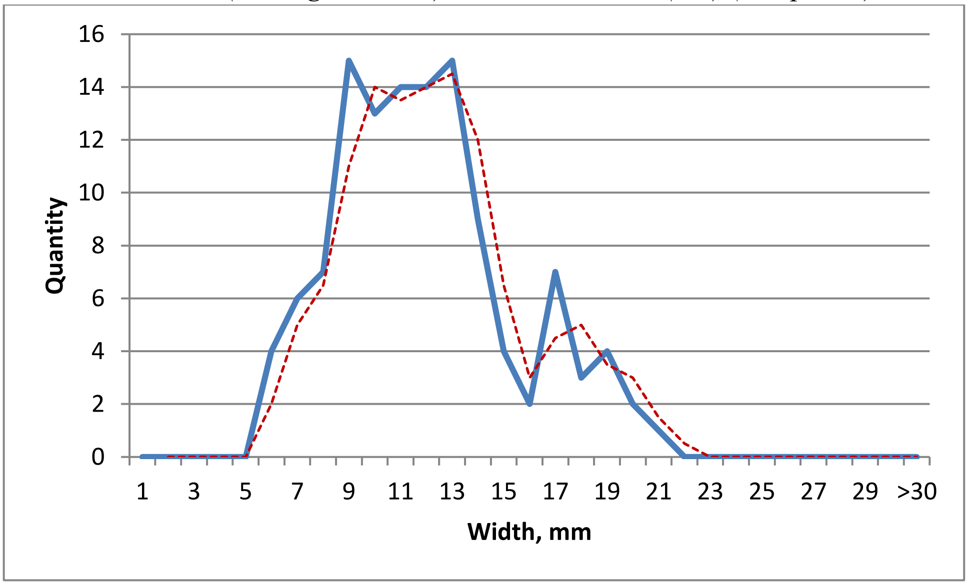


Fig. 6.2. The width of all unmodified blades and microblades from Garthdee Road, Aberdeen (blue). A trendline (moving trendline) has been inserted (red) (119 pieces).



This sub-assemblage includes 13 burnt pieces, or 8%. All burnt pieces are debitage, and they were recovered from contexts inside as well as immediately outside Structure 1917. One crested piece (CAT 10151) was recovered from the trample inside the structure. It measures 20 x 11 x 5mm.

The leaf-shaped arrowhead

Only one tool was retrieved from Structure 1917 and its surroundings, namely leaf-shaped point CAT 10060, which is datable by its typo-technological attributes to the Early Neolithic period. This piece is a minuscule drop-shaped arrowhead measuring 18 x 14 x 3mm, and it belongs to Green's type 4A (1980, 72). It is based on an indeterminate flake, and it has been formed by bifacial invasive flaking. It was recovered from Pit 1927 immediately outside the structure. It is quite possible that the arrowhead represents a deliberate deposition in this pit (see discussion below), whereas the 34 pieces of debitage from Layer 1928, which sealed the pit, may represent a depleted knapping floor. Layer 1928 is dated by the presence of Carinated Bowl type pottery to the same period as the arrowhead, namely the Early Neolithic.

Table 6.2. The distribution of lithic artefacts across Zone 6.

	Features	*Chips*	*Flakes*	*Blades*	*Micro-blades*	*Indet. pieces*	*Crested pieces*	*Leaf ar-rowh.*	*Total*
Floor **IN** Str 1917	1766	27	12	2	3				44
Trample **IN** Str 1917	1824	13	4	4	1	1	1		24
Tumble **IN** Str 1917	1775	12	2	1		1			16
Pit **IN** Str 1917	1648	2		1					3
Posthole **IN** Str 1917	1783		1						1
Posthole **IN** Str 1917	1865	10	7						17
Spread **AT** Str 1917	1916	8	7	1					16
Pit **AT** Str 1917	1927							1	1
Layer sealing Pit 1927	1928	18	10	2	4				34
Pit **AT** Str 1917	1754				1				1
Posthole **AT** Str 1917	1827		1						1
Pit **between** Z5 and Str 1917	1747		1						1
Pit **beyond** Str 1917	Pit 15	4	1			1			6
TOTAL Zone 6		**94**	**46**	**11**	**9**	**3**	**1**	**1**	**165**

Summary and discussion – Zone 6

It is difficult to be definite about the internal chronology of Structure 1917 and its surroundings, but the presence of a Late Mesolithic hearth in the area means that it can not be ruled out that some of the lithic finds from spreads and features may date to this period. However, the fact that the material from contexts inside as well as outwith the building appears to be technologically homogeneous (see for example Figs 2.1-2), that all contexts are entirely devoid of diagnostic Mesolithic objects like microliths and microburin (Table 6.2), as well as the fact that Spread 1916 outside the structure contained Carinated Bowl type pottery suggest that all or most of the sub-assemblage from Zone 6 (apart from those from features east and west of the building) may represent one assemblage of knapping debris contemporary with Structure 1917. Structure 1917 has been dated by two radiocarbon dates to the framework 3961-3714 cal BC – one date is based on charcoal (Corylus avellana) from Hearth 1638 within the structure (3961-

3797 cal BC; SUERC-58194), whereas the other one is based on charcoal (Corylus avellana) from Trample 1824 outside the structure (3945-3714 cal BC; SUERC-68114).

The fact that only a leaf-shaped arrowhead (CAT 10060) was recovered from Pit 1927 outside the building (apart from the knapping debris from the sealing Layer 1928), indicates that this may be a deliberate deposition. Brophy & Noble (2012) discuss the function of Neolithic pits from lowland Scotland and, apart from pits defined as hearths (including so-called 'fire-pits'), most have been defined as either domestic ('rubbish pits') or ceremonial ('ritual pits'). However, this is, as stated by Brophy & Noble, clearly a simplification. Knapping debris in pits would probably frequently simply be artefactual material from settlement surfaces which entered the features with the back-fill, and some lithic pit assemblages containing 'nice pieces' and knapping debris could represent a mixture of intentionally deposited objects and back-fill (see for example the assemblage from Barassie in South Ayrshire; Ballin forthcomingc). In addition, there are pits and post-holes relating to buildings (eg, pits and postholes from Early Neolithic timber halls; see for example the pit deposits from Doon Hill in East Lothian and Warrenfield in Aberdeenshire; Ballin [2011b, 52; Warren [2009, 106, Fig. 36), which tend to contain 'special pieces', linking them to ceremonial pits.

The author's discussion of Arran pitchstone from radiocarbon-dated pits in southern, central and eastern Scotland (Ballin 2015a), suggests that ceremonial pits (including those from buildings) from the Early Neolithic period usually embrace a well-defined set of 'special' lithic and stone objects, in addition to Carinated Bowl type pottery and occasionally burnt bone. These 'special' pieces include: 1) microblades (occasionally struck for the occasion; see the finds from the pit below Fordhouse Barrow in Angus; Ballin 2004a); 2) well-executed, frequently invasively retouched implements (eg, leaf-shaped points and scale-flaked knives; a recently excavated pit at Feteresso in Aberdeenshire included, *inter alia*, a scale-flaked knife, *c*. 200 sherds of Carinated Bowl type pottery, and burnt bone; Ballin 2016c); 3) flakes from polished axeheads (possibly deposited as a form of *pars pro toto* sacrifice; see discussion of an incomplete leaf-shaped point deposited in a pit at Colinhill in South Lanarkshire; Ballin 2016b; Henriksen 1998); and 4) exotic material (eg, Arran pitchstone and Cumbrian tuff; cf. Beck & Shennan 1991, 138). On this background, it seems reasonable to define Pit 1927 as a ceremonial or ritual pit, and its leaf-shaped arrowhead as representing deliberate deposition.

BASE OF SLOPE

Introduction

The sub-assemblage from the Base of the Slope was recovered from a large number of features across the zone (Table Base.3). Diagnostic artefact types and technological attributes, as well as a number of radiocarbon dates, define the bulk of the activities in this area as dating to either the Late Mesolithic period or the Early Neolithic period. One radiocarbon-date SUERC-68111 suggests a visit to the area after this period (1258-1051 cal BC, or the Middle/Late Bronze Age), but no lithics are identifiable as being this late.

Although all lithic objects were recovered from features like hearths, pits, and postholes, it is thought that most, if not all, artefacts from these features may be residual and testify to the presence in this area of a number of small domestic sites. The lithic concentrations of these sites were probably not numerically 'dense' enough to allow them to be noticed during the project's early stages.

It is thought that some of the pits were dug in the Late Mesolithic period and others during the Early Neolithic, but some probably Mesolithic pits appear to have been recut and used for the deposition of a number of pots. These vessels are generally identifiable as traditional Carinated Bowl type ceramics, and in several cases associated with Early Neolithic radiocarbon dates (Spanou 2015).

General overview

This group of finds embraces 207 lithic artefacts. They are listed in Table Base.1. In total, 97% of this assemblage is debitage, whereas 3% is tools. No cores were recovered.

Table Base.1. General artefact list – Base of slope.

Debitage	
Chips	83
Flakes	68
Blades	28
Microblades	10
Indeterminate pieces	11
Crested pieces	1
Total debitage	*201*
Tools	
Obliquely blunted points	1
Scalene triangles	1
Frags of microliths or backed bladelets	1
Microburins	2
Short end-scrapers	1
Total tools	*6*
TOTAL	**207**

Debitage

In total, 201 pieces of debitage were recovered from this zone (Table Base.2). The debitage includes 83 chips, 68 flakes, 28 blades, 10 microblades, 11 indeterminate pieces, and one crested piece. In Ballin (1999), the author demonstrated that the chip ratio of sieved assemblages usually varies between *c.* 30% and 55%, and the present chip ratio is within this framework. A relatively high chip ratio usually indicates that primary production took place at a location.

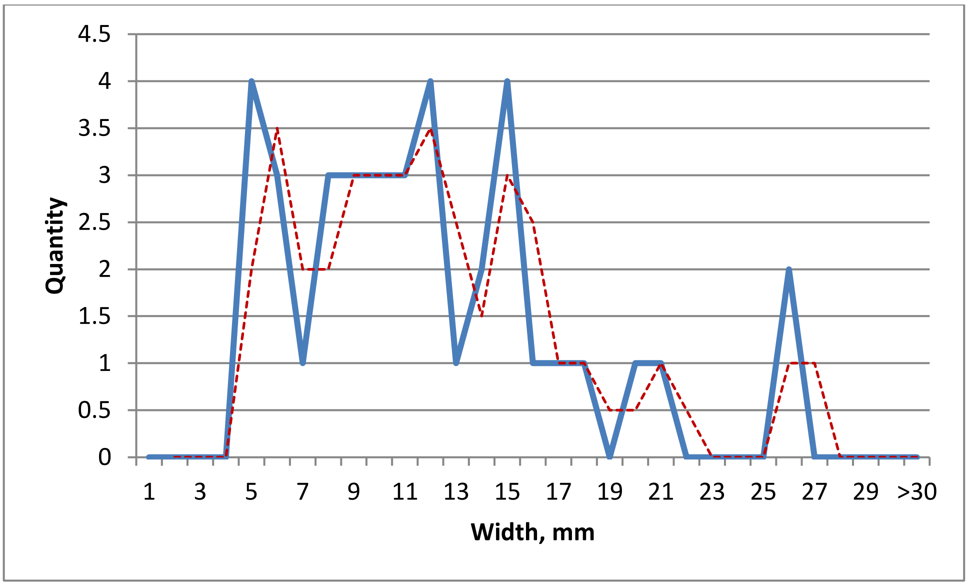
Table Base.2. Relative composition of the debitage.

	n	*%*
Chips	83	41
Flakes	68	34
Blades	28	14
Microblades	10	5
Indeterminate pieces	11	5

Preparation flakes	1	1
Total debitage	*201*	*100*

Due to the low number of blades and microblades recovered from the zone (38 pieces), the curve representing the widths of these pieces (Fig. Base.1) is highly irregular. Although the insertion of a trendline in diagrams like this occasionally evens out the random statistical fluctuations, in the present case this did not happen – the raw curve and that of the trendline are both highly irregular, suggesting that the finds (which include a variety of microblades and broad-blades) may represent the remains of several visits to the area over an extended period of time.

Fig. Base.1. The width of all unmodified blades and microblades from the Base of the Slope (blue). A trendline (moving trendline) has been inserted (red) (38 pieces).



A total of 63 flints are fire-crazed, or slightly more than one-quarter of the sub-assemblage. Approximately half of these are minuscule chips, supplemented by some flakes, blades and indeterminate pieces – or in other words: they are residual settlement debris. As such, they reveal nothing at all as to the function of the features, or the activities relating to their construction or use.

One crested flake (CAT 10156) is a fairly large and thick piece (45 x 26 x 11mm). Its proximal end has been removed by repeated battering, possibly to thin the flake and allow it to be inserted into a haft. Both lateral edges display notable flat modification, but probably more likely as a result of use than of retouch. Both edges also display macroscopically visible *gloss*, indicating that the piece may have been use for cutting or sickling vegetable matter (Juel Jensen 1994). CAT 10156 is probably an informal sickle. It was recovered from a feature (C1398), which was initially defined as a posthole, but it is possible that this cut may actually be a pit, and that CAT 10156 may be the area's only deliberate deposition. One important point in this context is the fact that, in contrast to most other features at the Base of the Slope, this feature did not contain any knapping debris, nor pottery – it only contained this solitary and heavily used ?sickle. The feature has not been radiocarbon-dated, but two neighbouring pits – Pit 1193 and Pit 1714 – provided almost identical dates, namely 3964-3800 cal BC (SUERC-58023) and 3943-3712 cal BC (SUERC-68105).

Tools

The six formal tools (Table Base.1) embrace three microliths, two microburins and one scraper.

Two microliths include one *obliquely blunted point* (CAT 10564) and one *scalene triangle* (CAT 10474). The former is a distal form of obliquely blunted point, and it measures 13.3 x 3.6 x 1.1mm. Its oblique truncation is proximal and notably concave, revealing that this piece was produced by the application of microburin technique. Part of the microburin facet survives and forms the sharp tip of the piece. The scalene triangle measures 24.1 x 4.9 x 1.6mm, and its shortest side is distal. In addition to having been blunted along the left lateral side (the two legs of the triangle), the piece also has ancillary retouch along the RHS. A *fragment of a microlith or backed bladelet* (CAT 10568) is based on a microblade blank and has a width of 3.8mm.

One of the *microburins* is a proximal form (CAT 10393) and the other a distal form (CAT 10475). They both have a notch in their LHS, but where the former successfully produced an oblique microburin facet, the latter simply snapped. They are both 4mm wide. The dimensions of the three microliths, as well as the microburins, indicate a date in the Late Mesolithic period.

One scraper was recovered from a feature in the area, namely *short end-scraper* CAT 10229. This piece is almost intact (only missing one corner of its working-edge), and it measures 18 x 18 x 4mm. Its distal scraper-edge is convex, slightly denticulated, and steep, and it corresponds formally to the scraper types expected from Scottish Mesolithic and Early Neolithic sites. It was recovered from Layer 1909 in Pit 1904, which merged with Pit 1895. Layer 1898 in the latter pit was radiocarbon-dated to 3966-3800 cal BC (SUERC-58617), and Layer 1909 was above Layer 1898's continuation in Pit 1904, Layer 1907. The uppermost layer in Pit 1898 contained numerous sherds of Carinated Bowl type pottery.

Summary and discussion – the Base of the Slope

As shown in Table Base.3, the area's small assemblage of 207 pieces were recovered from a large number of features – three hearths, 17 pits, eight postholes, and two 'tree-throw holes' which clearly form the two lateral halves of one original single tree-throw hole (cf. Kooi 1974). Four of the flint-bearing pits have been recut, and three of these had pottery of Carinated Bowl type inserted into the new cut (1127/1092; 1529/1580; 1714/1941). Pits 1904 and 1895 seem to form one feature. Pit 1942 also contained Early Neolithic pottery. Most features contained one piece or a few pieces of worked flint, but some contained up to 20-40 pieces.

Table Base.3. The distribution of lithic artefacts across the Base of the Slope.

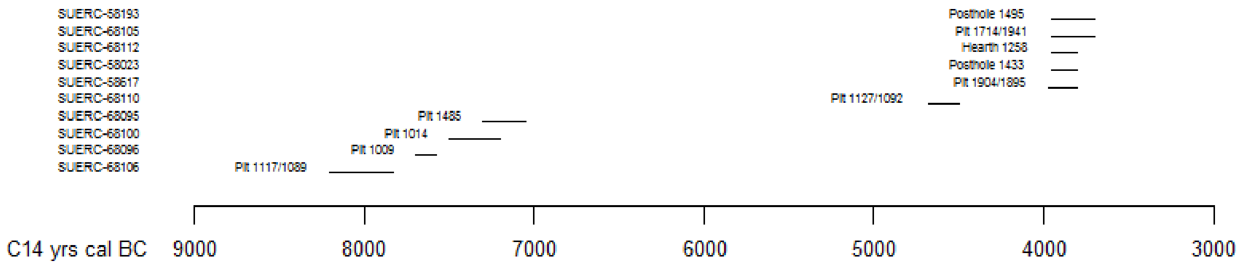
		Chips	*Flakes*	*Blades*	*Microblades*	*Indet. pieces*	*Crested pieces*	*Microliths*	*Microburins*	*Scrapers*	*Total*	*C14*	*Recut*	*Pottery*
Hearth	1258	2		1							3	EN		

	1575	1									1			
	1691			1							1			
Pit	1003		1	2							3			
	1009	1									1	LM		
	1014	13	7	12	3	2		1	2		40	LM		
	1052		12	3	4	1					20			
	1127/1092	13	10	1	1	2					27	LM	x	x
	1117/1089							1			1	LM	x	x
	1393	1									1			
	1399	2									2			
	1485		1								1	LM		
	1493	1									1			
	1522	1	1								2			
	1529/1580		1								1		x	x
	1658		1								1			
	1714/1941	4	1	1		2					8	EN	x	x
	1717		1								1			
	1904/1895	16	11			3				1	31	EN		
	1942	4	2	1							7			x
Posthole	1265	1									1			
	1279		1								1			
	1398						1				1			
	1427		1			1					2			
	1433	9	6	1	1						17	EN		
	1495	2	2	1							5	EN		
	1617	1	1								2			
	1670			1							1			
Tree-throw	1759	7	3	2	1			1			14			
	1761	4	5	1							10			
TOTAL		**83**	**68**	**28**	**10**	**11**	**1**	**3**	**2**	**1**	**207**			

As mentioned above, most of the flint is in the form of plain knapping debris, and it is suggested that this material may generally be residual and relate to one or more small domestic scatters in the area. The only exception is the informal 'sickle' (CAT 10156) which may – this being a slightly unusual piece – represent a deliberate deposition (Pit or Posthole 1398 in the zone's south-western corner). It was possible to group the find-richest features (containing two-digit figures of flint artefacts) spatially, with three having been located at the slope's upper levels, in the north-west corner of the pit cluster (Pits 1014 and 1052, as well as tree-throw hole 1759/1761); Pit 1127/1092 was located centrally, but slightly towards the east; Posthole 1433 was located centrally and formed part of the two lines of Neolithic 'fence posts'; and Pit 1904/1895 was located immediately adjacent to, and above, Zone 5.

As shown in Fig. Base.2, the radiocarbon-dated flint-bearing features form three groups, with one suggesting the digging of individual pits (Pits 1117/1089, 1009, 1014, 1485) over a period of *c*. 1000 years in the early part of the Late Mesolithic; one pit (1127/1092) was dug at the very end of the Late Mesolithic period; and one hearth (1258), two pits (1904/1895, 1714/1941), and two postholes (1433, 1495) could potentially be contemporary features and constructed either at the same time or within a very narrow time band.

Fig. Base.2. The radiocarbon dates from flint-bearing features at the Base of the Slope. Hearth 1575, which contained one chip, returned a date of the later Bronze Age.



Four of the microliths and microburins of this sub-assemblage were recovered from features in the area's north-western corner (Table Base.3), including the find-rich Pit 1014, and it is highly likely that a small Mesolithic camp was located here. A radiocarbon-sample from this pit suggests a date of 7489-7204 cal BC (Fig. Base.2).

It cannot be said with certainty whether the knapping debris in the features with Early Neolithic dates and/or pottery is also of Mesolithic date, or whether it may be associated with Neolithic primary production in the area. The dating of one of the hearths (1258) to the Neolithic period makes the latter option quite possible. The Early Neolithic hearth, pits and postholes all date to the band 3966-3709 cal BC making them contemporary with the habitation of the structure in Zone 6 (3961-3797 cal BC and 3945-3714 cal BC; SUERC 58194, 68114). It is not possible to determine whether the Early Neolithic use of the Base of the Slope and Zone 6 formed one settlement episode or several episodes of settlement and re-settlement within a short space of time.

It has been suggested (Spanou 2015) that some, if not all, of the recut pits may have been dug in the Late Mesolithic period and reused in the Early Neolithic. To test this proposition, Table Base.4 was produced. Basically, the lithics are of little use in this context, as it is not possible to distinguish typo-technologically between pieces from the various levels within the pits. However, the location of the pottery and radiocarbon samples do make the proposed internal chronology of the redug pits likely. A fragment of a microlith or backed bladelet (CAT 10568) was recovered from one of the original fills of redug Pit 1117/1089, which contained pottery in its upper levels, but whenever this pit was originally dug, this piece is likely to have been residual and it is therefore not very helpful.

Table Base.4. Lithic artefacts from recut pits with multiple lithics and pottery.

			Chips	*Flakes*	*Blades*	*Micro-blades*	*Indet. pieces*	*Total*	*C14*	*Pottery*
Pit 1092/1127	1093	Top recut	9	3	1	1	1	27		x
	1128	Bottom recut	4	7			1		LM	
Pit 1714/1941	1786	Top recut	4	1			2	8	EN	x
	1797	Original cut			1					

ZONE WEST

Introduction

The sub-assemblage from Zone West was recovered entirely from cut features, including 10 small pits and a linear feature, initially assumed to be Mesolithic, four possibly Neolithic or Bronze Age pits, and one undated hearth. As no surfaces were excavated, it was not possible to identify any knapping or other scatters, but it is thought that most of the lithic debris in the features may be residual material from scatters, which entered the later features with the back-fill (see below).

Although many of the cut features were first interpreted as probably dating to the Mesolithic period, due to their content of mainly Mesolithic style blanks, cores and tools, these finds only provide a *terminus post quem* for the digging of the features, and they could potentially date to the Mesolithic, Neolithic or Bronze Age periods. This suggestion is supported by the fact that some of the cuts included Neolithic blanks, tools and pottery.

General overview

This group of finds embraces 160 lithic artefacts. They are listed in Table West.1. In total, 93% of this assemblage is debitage, whereas 1% is cores and 6% tools. Apart from 10 chips in rock crystal, one flake and a blade in jasper, and one chip in quartz, all pieces are flint.

Table West.1. General artefact list – Zone West.

Debitage	
Chips	79
Flakes	44
Blades	9
Microblades	11
Indeterminate pieces	8
Crested pieces	1
Total debitage	*152*
Cores	
Single-platform cores - plain	1
Bipolar cores	1
Total cores	*2*
Tools	
Crescents	1
Frags of microliths or backed bladelets	1
Microburins	1
Short end-scrapers	1
Scraper-edge fragments	1
Burins	1
Scale-flaked knives	1
Serrated pieces	1
Pieces w edge-retouch	2
Total tools	*10*

TOTAL	**164**

Debitage

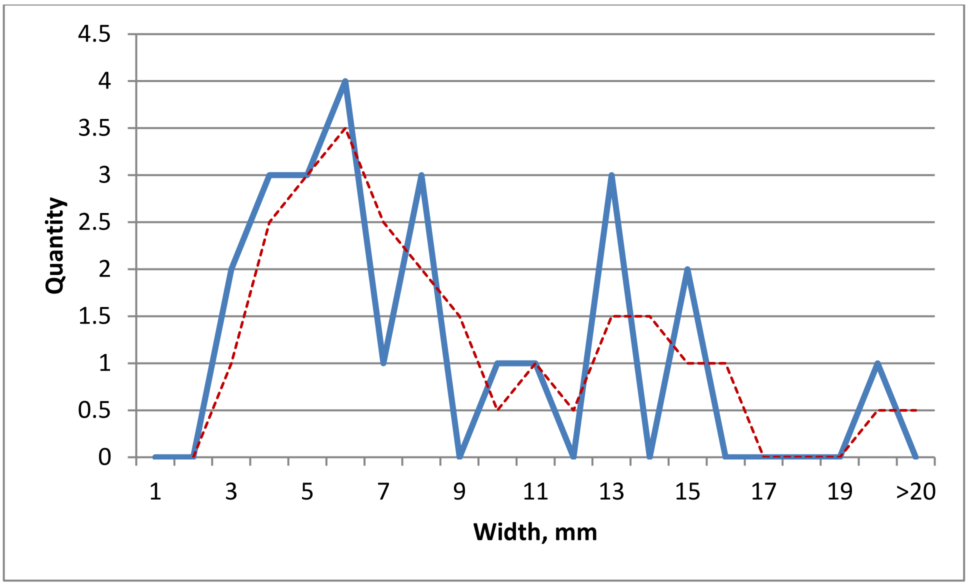
In total, 152 pieces of debitage were recovered from this zone (Table West.2). The debitage includes 79 chips, 44 flakes, nine blades, 11 microblades, eight indeterminate pieces, and one preparation flake. In Ballin (1999), the author demonstrated that the chip ratio of sieved assemblages usually varies between *c.* 30% and 55%, and the present chip ratio is within (although at the upper end of) this framework. A relatively high chip ratio usually indicates that primary production took place at a location.

Table West.2. Relative composition of the debitage.

	n	*%*
Chips	79	52
Flakes	44	29
Blades	9	6
Microblades	11	7
Indeterminate pieces	8	5
Preparation flakes	1	1
Total debitage	*152*	*100*

Due to the low number of blades and microblades recovered from the zone (20 pieces), the curve representing the widths of these pieces (Fig. West.1) is somewhat irregular. A trendline evens out the random statistical fluctuations, with most of the blades (microblades) forming a peak centred on 6mm. The curve has a long 'tail' of macroblades with widths between13-16mm. This suggests one or more visits to the site in the later Mesolithic period, as well as some activity in the area during the Neolithic. One flake (CAT 11713) is a typical Levallois-like flake (Ballin 2011a), indicating activity in Zone West in the later Neolithic period. Only one preparation flake was recovered from this zone, namely crested microblade CAT 11783. This piece is the distal fragment of a crested piece, and its width is 5.5mm.

Fig. West.1. The width of all unmodified blades and microblades from Zone West (blue). A trendline (moving trendline) has been inserted (red) (20 pieces).



A total of 52 pieces are affected by fire, or approximately one-third of the sub-assemblage. Forty-six of those were recovered from two small pits and a linear feature, namely Ditch 2152 (27 pieces), Pit 2164 (11 pieces), and Pit 2222 (eight pieces). The burnt pieces make up substantial proportions of the individual pit assemblages, with two-thirds or the assemblage from Ditch 2152 being burnt, one-quarter of the assemblage from Pit 2164, and almost half of the assemblage from Pit 2222. Several burnt flake fragments from Ditch 2152 were conjoined (flake CAT 11625 [2 fragments] and flake CAT 11632 [2 fragments]), but it is thought that many more burnt fragments from CAT 11622-11657 could be conjoined if an effort was made. Although the burnt pieces include many chips, these pieces are not chips from primary reduction but simply bits of disintegrated burnt flakes.

Cores

A total of two cores were retrieved from Zone West, namely one single-platform core, and one bipolar core. The cores were measured following the principles described in the methodology section.

The solitary *single-platform core* (CAT 11776) has been knapped along most of its circumference, and it was abandoned when a series of attempted flake detachments failed and developed deep hinge- and step-fractures in the core's flaking-front. The platform is plain and partially trimmed. This plain single-platform core measures 36 x 28 x 21mm.

The area's *bipolar core* is fairly small (15 x 12 x 6mm). It is a bifacial core, with two reduction axes (two sets of opposed terminals), showing how this piece was reorientated during the reduction process.

Tools

A total of 10 tools were recovered from features in Zone West, namely two microliths, one microburin, two scrapers, one burin, one scale-flaked knife, one serrated piece, and two pieces with edge-retouch.

One of the two microliths is an intact, regular *crescent* (CAT 11782), and the other is a *fragment of a microlith or backed bladelet* (CAT 11777). CAT 11782 measures 20.1 x 4.7 x 1.8mm. Size-wise, it corresponds to the crescents from for example Zone 5 (the only Zone with a substantial number of this type of microlith), and like those, it is somewhat larger than the average scalene triangles found across Site 2D. It has retouch along its LHS and some ancillary retouch along the opposite lateral side. CAT 11777 is the medial fragment of a microlith or backed bladelet with retouch along its RHS. The zone's solitary *microburin* (CAT 11781) is a proximal form with a surviving oblique microburin facet. It is of approximately the same size as most of the microburins from Site 2D (width 6.1mm), and it has its notch in the RHS.

A *short end-scraper* (CAT 11779) is based on a robust hard-hammer flake (29 x 29 x 7mm), and it has a pointed convex, steep working-edge at its distal end, supplemented by blunting of most of its two lateral sides. Although the purpose of the lateral modification may partly have been two protect the user's fingers, the two lateral retouched areas form continuations of the distal scraper-edge, and there is notable wear of the distal end as well as the lateral sides from scraping. The *scraper-edge fragment* (CAT 11778) also has a pointed working-edge with a retouched concavity on either side of this part of the tool. This fragment has a GD of 23mm, and the shape and size of the original scraper is uncertain. Like CAT 11779, this piece has also clearly been used.

CAT 11773 is the distal fragment of an *angle-burin* (17 x 16 x 6mm). The distal end broke off (or was deliberately broken off) the original flake or blade-blank, and the break facet was used as a platform for three burin strikes which detached three chips (technically, very small burin spalls) and formed a burin edge at the distal right corner of the piece. Inspection by the use of a magnifying glass (8X) shows that the burin-edge has been used. In Scotland, burins are diagnostic of the Upper Palaeolithic and Mesolithic periods, but it is not possible to say whether CAT 11773 dates to one or the other of these two periods.

One soft-hammer blade (CAT 11774) has full retouch of both lateral sides, and it was first considered whether this could be a double side-scraper. However, the two lateral edges were modified in different ways, with the retouch of the LHS being steep and uneven, whereas that of the RHS is scale-flaked and straight. The piece was therefore classified as a *scale-flaked knife*, with the RHS being the cutting-edge, and the LHS backing of the knife. The distal end is missing, and the surviving fragment measures 32 x 11 x 5mm. Although scale-flaked knives are known from the entire Early Neolithic – Early Bronze Age period, scale-flaked knives on blades are particularly common in the later part of the Neolithic (Manby 1974, 88-9).

CAT 11780 is the medial fragment of a *serrated blade*, measuring 19 x 10 x 2mm. It has fine serration along its left lateral side (*c*. 11 teeth per cm), but the teeth have been worn almost completely away by use. Like scale-flaked knives, serrated pieces are known from the entire Neolithic – Early Bronze Age period (cf. Ballin 2011a, Fig. 2.5-6), but they are rare or absent in Scottish Mesolithic contexts (cf. Ballin 2013a). Two pieces and fragments with varying forms of *edge-retouch* are thought to be artefacts, or fragments of artefacts, with different functions.

Summary and discussion – Zone West

All finds from this are were recovered from cut features, and they include early as well as late elements (Table West.3)

Table West.3. The distribution of finds across Zone West.

Feature	*Feature type*	*Total finds*	*Including*
2077(2064)	Pit	12	Ten rock crystal chips
2078	Hearth	1	
2080	Pit	2	Indeterminate pottery sherd
2152	Ditch	40	Single-platf core, burin, scale-flaked knife
2164	Pit	44	Frag. of micro. or backed bladelet
2170	Pit	4	
2179	Pit	2	End-scraper, serrated blade
2209	Pit	2	
2214	Pit	1	
2216	Pit	7	Levallois-like flake, microburin
2218	Pit	21	Crested microblade, crescent, two pieces in jasper
2220	Pit	7	
2222	Pit	18	Bipolar core
2241	Pit, small	2	
2268	Pit	1	
TOTAL		**160**	

Most of the finds were retrieved from Features 2077 (12 pieces), 2152 (40 pieces), 2164 (44 pieces), 2216 (seven pieces), 2218 (21 pieces), and 2222 (18 pieces). Although the bulk of the finds are undiagnostic, some are chronologically informative or interesting in other ways.

Feature 2077 is a pit cut into the top of an existing pit (2064) in the northern half of the trench, and it included 10 small chips of rock crystal. The date of these pieces is uncertain, but as the vast majority of finds from Site 2D are flint, they may indicate unspecified non-functional deposition. Ditch 2152 in the south-eastern corner of the trench includes 40 pieces of worked flint, including a pre-Neolithic burin (CAT 11773), a single-platform core which may be Mesolithic or Neolithic (CAT 11776), and a probably later Neolithic scale-flaked blade-knife (CAT 11774). Three microblades (W = 4-8mm) are thought to be later Mesolithic, whereas three broadblades (W = 11-15mm), are more likely to be Neolithic. Pit 2164 in the south-western corner of the trench included 44 lithic artefacts, one of which is the fragment of a microlith or backed bladelet (CAT 11777). All other pieces from this feature are chips and flakes. CAT 11777 is most likely to date to the later Mesolithic or the Early Neolithic.

Pit 2179, immediately next to Ditch 2152, yielded a relatively large short end-scraper (CAT 11779) with extended retouch along both lateral sides and a worn serrated blade (CAT 11780). Both are forms which would fit a Neolithic date better than a Mesolithic date. Pits 2216 and 2218 were located in the same general area, next to Ditch 2152. The former contained, among other things, a microburin (CAT 11781) and a Levallois-like flake (CAT 11713), datable to the later Mesolithic and the later Neolithic, respectively. Pit 2218 contained a crested microblade (CAT 11783), a crescent (CAT 11782), as well as a flake and a blade in jasper. The former two pieces are of a later Mesolithic date, and this date is supported by the presence in the pit of four delicate microblades (W = 5-7mm). It is uncertain whether the jasper pieces could represent non-functional deposition. Pit 2220, between Pits 2179 and 2220 only contained some debitage, but three of these pieces are broadblades with widths up to 14mm, suggesting activity in the Neolithic period. Pit 2222 in the northern half of the trench yielded one bipolar core (CAT 11784). Two broad blades (W = 9-13mm) from this feature may suggest a post Mesolithic date.

The lithic evidence suggests that Zone West was the focus of activity during the later Mesolithic, as well as during the Neolithic period. Some of the Neolithic finds are not datable within this period, but a Levallois-like flake (Pit 2216) and a scale-flaked blade knife (Ditch 2152) may be later Neolithic. Both features also contained Mesolithic objects. As mentioned in connection with the discussion of the sub-assemblage from, among other areas, the Base of the Slope, minuscule debris like chips may indicate that pits were dug through existing knapping floors and entered the features with the backfill. The fact that several closely situated features in the south-eastern corner of the trench contain diagnostic Mesolithic material as well as mainly later Neolithic objects, supports this interpretation. Pit 2241 included two small pieces of worked flint, and a radiocarbon date indicates that this feature may date to the very end of the Mesolithic (4233-3996 cal BC; SUERC-73592); however, it is not certain that the Mesolithic material from the area's other pits dates to the same segment of the later Mesolithic. Pit 2080 only contained two undiagnostic pieces of flint, but one indeterminate pottery sherd.

The nature of the various lithic-bearing features is uncertain, but some finds may represent non-functional deposition, such as unusual raw materials (eg, rock crystal chips and jasper flakes and blades) and well-executed tools (eg, the scale-flaked blade-knife and the short end-scraper). Three features (2152, 2164, and 2222) contained higher than expected proportions of burnt lithics (between two-thirds and one-quarter). It was possible to refit several burnt pieces from Ditch 2152, and it is thought that probably many more bits from this feature may be conjoinable with the established refit complexes. A vitrified flake from Pit 2164 suggests activities which involved more intense use of fire than what would be associated with ordinary domestic fireplaces, such as cremation or industrial activities (cf. the finds from Skilmafilly cremation cemetery; Ballin 2012a).

ZONE EAST

Introduction

The sub-assemblage from Zone East was recovered entirely from cut features, including six large pits, initially assumed to be mainly Mesolithic, one probably Neolithic or Bronze Age pit, one undated pit, two undated postholes, and one undated ditch. As no surfaces were excavated, it was not possible to identify any knapping or other scatters, but it is thought that most of the lithic debris in the features may be residual material from scatters, which entered the later features with the backfill (see below).

Although many of the cut features were first interpreted as probably dating to the Mesolithic period, due to their content of some small cores and microblades, Mesolithic finds in the pits only provide a *terminus post quem* for the digging of the features, and they could date to the Mesolithic, Neolithic or Bronze Age periods. One pit with a Late Neolithic pottery sherd only contained one other artefact, namely a flint chip.

General overview

This group of finds embraces 53 lithic artefacts. They are listed in Table East.1. In total, 92% of this assemblage is debitage, whereas 6% is cores and 2% tools.

Table East.1. General artefact list – Zone East.

Debitage	
Chips	30
Flakes	11
Blades	1
Microblades	6
Crested pieces	1
Total debitage	*49*
Cores	
Opposed-platform cores	1
Bipolar cores	2
Total cores	*3*
Tools	
Pieces w edge-retouch	1
Total tools	*1*
TOTAL	**53**

Debitage

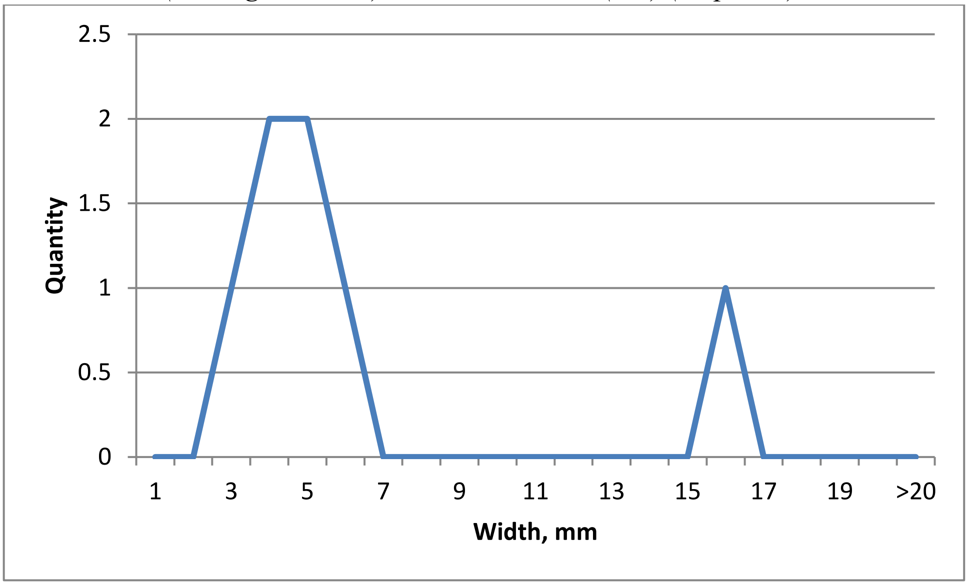
A total of 53 pieces of debitage were recovered from this zone (Table East.2). The debitage includes 30 chips, 11 flakes, one blade, 11 microblades, and one preparation flake. Although a high chip ratio usually indicates that primary production took place at a location, the small numerical size of this sub-assemblage should be borne in mind, as this may introduce random statistical fluctuations.

Table East.2. Relative composition of the debitage.

	n	*%*
Chips	30	61
Flakes	11	23
Blades	1	2
Microblades	6	12
Preparation flakes	1	2
Total debitage	*49*	*100*

Only one blade and six microblades were recovered from Zone East. Although the number of blades and microblades is low, the pieces form two clear groups, with all microblades forming a cluster (Fig. East.1) centred on width 4-5mm, and the solitary blade forming a small 'satellite' on its own at width 16mm. Microblades were primarily produced during the later Mesolithic and the Early Neolithic, and a blade with a width of more than 16mm must be datable to a time before or after this framework. Only one preparation flake was recovered from this zone, namely crested microblade CAT 11770. This piece is the distal fragment of a crested piece, and its width is 5.5mm. Only three pieces are affected by fire, all from Pit 2028 (7% of this sub-assemblage).

Fig. East.1. The width of all unmodified blades and microblades from Zone East (blue). A trendline (moving trendline) has been inserted (red) (20 pieces).



Cores and tools

A total of three cores were found within this zone, namely one opposed-platform core, and two bipolar cores. The cores were measured following the principles described in the methodology section.

The *opposed-platform core* (CAT 11767) is a flat piece with a cortical 'back-side', and it measures 31 x 24 x 15mm. The platform is plain and not only neatly trimmed, but abraded. This piece was not abandoned due to 'mishaps', such as the development of deep hinge- or step fractures (see for example the single-platform core from Zone West). It is simply exhausted. As described in connection with Site 2D's Zone 4, there is a notable Late Upper Palaeolithic presence in this area, and the main focus of the operational schema of this industry is the production of blades from opposed-platform cores. However, it is not possible to determine whether CAT 11767 is Late Upper Palaeolithic or whether it may simply be the final stage of the reduction of a Mesolithic/Early Neolithic single-platform core.

One (CAT 11768) of the area's two *bipolar cores* is small (15 x 19 x 7mm), whereas the other (CAT 11771) is very small (11 x 9 x 3mm); the latter is missing one lateral side. Both are bifacial specimens with one reduction axis (one set of opposed terminals).

The only tool from Zone East is an indeterminate flake fragment with *sporadic retouch* along one edge. The piece is heavily affected by exposure to fire, which has caused it to shed parts of its surface, including parts of the retouched edge.

Summary and discussion – Zone East

All artefacts from this area were recovered from cut features, and they probably include finds from several different periods (Table East.3)

Table East.3. The distribution of finds across Zone East.

Feature	*Feature type*	*Total finds*	*Including*
2009	Posthole	2	Opposed-platf core, bipolar core
2011	Posthole	1	
2018	Pit	2	
2028	Pit, large	43	Crested microblade
2035	Pit	3	Bipolar core
2058	Pit	1	Later Neolithic pottery sherd
2128	Ditch	1	
TOTAL		**53**	

Approximately 80% of the finds were recovered from one large feature, namely Pit 2028. The remaining ten pieces were distributed across another six features, including a ditch, two postholes and three small pits (Table East.3). As the latter finds are in no way spectacular or functional – apart from the opposed-platform core the finds from these features are tiny chips and completely spent bipolar cores – they are most likely to be residual material which entered the features with the back-fill (see discussion of pit depositions in the Zone Base of the Slope section). Table East.4 was produced to test whether the sub-assemblage from Pit 2028 should be interpreted in the same way.

Table East.4. The composition of the sub-assemblage from the large Pit 2028.

	n	*%*
Chips	25	59
Flakes	9	21
Blades	1	2
Microblades	6	14
Crests	1	2
Pieces w edge-retouch	1	2
TOTAL	**43**	**100**

Like most of the flint from the features in Zone Base of the Slope (Table Base.3), the sub-assemblage from Pit 2028 is in the form of plain knapping debris, with 59% being minuscule chips and 24% simple waste flakes. This plain debris is unlikely to represent non-functional deposition, and due to the size of most of the pieces it is also unlikely to represent the deliberate deposition of waste in a so-called rubbish pit (Brophy & Noble 2012). Most or all of the flint is therefore likely to be residual and relate to one or more small domestic scatters in the area. The size of the six microblades (Fig. East.1) suggests that most of the lithic material may date to the later Mesolithic/Early Neolithic framework, whereas the size of blade fragment CAT 11763 (W = 16mm) indicates that this piece may relate to earlier or later industries.

CAT 11763 is of little use in terms of dating this pit, but the later Mesolithic finds in it provide a *terminus post quem* for its construction (later Mesolithic/Early Neolithic or later). A later Neolithic pottery sherd from Pit 2058 and an Early Bronze Age radiocarbon date from Pit 2011 (2137-1953 cal BC; SUERC-73593) indicate later activity in the area. The pit's function is uncertain.

ZONE SOUTH

Introduction

Two flakes (CAT 11620-21) from Zone South were recovered from one probably Neolithic or Bronze Age pit (Pit 2089). They may or may not be residual in relation to the feature. As no surfaces were excavated, it was not possible to identify any knapping or other scatters. Pit 2089 also contained 28 sherds from an almost complete vessel, three sherds of which were identified as later Neolithic. A radiocarbon date from Pit AMA-2216 within Zone South indicates a Mesolithic presence in the area (7306-7072 cal BC; SUERC-73594), but no Mesolithic-style lithic artefacts were recovered during the excavation of Zone South.

SITE 2D – SUMMARY AND DISCUSSION

In the introduction, a number of general and more specific research questions were defined, and below the results of the investigation of the site's various lithic sub-assemblage are briefly summarised.

Late Mesolithic activity at Site 2D

Following detailed examination and characterization of all lithic finds from Site 2D, it is possible to conclude that the vast majority of the artefacts and the scatters are datable to the Mesolithic, and within this period exclusively the Late Mesolithic. The dating of the Mesolithic finds is based partly on the typo-technological diagnosticity of artefacts, but also on a number of available radiocarbon dates. The site's Mesolithic radiocarbon-dates cover most of the Late Mesolithic period, with the earliest indicating a visit to the site around 8222-7965 cal BC (SUERC-68101) and the latest at 4685-4501 cal BC (SUERC-68110).

Generally, this industry is defined by the production of microblades from conical cores, followed by the modification of these blanks into a number of microlith forms, probably aiming to replace damaged and missing microliths in composite hunting equipment. At Site 2D, these microlith forms are prediminantly scalene triangles and crescents, supplemented by small numbers of edge-blunted and obliquely blunted pieces. Non-microlithic implement forms are relatively rare.

As at Nethermills Farm, also in Aberdeenshire (Ballin 2013a), the microliths seem to have been manufactured almost exclusively by the application of microburin technique, with microliths and microburins being almost equally numerous. The microlith:microburin ratio is 47:53 in the favour of microburins, which in a sense is logical as some microliths must have been exported out of the site, having been inserted into slotted bone points and other composite tool forms (at Nethermills Farm, this ratio was 44:55 in favour of the microburins; Ballin 2013a). Comparing this scenario with assemblages from western Scotland, a clear east:west split becomes apparent, as microburin technique seems to have been used considerably less frequently in the west than in the east.

The lithic assemblage from Shieldaig, Loch Torridon, for example, was examined in two stages, first the quartz assemblage (Ballin 2001b) and then the flint assemblage (Ballin 2002b). Both include roughly the same number of microliths and microburins, with each sub-assemblage containing *c*. 25 microliths and one microburin, that is, microburins made up *c*. 4% of the two microlithic sub-assemblages. These results are supported by the assemblages recovered by Mercer from Mesolithic sites on Jura, such as Lealt Bay (Mercer 1968), which had a microburin ratio of only 16%. West-coast assemblages recovered more recently also have relatively few microburins, and for example at Camas Daraich on Skye (Wickham-Jones & Hardy 2004) microburins only make up 3% of pieces and fragments with microlithic retouch.

It is possible that this difference reflects the use of different raw materials in the two regions, with the Mesolithic of Aberdeenshire being defined by the almost exclusive use of high-grade flint, whereas quartz and other raw materials with relatively poor flaking properties (eg, bloodstone, baked mudstone, flint-like chert) were used extensively in the west (eg, Ballin 2014b). It is also possible that the fewer microburins in the west reflects more wide-spread use of bipolar technique (for example adapting to the region's small flint pebbles and quartz), and the use of naturally pointed bipolar spalls as blanks, rather than true microblades. Although this difference is likely to be real, it is probably equally likely that at least the microburin ratio of older assemblages from the west represents less meticulous examination of the finds, and in connection with the examination of the finds from the present project every single minuscule chip was examined in magnification (8X) to allow microburins with GDs of as little as 2mm to be identified. It would be helpful if, to test this, some older west-coast assemblages were re-examined.

During the investigation of the lithics from Zone 5, it was noticed that scalene triangles and crescents were recovered from different parts of that area; that crescents were approximately twice as wide as scalene triangles; and that the two microlith forms were based on microblades of different width. This scenario led to a discussion of the reasons for this variation, where one interpretation is that the different width of the different microlith types may indicate different ages. However, it is presently not possible to rule out that the variation may indicate functional differences, or simply idiosyncratic preferences amongst the Late Mesolithic knappers. The Late Mesolithic microlith assemblage from Fife Ness (Wickham-Jones & Dalland 1998) is also based predominantly on crescents, with other Late Mesolithic microlith assemblages from Scotland – not least from the west-coast and the Hebridean region – being dominated by scalene triangles or being mixed.

Research from other parts of north-western Europe (eg, Brinch Petersen 1973; Vang Petersen 1993; Sørensen 2006) has shown that chronologically unmixed microlithic assemblages tend to include relatively few morphological types (two to three well-defined forms, supplemented by idiosyncratic types), with the different shapes probably relating to different functions in composite tools, such as tips, edges and/or barbs. To determine whether this is the case in Scotland, it would be necessary to select a number of assemblages for analysis, which had been defined by detailed technological attribut analysis (for example of the blades and microblades) and intra-site spatial analysis (number of fireplaces, knapping floors, etc.; eg, Ballin 2013b) as being most likely chronologically undisturbed/unmixed.

A number of individual Late Mesolithic scatters were identified within the zones (most importantly, six scatters within Zone 4 and an equal number within Zone 5), and they are generally characterized by the same attributes: 1) in terms of their spatial extent, the scatters are small; 2) they include relatively few lithics (up to *c*. 4,000 pieces; also see Site 3B; this volume); 3) the lithic finds are heavily dominated by production waste and microliths, supplemented by small number of other implement forms; 4) the scatters are located in direct association with a central hearth (defined by burnt flints); 5) in contrast to the situation at Site 3B, there are no features which can be interpreted as having formed part of any robust or flimsy structures; and 6) in some cases, the distribution patterns suggested 'tossing' (Binford 1983) of larger objects, supporting the absence of any walls.

Combined, this allowed the Late Mesolithic scatters to be interpreted as representing short-term visits to Site 2D, which would have been located near the banks of the River Dee, as indicated by the presence of palaeo-channels in the area (Spanou 2015, 21), some distance from the present current of the river. Most likely, the visiting groups were small bands of hunter-gatherers who stopped at a location for a short period of time – possibly as little as hours or days – with the main purpose of manufacturing large numbers of microblades and microliths to replenish their depleted hunting equipment. Small numbers of scrapers and knives may represent subsistence-related activities, such as preparing food, although some may also have been used to process killed prey.

It has been suggested that the presently unique group of polished-edge implements – which in terms of appearance differ somewhat from related Neolithic pieces (Ballin 2011b) – may date to the Late Mesolithic period. They were clearly used to process relatively hard materials, causing the development of rounding, facets, and striations, but at the present moment their specific use is somewhat enigmatic. It is hoped that Karen Hardy's use-wear analysis of these pieces may shed light on the function of this artefact group. In terms of future research, it is suggested to also carry out analysis of wear-patterns on the later Neolithic polished-edge implements, defined by more shining and mirror-like surfaces, to define the differences between these two related groups of heavily abraded implements.

The pits at the Base of the Slope represent a separate form of activity which may relate to the Late Mesolithic groups camping further down the slope. Several of the pits returned radiocarbon dates suggesting that they may have been dug during this period. However, it is thought that the Late Mesolithic lithic artefacts in these pits may entirely be residual knapping debris which entered the pits with the back-fill, and as such this material does not contribute to the interpretation of the pits. The Late Mesolithic lithics from these features only inform us that there may have been one or more small domestic sites at the Base of the Slope prior to the digging of the pits, pre-dating the pit-digging by days or centuries. At present, there is no evidence to suggest whether these features were constructed for domestic purposes (rubbish, storage) or as ritual pits (cf. Brophy & Noble 2012). The only 'evidence' is the absence of evidence, in the sense that the apparent lack of any unusual or 'special' Mesolithic lithics in the pits give the pits a domestic appearance.

A small group of features was discovered between Zones 1-5 and the Early Neolithic house of Zone 6. They included two pits (1693 and 1747) and Hearth 1715. Charcoal from the hearth returned a date at the centre of the Late Mesolithic period, setting this group apart from most other Late Mesolithic activity at Site 2D, which occurrred towards the beginning and end of the period. The only lithic material recovered from this group of features is plain, probably residual knapping waste.

The site's Late Upper Palaeolithic component: The initial typo-technological characterization and cataloguing of the site's 11,784 lithic artefacts showed that it was possible to subdivide the assemblage into two fundamentally different parts, namely one based on the production of microblades and narrow-blades and one based on the production of impressively large broad-blades. The former was associated with narrow microliths, defining it as predominantly Late Mesolithic, whereas the latter only included small numbers of likely point fragments, making it impossible to date it by typological analogy. Broad-blades are associated with the Early Mesolithic as well as the later Neolithic periods, but the blades of these periods rarely reached the dimensions of many of the larger blades (many of them crested) recovered from Site 2D.

It was therefore attempted to date this broad-blade assemblage by technological attribute analysis and definition of the associated operation schema, and in Table 4.7 the operational schema of this industry is compared with that of Site 2D's dominant Late Mesolithic industry(-ies). The most important elements of the broad-blade operational schema defined above are:

1) The production is based on the procurement of exceptionally large flint nodules – possibly up to 200mm across – which are thought to have been unavailable after the formation of the North Sea. It is suggested that these nodules may have been obtained from sources on Doggerland.
2) The broad-blades are generally struck from large opposed-platform cores, whereas the microblades and narrow-blades from the Late Mesolithic and the Early Neolithic periods were mostly struck from small conical cores.
3) The operational schema associated with Zone 4's broad-blade industry is associated with the serial detachment of preparation flakes (crests and core tablets) during the initial preparation of the cores, as well as during the actual blank production, whereas core preparation during the Late Mesolithic and Early Neolithic of eastern Scotland generally involved little initial preparation and only limited core rejuvenation.

Summing up, and referring to this report's Table 4.8, this indicates that Zone 4's broad-blade industry must be pre-Mesolithic and date to a time when Doggerland was still in place (cf. Ballin 2016d). It is not possible on the basis of the recovered fragments of tanged and backed points to narrow the date down to a specific industry or material culture – the Hamburgian, the *Federmesser-Gruppen* complex, or the Ahrensburgian – as on the Continent they are all associated with blade production from large opposed-platform cores. However, the broad-blade industry discovered at Site 2D must date to the period *c.* 13,000-10,000 cal BC (see the Zone 4 section, above). As put by Arthur Conan Doyle (1890) in his Sherlock Holmes novel 'The Sign of Four': '*When you have eliminated the impossible, whatever remains, however improbable, must be the truth*'.

However, the importance of this discovery goes beyond simply being able to state the presence of a Late Upper Palaeolithic settlement site in eastern Scotland – only the fourth actual Late Upper Palaeolithic settlement site to have been discovered in Scotland (in addition to Howburn, Kilmelfort Cave and Rubha Port an t-Seilich; Ballin *et al.* 2010; Saville & Ballin 2010; Mithen *et al.* 2015). It also introduces a new approach for the identification of Late Upper Palaeolithic settlement sites in Scotland.

The first stage in the search for a Scottish Late Upper Palaeolithic has, for obvious reasons, been the recovery of diagnostic implement forms dating to this period, in particular the well-known and highly diagnostic pre-Mesolithic tanged and backed points (eg, Livens 1956; Ballin & Saville 2003; Ballin & Bjerck 2016). The inclusion of a technologically based approach now allows us to identify Late Upper Palaeolithic settlement sites where typological evidence may be absent or sparse, such as at Site 2D Zone 4.

Another detail of relevance to the future investigation of the Scottish Palaeolithic is the likelihood of the period's lithic scatters possibly having been scavenged by later visitors to the sites, to whom the large cores, blanks and implements left by Palaeolithic people may have represented a valuable, and easily accessible, resource of lithic raw material. It was suggested above – on the basis of the distribution of probable early elements – that Zone 4 may have been the focus of settlement during the Late Upper Palaeolithic; that the pre Meolithic scatter may have been 'strip-mined' by later visitors; and that this caused identifiable early elements to be distributed across the site outside Zone 4, with some Palaeolithic objects possibly having been reduced to a degree that now makes it impossible to associate them with the site's earliest visit(s).

In terms of the interpretation of the Late Upper Palaeolithic camp discovered at Site 2D, and not least its specific character, it is important to note the composition of this pre-Mesolithic assemblage and how it differs from other assemblages from this general period. Where Scottish Mesolithic sites may yield a relatively low number of burins (eg, Glentaggart in South Lanarkshire and Donich Park in Argyll – four and two pieces, respectively; Ballin & Johnson 2005; Ballin 2012b), Scottish Upper Palaeolithic sites occasionally yield notably higher numbers (eg, Howburn Farm in South Lanarkshire – 40 pieces; Ballin *et al.* 2010; forthcoming). The Late Upper Palaeolithic sub-assemblage from Site 2D includes no burins at all, adding to the impression that activities at this location and at this time were 'narrow-spectred' and corresponded to the activities taking place at the site in Mesolithic times, namely the production of blanks for the production of points and microliths to replace lost and damaged ones – in Keeley's (1982) terms: re-tooling.

Neolithic activity across the site: A number of radiocarbon dates from features across Site 2D indicate that the site was visited at various stages of the Early and Middle Neolithic periods, but this activity generally involved little or no reduction or use of flint. It is possible to subdivide this activity into four different areas, namely 1) activity across the site in general (Zones 1-5); 2) activity at the Base of the Slope; 3) activity in Zone 6; and activity in Zones West, east and South.

Zones 1-5: There are no radiocarbon-dates for Zone 4 at all, but all other zones returned one or more Neolithic dates. Early Neolithic dates are available from Zones 3 and 5, and Middle Neolithic dates from Zones 1-3. However, practically no lithic artefacts from Zones 1-5 had a Neolithic appearance, and the vast majority of the lithics from this area are thought to be Late Mesolithic, supplemented by a small sub-assemblage of Late Upper Palaeolithic material.

As bipolar technology seems to have formed an insignificant part of the operational schema during the region's Mesolithic and Early Neolithic periods (cf. Ballin 2014a), with the proportion of bipolar material in assemblages growing through the later Neolithic and becoming notable in the Early Bronze Age, it was suggested above that a relatively large bipolar core (CAT 10153) from Pit 1084 in Zone 1 (a nearby pit was radiocarbon-dated to the Middle Neolithic) might represent a deliberate deposition dating to this period. However, all other lithic material in this and other pits in Zone 1 is residual Late Mesolithic knapping debris, and the dating of CAT 10153 to the Neolithic is uncertain.

In connection with the discussion of Zone 2, it was suggested that an edge-retouched broad-blade fragment (CAT 10278) from Pit 1320 (a neighbouring pit returned a Middle Neolithic radiocarbon-date) could possibly represent a deliberate Middle Neolithic deposition, but this date is also uncertain. Again, this find was associated with residual Late Mesolithic knapping debris, including a small conical microblade core, and at Site 2D a broad-blade fragment could just as well represent Late Upper Palaeolithic activity and residuality.

Zone 3 returned Early Neolithic as well as Middle Neolithic radiocarbon-dates, but no artefacts suggested lithic reduction, or other activity involving lithics, during these periods. There is no evidence of any kind indicating post Mesolithic activity in Zone 4.

An Early Neolithic radiocarbon-date was obtained for Zone 5, but this date is from a feature (Pit 1879) which was entirely devoid of lithic artefacts. This pit was located immediately south of the border drawn in Fig. Intro.4 to separate Zones 1-5 from the zone Base of the Slope, and it is possible that Pit 1879 formed part of the Early Neolithic activities taking part at the Base of the Slope and in Zone 6 (below). However, one serrated blade (CAT 10237) was defined as Neolithic (cf, Saville 2006; Suddaby & Ballin 2011), and the delicate nature of this piece (W = 10mm) defines it as more likely to be Early Neolithic than later Neolithic. It was recovered from the zone's main scatter, but like Pit 1879 it should possibly be seen as representing the southern periphery of an Early Neolithic activity area, the main focus of which was the Base of the Slope.

In summary, the Neolithic activity in Zones 1-5 seems to have focused on the construction of features like pits and postholes, possibly representing agricultural activities (eg, fences) and activitities around pits which may be either domestic or ritual. Less than a handful of lithic objects recovered from Zones 1-5 were identifiable as possibly Neolithic, with one piece likely to represent domestic activity (the heavily worn serrated blade), and the others possibly pit deposition.

<u>The Base of the Slope</u>: As mentioned above, some pits within this zone appear to have been dug during the Late Mesolithic, but radiocarbon-dates from other pits suggest that some may also have been dug during the Early Neolithic (Table Base.3). The evidence also shows that some pits likely to have been dug during the Late Mesolithic were redug in the Early Neolithic (Table Base.4), and in some cases pottery of Carinated Bowl Tradition was inserted, in most cases approximately half way between the pits' top and bottom.

However, the lithic artefacts throughout the pits appears to be residual knapping debris. Although the pits only include diagnostic Mesolithic artefacts (Table Base.3), it can not be ruled out that some of the mostly undiagnostic debris may relate to small Early Neolithic knapping floors. Hearth 1258 in this zone was radiocarbon-dated to the Early Neolithic, and although a hearth could relate to the ritual activities associated with the deposition of the pots (feasting?), it is also conceivable that this hearth relates to Early Neolithic domestic/agricultural activities evidenced by for example fence-lines, possibly pre- or post-dating the digging of ritual pits by days, years or decades.

As shown in Fig. Base.2, the Late Mesolithic pits in the area are scattered across large parts of the period, whereas the radiocarbon-dates relating to the Early Neolithic hearths, pits and postholes suggest that these features were constructed within a very narrow time-span, probably in the first half of the Early Neolithic period.

Only one likely Early Neolithic flint was recovered from this zone, namely CAT 10156. This piece is a robust crested flake, which may have been prepared for hafting, and with flat use-wear along both lateral sides. More importantly, the edges also display macroscopically visible *gloss*, indicating that the piece may have been use for cutting or sickling vegetable matter, which defines the piece as a potential informal sickle (Juel Jensen 1994). The feature from which it was recovered (C1398) was first interpreted as a posthole, but may in fact be a pit, and this piece may be the area's only deliberate deposition. This pit did, unusually, not contain any knapping debris, and two neighbouring pits – Pit 1193 and Pit 1714 – suggested a date at the very beginning of the Early Neolithic period. The Early Neolithic dates from this area overlap with the Neolithic dates from Zone 6, and these two areas may in the Early Neolithic have been used by the same group of people.

Zone 6: Two radiocarbon-dates from Zone 6 suggest that the features and, indeed, the entire structure discovered towards the eastern periphery of Site 2D may date to the Early Neolithic period. SUERC-68114 is from 'trample' within the building and it suggests a date of 3945-3714 cal BC, and SUERC-58194 from Hearth 1638 returned an almost identical date of 3961-3797 cal BC. Unfortunately, practically all lithic finds from this part of the site is knapping debris with little information value. The only lithic object of some interest is the leaf-shaped arrowhead CAT 10060, which was recovered from Pit 1927 a few metres south of Structure 1917 and immediately adjacent to an old ground surface (C1916). This pit was sealed by lithic debris-bearing soil, but the pit itself only contained the leaf-shaped point which – being a so-called 'special' object – has been interpreted as a deliberate, probably ritual deposition.

Zones West, East and South: Although a large number of pits from these areas were initially interpreted as potential Mesolithic features, the features' content of primarily fine knapping debris suggests that – as in the case of the pits from Base of the Slope – represents residuality, and that this material is primarily debris from knapping floors through which the pits were dug. This material, which also contained some diagnostic Mesolithic pieces (such as a crescent, a microburin and a burin; CAT 11782, 11781, 11773), probably entered the features with the backfill. Several of the pits also contained Neolithic objects (such as a Levallois-like flake (CAT 11713), a scale-flaked blade (CAT 11774), a serrated blade (CAT 11780, and Neolithic pottery sherds), and the Levallois-like flake, the scale-flaked knife, and Impressed Ware pottery suggest that some of the pits may have been dug during the later Neolithic period.

Radiocarbon-dates from these generally mixed features include a date from the early half of the Late Mesolithic (Zone South – 7306-7072 cal BC; SUERC-73594), the end of the Late Mesolithic (Zone West – 4233-3996 cal BC; SUERC-73592), and the Early Bronze Age (Zone East – 2137-1953 cal BC; SUERC-73593), but the material culture evidence suggests that possibly most of the pits were dug in the later Neolithic period, with some Late Mesolithic scatters probably having been present.

Summary of the general activity patterns at Site 2D: In general, all the scatters and features of Site 2D are situated within Terrace 1 (Spanou 2015), and the Late Upper Palaeolithic, Late Mesolithic, Early Neolithic and Middle Neolithic visits to the site are therefore thought to date to a time-frame when the River Dee followed a considerably more northerly route than the present (Tipping; this volume).

The Late Upper Palaeolithic and Late Mesolithic scatters generally seem to be the remains of short-term visits (possibly a few days?) to the site by small groups of people, probably hunting parties. The lithic finds are heavily dominated by primary waste from the production of blades and microblades, supplemented by some fragments of points and numerous microliths. The latter are associated with roughly equal numbers of microburins, which were discarded during the production of the microliths. Most likely, the reason for these groups to make a stop at Site 2D was to produce large numbers of flint blanks, which were then transformed into points and microliths to be inserted into composite hunting equipment, to replace broken or lost pieces. Other flint implements are rare at the site, such as scrapers and knives (truncated pieces), adding to the impression that the site's scatters are most certainly not the remains of base camps, or parts of such camps, but *ad hoc* pieces produced for subsistence-related tasks during the brief visits to this location. Other evidence, albeit negative evidence, supporting this interpretation is the absence of features relating to structures, defining the various scatters as probably small open-air camps (in literature dealing with Lower, Middle and Early Upper Palaeolithic industries, 'open-air camps' are frequently defined as 'not cave sites', but in a Scottish prehistoric context this term could suitably be used to define scatters which are not associated with dwelling structures, that is, 'out-door' scatters instead of 'indoor' scatters). During the Late Mesolithic, a small number of pits were dug at the Base of the Slope, but it is uncertain whether they relate to domestic (storage, rubbish?) or ritual activities.

As mentioned above, post Mesolithic evidence is sparse, bordering on being absent, but there *are* indications of a Neolithic presence at Site 2D. Although some of the lithics are likely to date to this general period, most of the Neolithic evidence is in the form of features. The Early Neolithic features have been dated to a relatively narrow chronological band at the beginning of the period, and it is possible that they form part of the same complex, with a dwelling (house) located towards the east (Zone 6) and some agricultural activities taking place towards the west and north (Base of the Slope), where some post- and stakeholes may indicate fence-lines. Early Neolithic people also dug a number of pits, or redug Late Mesolithic ones, for ritual purposes, and pottery vessels were inserted into these pits (also Base of the Slope). It is uncertain whether an Early Neolithic hearth in this area relates to domestic or ritual activity.

The Middle Neolithic activity in the area is mostly confined to the lower parts of Site 2D (Zones 1-3) as well as Zones West, East and South, and includes groups of pits and some post- or stakeholes. Some of these features (such as rows of post-/stakeholes) may relate to agricultural activities (eg, fence-lines), whereas it is impossible to offer any interpretation as to whether the pits are domestic or ritual. Diagnostic pottery was retrieved from two later Neolithic feature, one in Zone East and one in Zone South. Overall, only a handful of lithics were interpretated as possible or probable Neolithic objects. Only the leaf-shaped point recovered from a pit in Zone 6 is an absolutely certain Neolithic implement.

In popular terms, the lithic finds from Site 2D may be associated with late Upper Paleolithic 'reindeer hunters', Late Mesolithic 'hunter-gatherers of the forest', and Early and Middle Neolithic 'farming communities'.

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Table 4.6. Selected likely Late Upper Palaeolithic pieces from Zone 4 and other parts of Site 2D.

	Zone	*CAT*	*Frag.*	*L*	*W*	*Th*	*Est original length*	*Cortex*	*Other observations*
Large blades from opp-platf cores	0	8391	Med-dist	25	13	5	C. 45mm		Reg trimmed platform-edge at distal end
	3	8395	Intact	79	38	15			
	4	899	Intact	74	30	18			Reg trimmed, rejuv platform-edge at distal end
	4	2775	Med	37	18	7	C. 60mm	Soft	
	4	3090	Prox	42	36	15	Poss 150mm or more		
	4	3100	Dist	16	24	7	C. 100mm or more		Reg trimmed platform-edge at distal end
	4	3186	Intact	81	24	15		Soft-ish	Reg trimmed platform-edge at distal end; prob used
	4	6592	Med-dist	56	21	13	C. 75mm		Reg trimmed platform-edge at distal end
	4	11371	Dist	31	34	20	Poss 100mm or more		Reg trimmed platform-edge at distal end
	4/5	9953	Intact	118	68	25			Reg trimmed platform-edge at distal end
	4/5	10020	Intact	60	28	11			Reg trimmed platform-edge at distal end
	5	3945	Intact	43	18	7			Reg trimmed platform-edge at distal end
Crested blades	3	10117	Intact	71	22	9			10117-8 refits dorsal-ventrally
	4	3187	Intact	65	23	8			
	4	10102	Prox-med	56	24	12	C. 68mm		From opp-platf core
	4	10103	Med-dist	59	21	9	C. 68mm		
	4	10110	Med-dist	93	33	19	At least 105mm		
	4	10183	Med	52	28	15	Poss 120mm or more		From opp-platf core
	4/5	9929	Med	59	31	11	C. 110mm		From opp-platf core
	4/5	10118	Intact	63	25	12			
	4/5	10121	Intact	66	24	14			From opp-platf core; use-wear from cutting
Platf rejuv flakes	0	10120	Intact	83	32	16			Platform length at least 83mm; use-wear from cutting
	3	10104	Intact	34	17	7			10104, 10182, 10184 refit, one on top of the other
	3	10182	Intact	37	33	6			10104, 10182, 10184 refit, one on top of the other
	3	10184	Intact	26	26	4			10104, 10182, 10184 refit, one on top of the other
	4/5	10138	Intact	43	33	12			
	5	10129	Intact	47	26	11			10129-10157 almost refit (same core)
	5	10157	Intact	52	29	13			10129-10157 almost refit (same core)
Opp-platf cores	4	10059	Intact	48	28	27			Typ UP opp-platf core, but very small
Idiosyncratic point	4	10456	Intact	29	11	3			Sur enclume retouch; straight base
Tip of tanged or other point	4	10265	Dist	15	8	2	Original size uncertain		Similar frags are known from Howburn, S. Lanark
Backed blade (point?)	4	10567	Prox-med	27	9	4			Sur enclume retouch
Backed blade (point?)	4	10289	Prox-med	20	9	3	C. 28mm		
Piece w double truncation (point?)	4	10236	Intact	36	16	4			Truncs are straight and oblique, and 10236 angle-backed
Large oval end-scraper (non-Meso)	4	10214	Intact	45	31	8			
Blade-scraper w acute scraper-angle	4	10507	Intact	70	34	15			On crested blade from opp-platf core
Large blade w abraded retouch	4	10291	Intact	91	24	10			W abraded retouch (pol-edge imp); use-wear from cutting

Appendix2.2.9 SL/003B Nether Beanshill Lithics Analysis - Julie Lochrie

The Nether Beanshill assemblage numbers 50 pieces of flint and was retrieved from a middle Bronze Age roundhouse and cremation cemetery which may have seen concurrent use. The assemblage is summarised in Table 1. For a detailed description of available local flint resources please refer to A.2.2.8.

The assemblage is mostly populated by chips, accounting for 64% leaving the remaining assemblage amounting to 18 pieces which are mostly characterised by flake fragments. In addition to the debitage the assemblage also includes three cores and an edge retouched flake. The characteristics amongst the assemblage all fit with a middle Bronze Age date, namely the hard and bipolar reduction and lack of more formalised blanks or tools. The three cores are bipolar cores, a type of reduction where a hammer on anvil technique is used. This reduction strategy can be an expedient way for producing sharp flakes. The three bipolar cores from Nether Beanshill are fairly typical, they are bifacially reduced and in two cases have been worked along two different axes. The single retouched piece is a secondary flake with retouch along its right lateral that would have been useable in a variety of tasks.

Table 1 Lithic assemblage summary

Debitage	
Chips	32
Flakes	12
Indeterminate pieces	3
Total debitage	47
Cores	
Bipolar Cores	3
Total cores	3
Tools	
Edge retouched	1
Total tools	1
TOTAL	51

Table 2 provides a summary of the lithic distribution. Most pieces were found in contexts relating to the roundhouse. Three pieces are associated with the cremation cemetery, one of which, from [3B-0104] is clearly burnt. There are 16 burnt pieces in total.

Table 2 Lithic distribution summary

Feature	Chips	Flakes	Indeterminate Pieces	Bipolar cores	Edge retouch	Total
Unstratified				1	1	2
Cremation Complex						
3B-0100	1					1
3B-0104	1					1
3B-0151	1					1
Roundhouse Complex						
3B-0025	1	2		1		4
3B-0032	1					1
3B-0039				1		1
3B-0049	3	1				4
3B-0050	3					3
3B-0063	1					1
3B-0092	1					1
3B-0111	1	1				2
3B-0130	1					1
3B-0140	1		1			2
3B-0150	2					2
3B-0180	1					1
3B-0189	1	1	1			3
3B-0212			1			1
3B-0218		1				1
3B-0219	1					1
3B-0233	1					1
3B-0241	1	2				3
3B-0281		1				1
3B-0285	1	1				2
3B-0287	1					1
3B-0291	4	1				5
3B-0302	2					2
3B-0293	1					1
Total	32	11	3	3	1	50

During the middle Bronze Age stone technology begins to wane and become more simplistic. Complex reduction strategies and formalised tools are eschewed for simpler, ad hoc reduction which presumably complemented other material available at the time. It is clear, looking at the Nether Beanshill roundhouse which must have been cleaned out as far as possible before its abandonment that the use of stone tools still formed was still an essential component of domestic lifestyles at this point.

Appendix2.2.10 SL/004 Gairnhill Lithics Analysis - Julie Lochrie

The Gairnhill assemblage is small, numbering 20 pieces of flint. The site has been radiocarbon dated to the Middle and Late Bronze Age. The datable lithics are earlier than this which mean that some, if not most are residual. The assemblage is summarised in Table 1. For a detailed description of available local flint resources please refer to A.2.2.8.

The assemblage is mostly populated by chips, accounting for 45% of the total. Once the chips and an indeterminate piece are excluded from analysis the assemblage amounts to nine pieces. The most diagnostic amongst these are a bipolar core, a soft-hammer blade and a plano-convex knife. The bipolar core is the only core in the assemblage. It is bifacial reduced along two different planes of direction. Bipolar cores can be found during most periods but there popularity soars in the middle Neolithic from which point onwards they remain a fairly popular reduction method.

One of the two blades in the collection is a soft hammer blade. It is long with a trapezoidal section and some edge damage perhaps indicative of use wear. Soft hammer percussion is more prevalent in the periods pre dating the middle Neolithic and although only one example this piece cannot ate to the middle to later Bronze Age. The remaining pieces of debitage showed seven flakes of hard-hammer percussion and a single bipolar flake.

The most diagnostic retouch seen in the collection is in the form of a Plano-convex knife. These knives are typically synonymous with the later Neolithic to Early Bronze Age and have most commonly been found in funerary or cinerary contexts. This example is fairly wide and may be at an early point in its life. Unfortunately this pieces is broken and extensively burnt.

Few pieces were visibly burnt, only four, which includes the plano-convex knife and a chip that has fractured from it. The level to which the knife has been burnt has left it with no dorsal surface, other potlid fractures crazing and a glassy vitrified appearance. Other than the small chip which likely detached more recently the other fractured pieces were not found with the knife.

Table 1 Lithic assemblage summary

Debitage	
Chips	9
Flakes	4
Blades	2
Indeterminate pieces	1
Total debitage	16
Bipolar Core	1

Tools	
Edge retouched	1
Piercer	1
Plano-convex knife	1
Total tools	3
TOTAL	20

Table 2 summarises where the lithics were found. Most of the chips were retrieved from soil samples and their distribution will likely be biased towards the sampling processing strategy. Added to this are that the chips are small and easily transportable making their distribution unlikely to reveal areas of knapping activity and or lithic use. The typologically earliest piece in the assemblage, the soft-hammer blade is from rig and furrow. The bipolar core and an edge retouched piece are both from Gairnhill 5 and the knife is from Gairnhill 4.

Table 2 Lithic distribution summary

	Feature	Chips	Flakes	Blades	Indeterminate Pieces	Bipolar core	Edge retouch	Piercer	Plano-convex knife	Total
Unstratified								1		1
Neolithic Pit	4C-0001		1							1
Rig and furrow	4D-0020			1						1
Gairnhill 1	4D-0011			1						1
Gairnhill 1	4D-0028		1							1
Gairnhill 2	4D-0102	1								
Gairnhill 4	4D-0120	1							1	2
Gairnhill 4	4D-0320	1								1
Gairnhill 4	4D-0240				1					1
Gairnhill 5	4D-0026						1			1
Gairnhill 5	4D-0017	1				1				2
Gairnhill 5	4D-0211	1								1
Gairnhill 7	4B-0002	1	1							2

Gairnhill 7	4B-0019	1	1							2
Gairnhill 7	4B-0040	2								2
	Total	9	1	2	1	1	1	1	1	20

Lithic use and manufacture in the Bronze Age begins to wane in the Middle Bronze Age and there is no firm evidence for lithic industry from the late Bronze Age to the Iron Age.

Appendix-2.2.11 NL/001C Chapel of Stoneywood Lithics Analysis - Julie Lochrie

The Chapel of Stoneywood assemblage is small and fragmentary, numbering 48 pieces. Absolute dating of the industry they belong to is not possible and they reveal very little. The assemblage is summarised in Table 1. For a detailed description of available local flint resources please refer to A.2.2.8.

The assemblage is hugely dominated by chips (62.5%), followed by small broken flakes and indeterminate pieces. The single blade discovered it not a true blade but the edge of a bipolar core that while twice as long as it is wide is as thick as it is wide. Bipolar cores number three and are essentially the remains of three small pebbles which have been struck on either opposing end and all have bifacial fractures. Bipolar cores are a type of reduction where a hammer on anvil technique is used. This reduction strategy can be an expedient way for producing sharp flakes. The single retouched piece is a burnt and broken flake with some edge retouch to the right lateral, near the proximal end. Burnt pieces number 14 but the presence of so many small pieces in the assemblage means this number is likely to be an underestimate. A clear concentration of the lithics occurs in [1C-0007], where 22 pieces were found. This feature is a gully of the Chapel of Stoneywood middle Bronze Age building and the lithics from here are most likely to relate to its occupation.

Table 1 Lithic assemblage summary

Feature	Chips	Flakes	Blade	Indeterminate Pieces	Bipolar cores	Edge retouch	Total
Unstratified					1		1
1C-0001	2						2
1C-0007	14	2	1	3	1	1	22
1C-0017	1						1
1C-0022	2						2
1C-0063	1						1
1C-0073	1						1
1C-0077				1	1		2
1C-0105	2	1					3
1C-0113		1					1
1C-0120	1	1					2
Trial Trenching	6	2		2			10
Total	30	7	1	6	3	1	48

During the middle Bronze Age stone technology begins to wane and become more simplistic. Complex reduction strategies and formalised tools are eschewed for simpler, ad hoc reduction which presumably complemented other material available at the time.

Appendix-2.2.12 NL/003B Standingstones Lithics Analysis - Torben Bjarke Ballin

Introduction

In connection with the construction of a ring road around the western periphery of Aberdeen, Headland Archaeology Ltd. carried out investigation of selected locations along the planned route (Spanou 2015). During this work, a number of prehistoric and later sites were examined by trial trenching and excavation, some of these dating to the Mesolithic period.

Along the Aberdeen Western Peripheral Route/Balmedie-Tipperty (Northern Leg), a highly promising Mesolithic site was discovered near a location referred to as Standingstones (NGR: NJ 85780 12950). This site (Site NL/003B) yielded a relatively large assemblage of flint (2,591 pieces), it was associated with structural evidence, and the presence of charcoal and burnt hazelnut shells has allowed the site and its assemblage to be dated to the central part of the Late Mesolithic period (probably just after 7000 cal BC). The composition of the lithic collection, which includes narrow microliths and microburins, is consistent with this date.

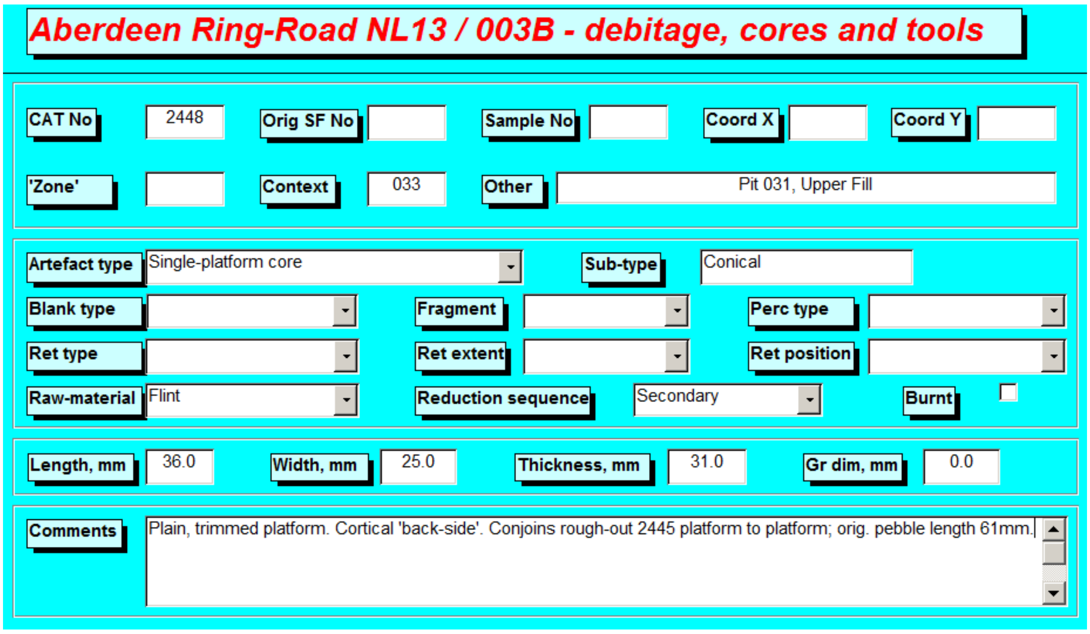
The typo-technological composition of the assemblage, as well as its distribution in relation to the site's features, defined Site 3B as a Mesolithic location with significant research potential, probably relating to one group of hunter-gatherers and deposited during one visit to the site, or a most a small number of visits within a limited time-span.

The purpose of this report is therefore to characterize the lithic assemblage in detail and discuss relevant research questions, such as: the nature and date of the assemblage, lithic procurement and technology, as well as intra-site spatial patterns and site behaviour, and the site and its lithic material will be compared with relevant contemporary sites and assemblages.

Cataloguing Principles

As a first step, a database format (Microsoft Access) was defined for the characterization and cataloguing of a number of sites investigated in connection with the Aberdeen Ring Road Project. This format was then adapted to fit the individual sites and assemblages. Fig. # shows the database form applied in connection with the processing of the lithic finds from Site 3B.

Fig.#. The applied database format showing the data relating to CAT 2448, a conical single-platform core.



Aberdeen Ring-Road NL13 / 003B - debitage, cores and tools

CAT No: 2448
Orig SF No:
Sample No:
Coord X:
Coord Y:
'Zone':
Context: 033
Other: Pit 031, Upper Fill
Artefact type: Single-platform core
Sub-type: Conical
Blank type:
Fragment:
Perc type:
Ret type:
Ret extent:
Ret position:
Raw-material: Flint
Reduction sequence: Secondary
Burnt:
Length, mm: 36.0
Width, mm: 25.0
Thickness, mm: 31.0
Gr dim, mm: 0.0
Comments: Plain, trimmed platform. Cortical 'back-side'. Conjoins rough-out 2445 platform to platform; orig. pebble length 61mm.

Due to the involved artefact numbers, the complexities of the sites, and the limited amount of time available for the analysis, it was decided to be strict in terms of which attributes were recorded, and how they were recorded. It was therefore agreed within the project to focus only on attributes which were certain to be of relevance to the discussion of the present project's site, including Site 3B, drawing on the analyst's recent experience with the cataloguing and discussion of other large assemblages, such as 1,670 flint cores and tools from the c. 30,000-piece assemblage from Nethermills Farm in Aberdeenshire (Ballin 2013a), c. 10,000 mainly Neolithic quartz artefacts from RUX6 (the Udal Project) on North Uist (Ballin 2015), and c. 10,000 mainly Early Bronze Age flint and quartz artefacts from the Barabhas dunes on Lewis (eg, Ballin forthcoming). The following principles were followed:

Chips: These pieces of debitage are defined by being smaller than 10mm and it is not necessary to know whether they measure 8mm or 3mm across – not to be measured.
Flakes: The measurements of these pieces are only rarely used, and although in some cases it would be interesting (technologically speaking) to know whether the blades and the flakes form one continuum or two separate clusters (cf. Figs 1-2), These measurements are not strictly necessary – not to be measured.
Blades/microblades: These pieces (and not least their sizes and technological attributes) are of some diagnostic value, and they are also important as blanks of microliths. It is suggested to measure intact pieces in three dimensions, and in the case of fragments, only the width (which is the key diagnostic dimension).
Indeterminate pieces: Like the flakes, these pieces are not measured.
Cores (incl. frags of cores which can be identified to type): To be measured in three dimensions.
Core frags (which can't be referred to any formal type): GD only.
Tools and core preparation flakes (crested pieces and platform rejuvenation flakes) and their frags: Three dimensions.
Microliths: It is suggested to measure intact pieces in three dimensions, and in the case of fragments, only the width (which is the key diagnostic dimension). As the only group of artefacts, the microliths and their fragments are measured with one decimal. This is the generally accepted standard, as the absence of this decimal would result in many microliths 'landing' on top of each other in a diagram showing their sizes, distorting the visual impression of these pieces.

The Assemblage

General overview

From the excavation at Site 3B, 2,591 lithic artefacts were recovered. They are listed in Table 1. In total, 94% of this assemblage is debitage, whereas 1% is cores and 5% tools.

Table 1 General artefact list.

Debitage	
Chips	1,553
Flakes	357
Blades	156
Microblades	313
Indeterminate pieces	48
Crested pieces	5
Total debitage	2,432
Cores	
Split pebbles	2
Core rough-outs	2
Single-platform cores	16
Cores w two platfs at angle	1
Total cores	21
Tools	
Microlith preforms	2
Scalene triangles	9
Crescents	3
Edge-blunted microliths	3
Backed bladelets	5
Frags of microliths	6
Frags of microliths/backed bladelets	29
Krukowski 'microburins'	6
Microburins	59
Short end-scrapers	5
End-/side-scrapers	1
Truncated pieces	3
Pieces w edge-retouch	7
Total tools	138
TOTAL	2,591

The definitions of the main lithic categories are as follows:

Chips: All flakes and indeterminate pieces the greatest dimension (GD) of which is ≤ 10mm.
Flakes: All lithic artefacts with one identifiable ventral (positive or convex) surface, GD > 10mm and L < 2W (L = length; W = width).
Indeterminate pieces: Lithic artefacts which cannot be unequivocally identified as either flakes or cores. Generally the problem of identification is due to irregular breaks, frost-shattering or fire-

crazing. Chunks are larger indeterminate pieces, and in, for example, the case of quartz, the problem of identification usually originates from a piece flaking along natural planes of weakness rather than flaking in the usual conchoidal way.
Blades and microblades: Flakes where $L \geq 2W$. In the case of blades $W > 8$mm, in the case of microblades $W \leq 8$ mm.
Cores: Artefacts with only dorsal (negative or concave) surfaces – if three or more flakes have been detached, the piece is a core, if fewer than three flakes have been detached, the piece is a split or flaked pebble.
Tools: Artefacts with secondary retouch (modification).

Av. dim.: Average dimensions
GD: Greatest dimension.
LHS/RHS: Left-hand side and right-hand side.

Raw materials – types, sources and condition

The lithic assemblage from Site 3B consists entirely of flint. Flint artefacts from the north-east of Scotland have traditionally been associated with honey-brown, red, orange and yellow colours (eg, Stevenson 1948, 181), but examination by the analyst of a number of Mesolithic, Neolithic and Bronze Age assemblages from the region has shown that the available flint varies greatly from location to location.

Approximately three-quarters of the assemblage from the Kingfisher Industrial Estate north of Aberdeen (Ballin 2008) is in flint of the brown-red-orange-yellow group, and the collection from Culduthel at Inverness (Ballin 2006) is also dominated by flint of this variety. Examination of other assemblages from the area between these two sites, particularly from Moray (Ballin 2014), supported the view that flints from this part of the north-east are dominated by reddish-brown colours.

In contrast, the lithic finds from Nethermills Farm near Banchory (Ballin 2013a) includes a multitude of varieties, with the two largest groups being flint of the reddish-brown type and flint of a light-grey mottled type. The assemblage from the present site is composed roughly like the one from Nethermills Farm, but possibly dominated by light-grey mottled pieces. The assemblage from the Carmelite Friary in central Aberdeen (Ballin 2001) is composed roughly in the same manner, but with the addition of some olive-coloured pieces and many dark-grey flints with the latter being medieval and post medieval pieces based on ballast flint and shaped into fire-flints (to be struck by steel strike-a-lights) and expedient implements. The site of Garthdee Road, Aberdeen (Ballin 2016), from the area near the mouth of the Dee, was dominated by a light-brown variety of flint, with reddish-brown pieces being fairly rare. It seems that sites along the Don and the Dee and further south in Aberdeenshire may include less flint of the reddish-brown forms than those further north, with the border between the two groups of sites running immediately north of Aberdeen (including, inter alia, the Kingfisher site; Ballin 2008).

All these sites include numerous sub-types, such as cream, beige, and black pieces, and although most are fine-grained and pure, some pieces are medium-grained, and some are characterized by impurities, such as chalk balls, fossils, and micro-crystals, which generally lower the knapping properties of the nodules. However, the bulk of the flint recovered from sites in the Scottish north-east is of high quality, as is the flint from Site 3B.

The fine-grained light-grey mottled flint so common at the present site is, in terms of appearance and quality, similar to flint from the Yorkshire area in north-east England (Ballin 2011), and it flakes well. However, where imported Yorkshire flint usually includes some pieces with soft or soft-ish cortex, all the cortical flint from Site 3B have abraded cortex, suggesting that it was most likely collected at a local pebble source, such as the beaches of Aberdeenshire, where it was washed ashore from deposits in the North Sea (Harker 2002). Some pieces (eg, CAT 2, 295, 2033, 2252, 2466, 2469) are characterized by the presence of relatively thick, very soft chalk, but this almost certainly represents internal chalk balls, which were exposed when the nodules were split and flaked, and not external cortex. The abraded character of the cortex of the site's primary and secondary flakes and blades (Table 2) is also indicative of local procurement of pebble flint.

Table 2. Reduction sequence of all unmodified flakes and blades.

	n	%
Primary	35	4
Secondary	205	25
Tertiary	586	71
TOTAL	826	100

The size of the intact cores (below) suggests that the collected pebbles had greatest dimensions of c. 40-70mm, an impression supported by refitted burnt pebble CAT 2441-2 (six pieces) which measures 67mm across, and the largest crested blade CAT 2465, which has a length of 58mm.

As shown in Table 3, a total of 520 pieces (20%) have been exposed to fire, causing crazing, splitting and discolouration. Pit 005 had the highest ratio of burnt flints (44%), whereas Hollow 7 and the two pits towards the west (Pits 3 and 16) had the lowest ratios (12-21%). Ratios just slightly lower than that of Pit 5 were found in Pits 23, 25, and 31 north of Hollow 7 (30-37%). For interpretation of the distribution of the burnt pieces, see the report's distribution section. In the pits with more than one fill, the lowest levels had consistently the highest ratio of burnt pieces.

Table 3. Burnt pieces, distribution across features. Totals and numbers of burnt pieces have been adjusted according to sampling strategy: if a feature was sampled 50%, the numbers were doubled to show the estimated 100%, if the feature had been fully sampled)

	Context	Totals		Totals (adjusted)		Burnt n		Burnt n (adjusted)		Burnt %	
Hollow 3B-0007	NW 3B-0008	67	467	134	534	13	97	26	110	19	21
	SW 3B-0018	135		135		52		52		39	
	NE 3B-0019	185		185		23		23		12	
	SE 3B-0009	80		80		9		9		11	
Pit 3B-0029	[No finds]	0	0	0	0	0	0	0	0	NA	NA
Pit 3B-0003	Fill (3B-0004)	329	329	658	658	67	67	134	134	20	20

Pit 3B-0016	Fill (3B-0017)	1,198	1,198	1,198	1,198	145	145	145	145	12	12
Pit 3B-0023	Upper fill (3B- 0024)	68	125	340	411	15	46	75	114	22	37
	Basal fill (3B-0027)	57		71		31		39		54	
Pit 3B-0025	Unstrat.	6	129	6	393	4	39	4	101	NA	30
	Upper fill (3B-0026)	47		235		9		45		19	
	Basal fill (3B-0028)	76		152		26		52		34	
Pit 3B-0031	Upper fill (3B-0033)	57	190	114	380	15	68	30	136	26	36
	Middle fill (3B-0032)	132		264		53		106		40	
	Basal fill (3B-0034)	1		2		0		0		NA	
Pit 3B-0020	Upper fill (3B-0021)	28	88	56	176	8	29	16	58	29	33
	Basal fill (3B-0022)	60		120		21		42		35	
Pit 3B-0005	Fill (3B-0006)	64	64	128	128	28	28	56	56	44	44
	Unstrat.	1	1	1	1	1	1	1	1	NA	NA
TOTAL		2,591	2,591	3,879	3,879	520	520	855	855	20	20

Most of the site's indeterminate pieces (see debitage section) are burnt pieces (94%), which caused flakes and blades to shed their dorsal and ventral faces, and the indeterminate pieces from Site 3B are probably mostly flakes and blades which lost their ventral faces, making it impossible to identify them as flaked pieces.

Although the vast majority of the burnt pieces are likely to be pieces which were burnt accidentally (falling into the site's fireplace during production or use of flint tools), it cannot be ruled out that heat treatment of flint took place to make the most of the relatively small pebbles available in Aberdeen-shire. Two burnt flint pebbles were recovered from the basal parts of Pits 23 and 25 and it is unlikely that these pieces were carried all the way from the North Sea shores to the present site to be used as 'pot boilers' (possibly in wooden or bark containers) when pebbles and cobbles of quartzite would have been more suitable. These pieces may have been heated to temperatures higher than intended and they subsequently split (CAT 2440) or 'exploded' (CAT 2441-2), representing failed 'flint roasting'.

Thirteen pieces were characterized in the catalogue as having a notable sheen, but several others display a lighter sheen. It is a well-known fact that surfaces of heat-treated pieces tend to be relatively matt, but that fresh surfaces may be shiny (eg, Olausson & Larsson 1982; Griffiths et al. 1987; Eriksen 1997; Coles 2009, 2011). However, it cannot be ruled out that this sheen is patination or residue, and it is necessary to analyse this phenomenon in detail before it can be determined whether this effect is due to deliberate heat treatment. The 13 pieces include a number of flakes and blades, as well as one single-platform core (CAT 2432), one end-scraper (CAT 2467), and three microburins (CAT 2522, 2526, 2527), and they were recovered from different levels in Pits 16, 20, 23, 25 and 31.

Debitage

In total, 2,432 pieces of debitage were recovered from the site (Table 4). The debitage includes 1,553 chips, 15 flakes, 156 blades, 313 microblades, 48 indeterminate pieces, and five preparation flakes (all crested pieces). Compared to other early prehistoric assemblages from Scotland, the chip ratio is extremely high (c. 64%), which is likely to reflect the fact that consistent sieving was undertaken (for sampling strategy, see elsewhere in this volume), as well as the fact that exceptionally small chips were noticed and retrieved during the processing of the samples. As demonstrated in Ballin (1999), the chip ratio of sieved assemblages usually varies between c. 30% and 55%.

Table 4. Relative composition of the debitage.

	n	%
Chips	1,553	64
Flakes	357	15
Blades	156	6
Microblades	313	13
Indeterminate pieces	48	2
Preparation flakes	5	trace
Total debitage	2,432	100

Although large numbers of flakes were recovered from Site 3B (357 pieces), the debitage is dominated by blades and microblades, totalling 513 pieces. If the flakes and blades are considered blanks (even if some are failed, for example misshapen, blanks), with chips and indeterminate pieces obviously representing production waste, the blanks' flake:blade ratio is 41:59.

Figs 1-2. The dimensions of all intact blades and microblades from Site 3B and Garthdee Road, Aberdeenshire (Ballin 2016).

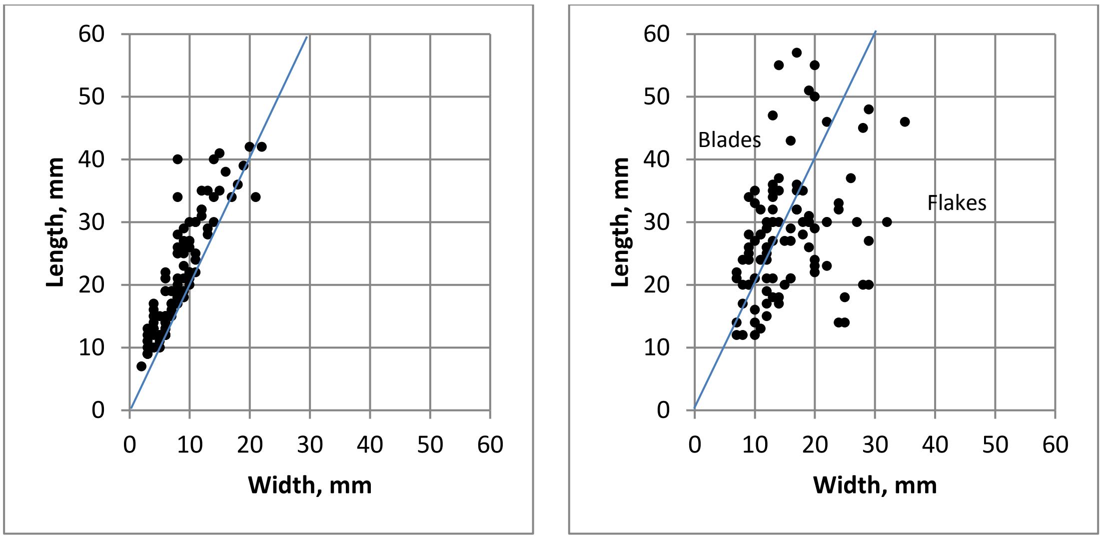


Fig. 1 shows the length:width of all intact blades and microblades from Site 3B, with blades/microblades having average dimensions of 19.8 x 7.6 x 2.7mm. The line running through the diagram defines the metric border between flakes and blades, and it is obvious (as indicated by the cluster's truncated nature) that, at Site 3B, metric blades and flakes formed a continuum, as for example at the Early Neolithic site Garthdee Road in Aberdeen (Fig. 2). The truncated nature of Fig. 1 is due to the fact that flakes were not measured during the cataloguing of the lithic finds from Site 3B (see methodology, above).

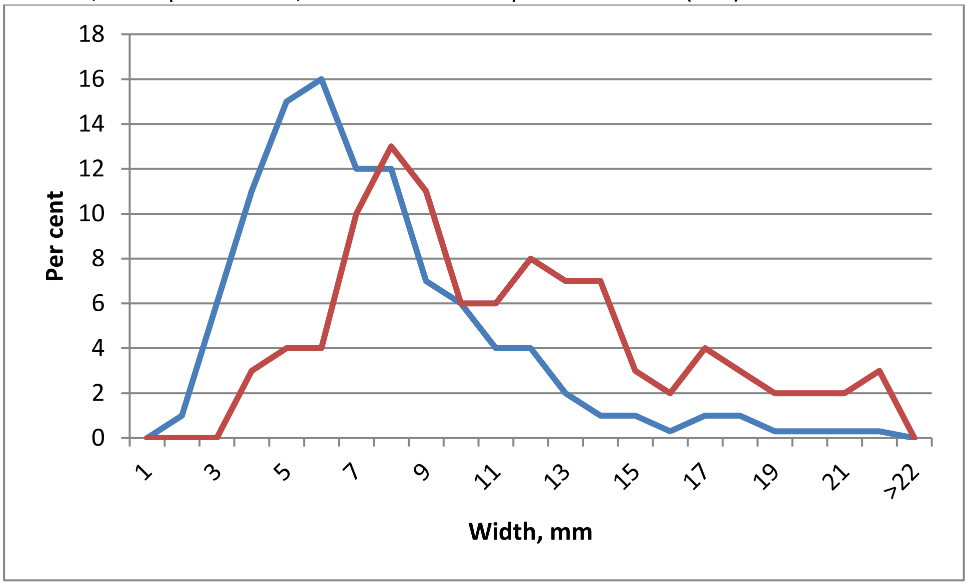
Table 5. Applied percussion techniques: definable unmodified flakes and blades.

	n	%
Soft percussion	321	68
Hard percussion	83	17
Indeterminate platform technique	21	4
Platform collapse	41	9
Bipolar technique	8	2
TOTAL	474	100

As shown in this report's technology section, the industry responsible for the Site 3B lithic assemblage is clearly a microblade industry, with microblades being this industry's main, or 'target', blanks. This is demonstrated by the highly regular appearance of most blades/microblades (av. L:W ratio 2.6, with some pieces having ratios of up to 6.5), and the squat nature of most flakes, as well as by the fact that 89% of all blades/microblades were detached by the application of soft percussion, whereas only 40% of the flakes were detached by soft percussion. The site's general soft percussion ratio is 68%, and – as at the slightly later Garthdee Road site – bipolar products are all but absent (Table 5).

The fact that the flakes are mostly waste from the decortication of nodules (although some of these pieces were used as blanks for scrapers), whereas the blades are the intended products of the reduction process, should have resulted in two more distinct diagrammatical groups. The fact that the difference between the two groups is not more distinct, may largely be due to prehistoric 'production errors', with some intended blades turning out shorter than planned. Most soft percussion flakes from Site 3B have regular, parallel dorsal arrises and parallel lateral sides, and they could be defined as failed blanks.

Fig. 3. The width of all unmodified blades and microblades from Site 3B (blue) and the width of all cortical, hard percussion, crested and overpassed blades (red).



In Fig. 3, the width of all Site 3B's intact blades and microblades are indicated by the diagram's blue curve. This curve is fairly neat (a statistically 'normal', or bell-shaped, distribution), indicating that the location's blades may represent a single visit to the site, or at least represent one relatively narrow chronological period. It does, however, have a fairly long 'tail' towards the diagram's left side of broad blades. It was thought that these pieces could be larger specimens produced at the beginning of the site's operational schema (see technology section) by the application of more robust approaches, and to test this, all cortical, hard percussion, crested and overpassed blades were measured separately, forming Fig. 3's red curve. Fig. 1's small group of large very broad blades (centred at 40 x 20mm) are all overpassed blades which expanded towards the pieces' distal ends and removed the parent cores' apices.

Summing up, comparison of Fig. 3's red and blue curves suggest that the site's broad blades are generally a form of preparation blades, and the narrower ones are intentional 'target' blanks. The former pieces have widths of c. 7-22mm, and the latter c. 3-11mm.

Table 6. Blades and microblades, distribution across features. The various numbers have been adjusted according to sampling strategy (see Table 3 caption).

		Excavated pieces			Adjusted		
		Microbl.	Blades	Total	Microbl.	Blades	Total
Hollow 3B-0007	NW (3B-0008)	10	7	17	20	14	34
	SW (3B-0018)	21	5	26	21	5	26
	NE (3B-0019)	33	12	45	33	12	45
	SE (3B-0009)	14	6	20	14	6	20
Pit 3B-0029	[No finds]	0	0	0	0	0	0
Pit 3B-0003	Fill (3B-0004)	38	12	50	38	12	50
Pit 3B-0016	Fill (3B-0017)	120	57	177	120	57	177
Pit 3B-0023	Upper (3B-0024)	7	6	13	35	30	65
	Basal (3B-0027)	8	4	12	10	5	15
Pit 3B-0025	Unstrat.	0	1	1	0	1	1
	Upper (3B-0026)	8	5	13	40	25	65

	Basal (3B-0028)	12	8	20	24	16	40
Pit 3B-0031	Upper (3B-0033)	10	5	15	20	10	30
	Middle (3B-0032)	19	9	28	38	18	56
	Basal (3B-0034)	0	0	0	0	0	0
Pit 3B-0020	Upper (3B-0021)	2	7	9	4	14	18
	Basal (3B-0022)	6	8	14	12	16	28
Pit 3B-0005	Fill (3B-0006)	4	5	9	8	10	18
TOTAL		312	157	469	437	251	688

Table 6 shows the distribution of microblades across the site, and apart from Pits 5, 20 and 29 towards the south-west. Hollow 7 and the remaining pits (particularly Pit 16) all contained notable numbers of blades, and with few exceptions the blade:microblade ratio is the same – roughly 1:2 or 1:3. For a more detailed discussion of the site's distribution patterns, see the report's distribution section.

As defined above, indeterminate pieces are lithic bits of debitage which cannot be unequivocally identified as either flakes/flake fragments or cores/core fragments. The key point is the lack on these pieces of a ventral face, whether whole or partial, and traditionally these pieces have been called 'chunks'. However, this is quite a misnomer, as the indeterminate pieces found in flint assemblages may mostly be flake and blades which have disintegrated due to thermal exposure, such as frost or fire., and which subsequently shed one or both main faces. If for example a flake fragment fell into a hearth and shed its ventral face, it would not be possible to determine its original nature, and it this rather flat piece would have to be referred to as an indeterminate (but most certainly not 'chunky) piece. At Site 3B, 48 pieces were defined as indeterminate pieces, and 94% of these mostly flat pieces are fire-crazed.

Only five crested pieces were recovered from the site, and no core rejuvenation flakes. Three of the crested pieces are broad (CAT 2462, 2465, 2470) and probably relate to the initial preparation of cores, whereas two (CAT 2459, 2468) are narrow, most likely relating to core adjustment during the reduction process.

Cores

In total, 21 cores were recovered during the excavation at Site 3B. They include the following core types: two split pebbles, two core rough-outs, 16 single-platform cores, and one core with two platforms at an angle.

The dimensions (L x W x T) of cores are measured in the following ways: in the case of platform cores, the length is measured from platform to apex, the width is measured perpendicular to the length with the main flaking-front orientated towards the analyst, and the thickness is measured from flaking-front to the often unworked/cortical 'back-side' of the core. In the case of bipolar cores, the length is measured from terminal to terminal, the width is measured perpendicular to the length with one of the two flaking-fronts orientated towards the analyst, and the thickness is measured from flaking-front to flaking-front. More 'cubic' cores, like cores with two platforms at an angle and irregular cores, are simply measured in the following manner: largest dim. by second-largest dim. by smallest dim.

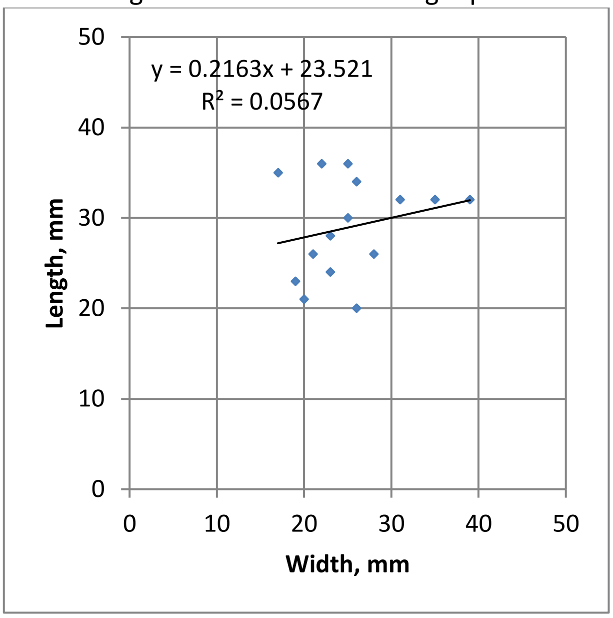
Split pebbles: Two split pebbles were recovered from Site 3B, namely CAT 2440 and CAT 2441-2. They both split as a result of exposure to fire, and are, strictly speaking, not artefacts but 'anthropogenically affected' pieces. CAT 2440 is one half of a pebble which split along the pebble's long axis, whereas CAT 2441-2 is an 'exploded' core, which disintegrated into several irregular angular bits. It was possible to re-establish most of the original pebble by conjoining five fragments – three from the basal layer of

Pit 23 and two from the basal layer of Pit 25. Split pebble CAT 2440 was also recovered from the basal layer of Pit 23. The original pebbles would have had sizes of c. 50-70mm. The surviving fragments are all crazed, dried out and discoloured (pink), and their abraded cortex display scorched, blackened areas. It is possible that it was attempted to improve the flaking properties of the two pebbles by heat-treating them (eg, Olausson & Larsson 1982; Eriksen 1997), but instead they were 'over-roasted' (as indicated by the scorch-marks) and they disintegrated.

Core rough-outs: The assemblage includes two core rough-outs (CAT 2428, 2445) of approximately the same general size (GD = 31-36mm). CAT 2428 had one end removed to form a striking platform, and attempts were made to detach flakes or blades from the edge of one broadside. A corner of the platform broke off, and the surface of this fracture is distinctly 'greasy' looking, indicating that this piece may have been heat-treated. CAT 2445 was split along its long axis, and the surface of the irregular surface produced in this manner was subsequently used as a striking platform. It was attempted to detach flakes or blades from the narrow end of the platform. In both cases, cresting was not carried out, and no proper blanks were produced. The two rough-outs were subsequently discarded.

CAT 2428 has peck-marks at its apex, and it was clearly used as a small hammerstone or percussoir at some stage. However, it is not possible to determine whether it was used this way before it was attempted to transform the original pebble into a core, or after abandonment of the core rough-out. CAT 2428 was part of the same pebble as conical core CAT 2445 (see below).

Fig. 4. The length:width of all intact single-platform cores.



Single-platform cores: This category dominates the site's cores (76%), with most pieces being highly regular (av. dim.: 29 x 25 x 21mm). Although some small flakes were occasionally detached from these cores, particularly in the later stages of their 'lives', they were clearly intended for the production of microblades and, subsequently, microliths (see below). Fifteen of the 16 single-platform cores have been defined as regular conical specimens, whereas one (CAT 2444) is an irregular flat piece.

The examination and characterization of the conical cores produced a number of interesting details in terms of the initial shaping and reduction of these pieces. It was possible to refit conical core CAT 2448 with rough-out CAT 2445, platform-to-platform, re-establishing most of the original pebble (L = 61mm) (both from Pit 31, middle and upper fill, respectively). It was probably common practice to split pebbles into two halves and then to transform these halves into two single-platform cores, with the contact surfaces becoming the cores' striking platforms. No cores have any remaining whole or partial crests, suggesting that cresting may not have been commonly practiced at Site 3B (as also indicated by the two rough-outs). However, the cores' apices were carefully shaped when needed (CAT 2429, 2434, 2444, 2446), although left cortical when the apices were naturally regular (most cores). Platform-edge trimming was carried out, probably before any attempt to detach a microblade, or a series of microblades. In most cases (10 pieces), the cores' 'back-sides' were left cortical.

Three cores have what appears to be slightly scorched cortical surfaces (CAT 2433, 2435, 2438), but it is not possible to determine whether this relate to heat treatment or secondary firing ('falling into the hearth'). CAT 2433 is crazed, suggesting that in this case the scorching may be due to secondary firing. Six of the site's conical cores are crazed and have clearly been burnt. Due to internal impurities, this caused CAT 2436 to split diagonally into two refitting halves. CAT 2430 represents six conjoined parts of one burnt 'exploded' conical core.

Although some of the smallest conical cores have clearly been exhausted completely, many seem to have been abandoned due to the development of deep step or hinge fractures (eg, CAT 2432), whereas series of circular impact scars on some cores' platforms (CAT 2437, 2448) are evidence of robust (hard-hammer) attempts to rejuvenate the cores by detaching entire flaking-fronts. These efforts were clearly unsuccessful, probably due to these particular cores being too dense (possibly a reason for heat treatment?).

Cores with two platforms at an angle: One core with two platforms at an angle was recovered from the site (CAT 2439). This core is a fairly large piece (compared to the location's single-platform cores), and it measures 42 x 40 x 37mm.The parent pebble was not split, but a primary flake was detached to form the first striking platform. Due to the presence of numerous internal impurities (chalk balls and fossils), this piece did not flake well, and the first platform and flaking front were abandoned. The old flaking-front was transformed into a new striking platform, but, again, no acceptable blanks were produced, and the core was subsequently abandoned.

Table 7. Cores, distribution across features. The totals have been adjusted according to sampling strategy (see Table 3 caption).

		Split+ roughs	Single-platf.	Others	Total	Total, adjusted
Hollow 3B-0007	NW (3B-0008)	1	1		2	4
	SW (3B-0018)					
	NE (3B-0019)					
	SE (3B-0009)		1		1	1
Pit 3B-0029	[No finds]					
Pit 3B-0003	Fill (3B-0004)					
Pit 3B-0016	Fill (3B-0017)		4		4	4
Pit 3B-0023	Upper (3B-0024)		2		2	10
	Basal (3B-0027)	1	3	1	5	8
Pit 3B-0025	Unstrat.					
	Upper (3B-0026)					
	Basal (3B-0028)	1			1	4
Pit 3B-0031	Upper (3B-0033)		3		3	8
	Middle (3B-0032)	1	2		3	6
	Basal (3B-0034)					

Pit 3B-0020	Upper (3B-0021)					
	Basal (3B-0022)					
Pit 3B-0005	Fill (3B-0006)					
TOTAL		4	16	1	21	45

Table 7 shows the distribution of cores across the site, and cores were retrieved from all pits apart from Pits 3, 5, 20 and 29 towards the south-west. Hollow 7 and the remaining pits all contained several cores, with refitting bits of one split pebble (CAT 2441-2) having been found in the basal layers of the two adjacent features Pit 23 and Pit 25. For a more detailed discussion of the site's distribution patterns, see the report's distribution section.

TOOLS

The 138 tools (Table 1) include a small number of separate implement categories, such as 63 microliths and microlith-related implements (46%), 59 microburins (43%), six scrapers (4%), three truncated pieces (2%), and seven pieces with edge-retouch (5%). With approximately nine of ten implements belonging to the category 'microliths and microlith-related implements', this formal group clearly dominate the tools.

Microliths and 'microlith-related implements': This category embraces a number of formal types, including two microlith preforms, nine scalene triangles, three crescents, three edge-blunted microliths, five backed bladelets, 35 fragments, and six so-called Krukowski microburins (which may or may not be microburins; see below).
In the archaeological literature, the term microlith is defined in a number of different ways, adding some confusion to the discussion of the category and its dating. In the present report, 'microlith' is defined as in the analyst's previous reports on early prehistoric assemblages (eg, Ballin et al. 2010):

Microliths are small lithic implements manufactured to form part of composite tools, either as tips or as edges/barbs, and which conform to a restricted number of well-known forms, which have had their (usually) proximal ends removed (Clark 1934, 55). This definition secures the microlith as a diagnostic (pre Neolithic) type. Below, microliths sensu stricto (ie, pieces which have had their usually proximal ends removed) and backed microblades (with surviving proximal ends) are treated as a group, as these types are thought to have had the same general function.

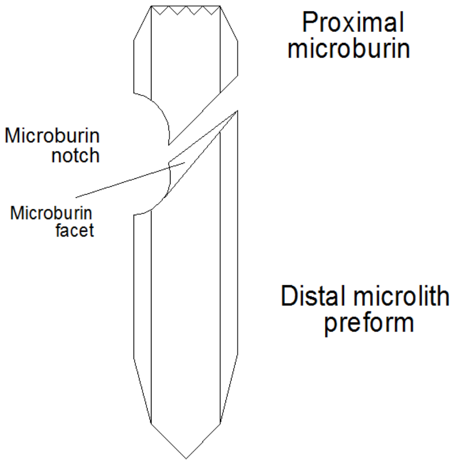
It has been attempted to keep the microlith typology basic, and in Table 1, only general formal types are included (cf. Saville 1981). The most frequently used microlith typologies, such as those of Clark (1934) and Jacobi (1978), include numerous sub-types, characterized by various forms of fine ancillary edge-retouch (also see Butler 2005). It is, however, the analyst's view that most of these forms of additional modification represent the finer shaping of the pieces, determined by the specific original shape of the individual microlith blanks, and that this fine retouch has little relevance to the understanding of the category, the assemblage or the site. The main formal types, on the other hand, may generally represent mental templates of the flint-knapper, and they are usually more or less diagnostic.

The orientation (and subsequently the use of terms like 'left' and 'right') of the microliths and microlith-related implements follow general consensus relating to the analysis of these pieces, although it would have been easier if it had been decided by the lithics specialist community to follow the practice adhered to when orientating other lithic artefacts, that is, with the bulbar end down.

A microlith is generally orientated with its tip up, and, as a microlith is defined as having been produced by removing its proximal end to form its tip, this usually means with the proximal end up.

A microlith fragment (or a fragment assumed to have formed part of a microlith) is generally orientated with the proximal end up, as it is assumed that it is most likely to have had its tip at this end.
A 'fragment of a microlith or backed bladelet' is orientated in the same way, as these pieces are more likely to have been microliths than backed bladelets. At the present site, the ratio microliths/microlith fragments:backed bladelets is 80:20.
A backed bladelet is orientated with its distal end up, as this end is supposed to have formed its tip.
A microburin is orientated with its proximal end up, to fit the consensus regarding the orientation of a microlith.
For the same reason, a microlith preform is orientated with its proximal end up.

Fig. 5. 'Standard' approach for the production of a microlith by microburin technique. A scalene triangle, for example, would be shaped by modifying the shortest lateral side of the distal part (in this case the left hand side) and parts of the oblique proximal facet.



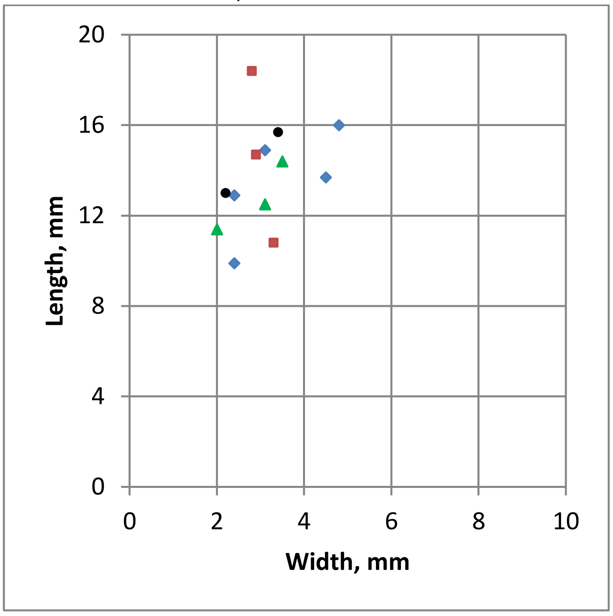
Microlith preforms: The definition of the site's microlith preforms is based on an understanding of how microliths were manufactured (the 'standard' approach is shown in Fig. 5), more specifically, how the proximal, and occasionally distal, ends were removed to produce the microliths. An illustration in Inizan et al. (1992, Fig. 24.10) shows how it is possible to produce several microliths from one long blade, but the evidence from Site 3B suggests that, at this site, only one microlith was produced from each blade or microblade blank (cf. Albarello 1987).

Generally, the purpose of the microburin technique was to create a microlith preform, which had at its end an acutely pointed tip, a so-called piquant triédre, '… [with] a sharp extremity [which] cannot be obtained by simple retouch' (de Wilde & de Bie 2011, 730). The presence of a sharp microburin facet which forms a linear extension of a segment of a microburin notch usually defines a microlith preform (Fig. 5; also see Clark 1934, Fig. 6). The microburin itself is defined by a small angular spur, formed by the meeting of a microburin facet and a segment of a microburin notch (Clark 1934, 67).

The evidence from Site 3B suggests that microliths were predominantly produced in two ways, namely 1) by producing a lateral notch and then breaking the microblade blank in the notch to create a microlith preform; or 2) by producing a usually shouldered linear retouch along one lateral side and then breaking the microblade blank towards the (most commonly) proximal end of the piece. As shouldered points are a specific Upper Palaeolithic implement form, it has been chosen (to avoid confusion) to refer to the latter shouldered preforms by their original French name, lamelles a cran.

Two microlith preforms were recovered during the excavation, namely CAT 2471 and CAT 2525. The former is a microblade with a distal lateral notch (11.2 x 5.7 x 2.1mm), whereas the latter is a so-called lamelle a cran, that is, a narrow blade with a shouldered retouch along its left lateral side (16.3 x 8.1 x 2.6mm).

Fig. 6. The main dimensions of the site's microliths and backed bladelets: blue = scalene triangles; red = crescents; green = edge-blunted microliths; and black = backed bladelets.



Scalene triangles: The scalene triangles, crescents and edge-blunted microliths are all defined by their blank forms and dimensions as later Mesolithic pieces, and their main dimensions are shown in Fig. 6. The nine scalene triangles measure on average 13.5 x 3.4 x 1.9mm, varying in length between 9.9mm and 16.0mm. Generally, the shortest retouched side is proximal, but in one case this side is distal (CAT 2556). Consequently, eight pieces have their two retouched short legs orientated towards the left, and one towards the right. Three of the scalene triangles have ancillary retouch of their longest side (CAT 2534, 2538, 2590), and in two cases the original piquant triédre is identifiable, although in slightly modified form.

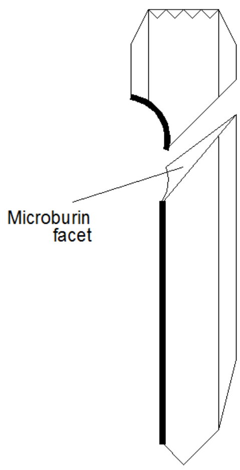
Crescents: As some edge-blunted microliths do have slightly convex lateral modifications, it was decided to define the crescents as microliths with highly regular curvatures, where it is obvious that the knapper deliberately aimed at producing this geometric shape (ie, that we are talking about a mental template rather than random morphology). The assemblage includes three crescentic microliths, which are all highly regular pieces. These pieces have average dimensions of 14.6 x 3.0 x 1.5mm (Fig. 6), varying in length between 10.8mm and 18.4mm. The crescents all have their left lateral side blunted. CAT 2586 has ancillary retouch of the cutting-edge. Its left lateral side was modified by the application of sur enclume retouch, that is, abrupt backing on an anvil (Burdukiewicz 2016).

Edge-blunted microliths: This category embraces three pieces. They are generally characterized by having one fully blunted lateral side, but where this retouch did not transform the blanks into geometric forms. This retouch may be straight, slightly curved or undulating. At Site 3B, these pieces form a continuum with the backed bladelets, but where this category is defined as microliths due to the removal of the proximal ends, backed bladelets have retained their bulbar areas. The fact that edge-blunted microlith CAT 2591 had its bulb of percussion removed by retouch diagonally through the bulbar are, rather than by microburin technique, also indicate that edge-blunted microliths and backed bladelets form a continuum, in contrast to for example at Nethermills Farm, near Banchory, where nine of 30 edge-blunted microliths had surviving microburin facets at their proximal ends, usually adjusted by very fine retouch (Ballin 2013a). The intact edge-blunted microliths measure on average 12.8 x 2.9 x 1.1mm (Fig. 6), varying in length between 11.4mm and 14.4mm. They all have their retouched lateral side towards the left, and CAT 2588 and CAT 2591 have ancillary retouch of the cutting-edge.

Backed bladelets: With one lateral side blunted, the five backed bladelets are probably functionally related to the edge-blunted microliths. However, where the latter have had their proximal ends removed by microburin technique, the backed bladelets display intact proximal ends. They measure on average 14.4 x 2.8 x 1.4mm, varying in length between 13.0mm and 15.7mm (Fig. 6). The pieces are roughly equally distributed across backed bladelets with the blunted edge orientated towards the left (three) and towards the right (two). CAT 2563 has additional fine retouch of the cutting-edge, whereas CAT 2541 has additional basal retouch at the proximal end.

Fragments of microliths and microlith-related implements: These edge-modified fragments were subdivided into two groups, namely 1) fragments of microliths, and 2) fragments of microliths or backed bladelets. Proximal fragments which had clearly had their bulbar ends removed, but which could not be formally defined as belonging to one or the other specific microlith type, were referred to the former category, whereas medial and distal fragments, which would not allow the character of their proximal ends to be defined, were referred to the latter category. In total, six fragments of microliths were recovered, and 29 fragments of microliths or backed bladelets. The pieces included in these two categories have an average width of 3.3mm; 26 of these fragments have a retouched left lateral side, seven have a retouched right lateral side, and two have bilateral retouch.

Fig. 7. The distal part of this microblade (with the microburin facet) is the most common form of Krukowski 'microburin'. The dark line represents the retouch of the piece. In this case, the Krukowski piece was produced by breaking a lamelle a cran, leaving a typical proximal microburin as a waste product.



Krukowski 'microburins' (Krukowski 1914): These objects are defined as parts of microblades (proximal or distal) with a surviving unmodified microburin facet at one end. Distal Krukowski pieces are the most common ones (Fig. 7; also see Inizan et al. 1992, Fig. 24.5-6). In some cases (eg, Bille Henriksen 1976, Fig. 75.35), the microburin facet is orientated differently in relation to the long retouched edge – where a 'standard' Krukowski piece has an obtuse angle where the retouched edge and the microburin facet meet, other pieces may be characterized by an acute angle at this point.

Basically, the term is a misnomer, and these pieces are not microburins. On a true microburin, the remains of the microburin notch and the microburin facet form a spur roughly one-third or one-half of the microblade width in from one lateral side, where the microburin facet of a Krukowski piece is unbroken, running from one lateral side to the other, as it does on true microliths.

A number of interpretations of the Krukowski pieces have been offered:

They are actual microburins (Vardi & Gilead 2010, 131).
They represent production failures, that is, microliths which broke during modification of a lateral edge (de Wilde & de Bie 2011, 730).
Or, they are microliths, or preforms of microliths, with unmodified piquant triédre facets, and in the case of the most typical form of Krukowski microliths these pieces have a scalene triangular outline (the interpretation favoured by this analyst). Fig. 7 (redrawn from Inizan et al. 1992, Fig. 24.6) shows how a Krukowski microlith was formed by breaking a lamelle a cran.

In terms of the Krukowski pieces from Site 3B, two (CAT 2544, 2592) have a scalene outline, and may be pieces used as microliths without further adjustment of the microburin facet. Two (CAT 2573, 2592) have additional retouch of the lateral side opposite the modified edge, which also supports the interpretation of the Krukowski pieces from Site 3B as microliths, rather than waste products or production failures. In the bigger picture – that is, going beyond the present site – it is quite likely that the group includes waste material as well as production failures, and each case (assemblage) should be considered on its own merits.

It is recommended to refer to the group as 'Krukowski pieces' rather than 'Krukowski microburins', as it is highly likely that the group includes few or no actual microburins. Five of these pieces have their left side retouched and one the right side. If Krukowski pieces are considered microliths, microliths and their fragments are distributed across left and right variants in the following manner@ LHS 83%, RHS 14%, and bilateral retouch 3%.

Fig. 8. The width of all microliths and microlith-related implements, incl. frags (blue) and all microburins (red; see below).

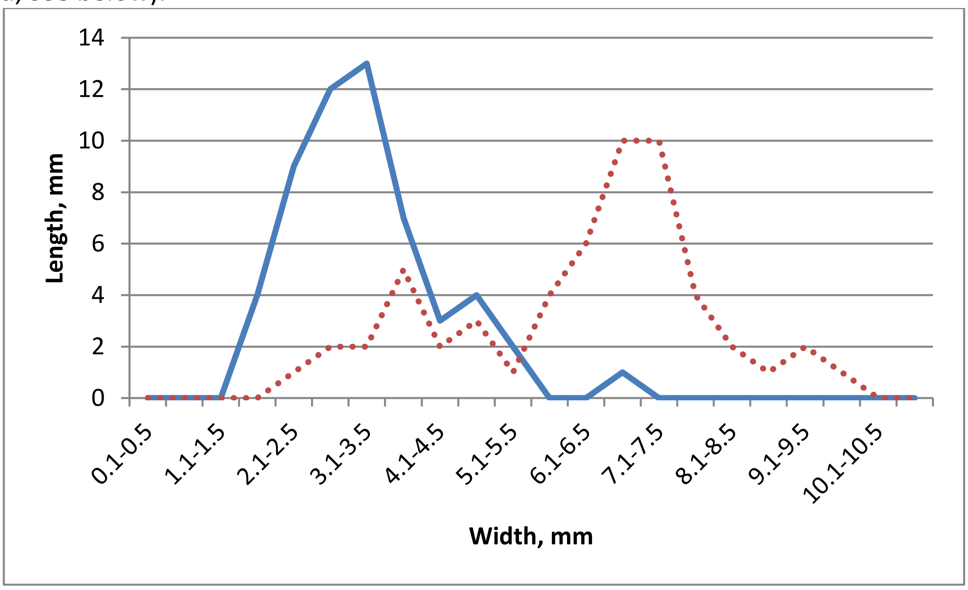


Fig. 8 shows the width of all microliths and microburins, the microliths and the microburins differ considerably in terms of width. This difference is probably mainly due to the fact that, during the lateral modification of microliths, up to half of the width of the original microblade blank was removed, whereas the widths of the microburins is in most cases identical to the width of the original blank (also see microburin section).

Table 8. Microliths, distribution across features. The totals have been adjusted according to sampling strategy (see Table 3 caption).

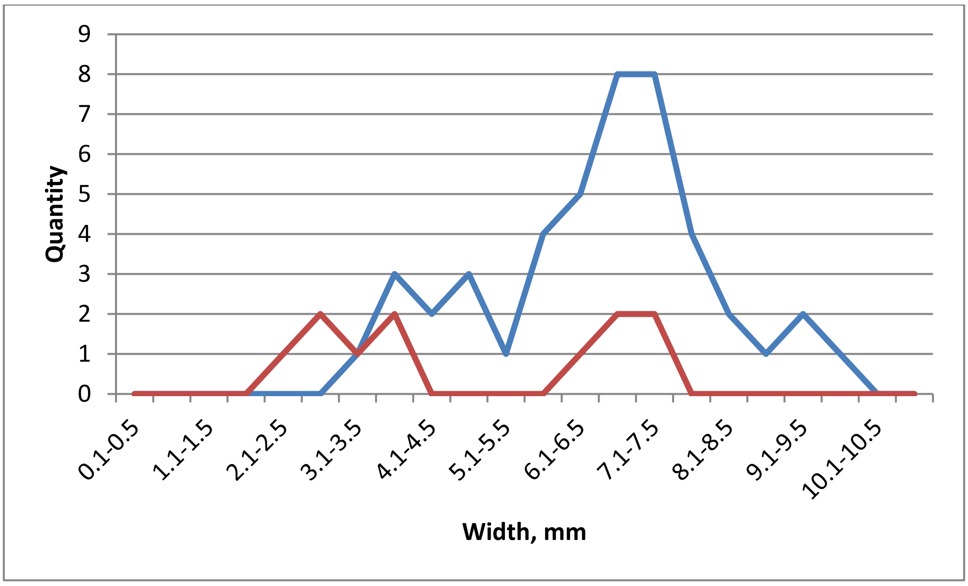
		Pre-forms	Scalene	Crescents	Edge-blunted	Backed bladelets	Frags	Krukow-skis	Total	Total, adjusted
Hollow 3B-0007	NW (3B-0008)									
	SW (3B-0018)		1			1	4	1	7	7
	NE (3B-0019)		1			1	7	1	10	10
	SE (3B-0009)		1				3		4	4
Pit 3B-0029	[No finds]									
Pit 3B-0003	Fill (3B-0004)					1	1		2	4
Pit 3B-0016	Fill (3B-0017)		2	2		2	13	1	20	20
Pit 3B-0023	Upper (3B-0024)		1				2	2	5	25
	Basal (3B-0027)									
Pit 3B-0025	Unstrat.									
	Upper (3B-0026)	1					1		2	10
	Basal (3B-0028)			1	2		1		4	8
Pit 3B-0031	Upper (3B-0033)	1							1	2
	Middle (3B-0032)		1		1			1	3	6
	Basal (3B-0034)									
Pit 3B-0020	Upper (3B-0021)									
	Basal (3B-0022)						2		2	4

Pit 3B-0005	Fill (3B-0006)		2				1		3	6
TOTAL		2	9	3	3	5	35	6	63	106

Table 8 shows the distribution of microliths across features. Most microliths were recovered from Hollow 7 and the adjacent features, Pits 16, 23 and 25.

Microburins: Microburins are the waste products from the production of microliths by microburin technique (Fig. 5). Most are proximal, some are distal (Clark 1934, 67), and, in microlith-producing industries characterized by the production of exceptionally long and slender blades/microblades, medial microburins were also produced (Inizan et al. 1992, Fig. 24.10). At Site 3B, the blade and microblade blanks only produced one microlith each.

Fig. 9. The width of all microburins from Site 3B.



At the present site, 59 microburins were recovered. A total of two fragments could not be characterized in detail, but of the remaining 57 pieces, 46 (81%) are proximal and 11 (19%) distal. As shown in Fig. 9, the proximal forms are slightly broader than the distal forms, which is a function of the generally tapering shape of most blades/microblades. The average width of the proximal microburins is 6.6mm, and that of the distal pieces 4.9mm.

However, Fig. 9 also indicates that the microburins include two sub-groups, and the proximal, as well as the distal specimens include a narrow group (peak c. 3.1-4.5mm) and a broad group (peak c. 7.1-7.5mm). This split may indicate either the production of two functionally different groups of microliths, or a minimum of two visits to the site (see discussion and interpretation below). Interestingly, the microliths form a statistically 'normal', bell-shaped curve (Fig. 8), rather than a dual-peaked one.

Table 9. Microburins, distribution across features. The totals have been adjusted according to sampling strategy (see Table 3 caption).

					Prox.		Distal							
		Prox.	Unc.	Distal	LHS	RHS	LHS	RHS	Facet	Snap	LaC	Burnt	Total	Total, adjusted
Hollow 3B-0007	NW (3B-0008)													
	SW (3B-0018)	5		3	5			3	7	1			8	8
	NE (3B-0019)	12	1	5	12		1	5	16	2	1	1	19	19
	SE (3B-0009)	6		1	6			1	6	1	1	2	7	7
Pit 3B-0029	[No finds]													
Pit 3B-0003	Fill (3B-0004)	6	1		6				7				7	14
Pit 3B-0016	Fill (3B-0017)	5		1	5			1	5	1	2		6	6
Pit 3B-0023	Upper (3B-0024)	2			2				1	1	1	1	2	10
	Basal (3B-0027)	1			1				1			1	1	1
Pit 3B-0025	Unstrat.													
	Upper (3B-0026)	1			1				1				1	5
	Basal (3B-0028)	1			1					1	1		1	2
Pit 3B-0031	Upper (3B-0033)													
	Middle (3B-0032)	3			3				1	2			3	6
	Basal (3B-0034)													
Pit 3B-0020	Upper (3B-0021)	2			2				1	1	1		2	4
	Basal (3B-0022)	2			2				1	1	1		2	4

Pit 3B-0005	Fill (3B-0006)													
TOTAL		46	2	10	46	0	1	10	47	11	8	5	59	86

Table 9 shows the distribution of microburins across features. Most microburins were mainly recovered from Hollow 7 and Pits 3 and 23 but only small numbers were retrieved from Pit 16, which held relatively large numbers of microliths. Interestingly, all proximal microburins have the microburin notch in the left-hand side, whereas all distal specimens (bar one) have the notch in the right-hand side. This would usually be considered indicative of the work of one knapper with one set of motoric habits; in contrast, the microliths include 83% LHS variants, 14% RHS variants and 3% with bilateral retouch, which would be more in tune with the composition of a 'normal' human population with most people being right-handed, and a proportion left-handed (cf. Andersen's [1982] discussion of right- and left-handedness amongst people in the Danish Maglemosian). This is discussed further below.

Scrapers: Only six scrapers were recovered from the site, namely five short end-scrapers and one end-/side-scraper.

Two of the end-scrapers (CAT 2452, 2461) are fairly large pieces, with CAT 2452 being the detached proximal working-edge of an oval scraper (GD 37mm), and CAT 2461 is an intact oval scraper with a distal working-edge (35 x 30 x 12mm). CAT 2466 and CAT 2469 are two almost identical, elongated, expedient pieces with slightly irregular scraper-edges (av. dim.: 36 x 23 x 17mm); the former has a dorsal crest. They are based on a dense, medium-grained form of flint, characterized by large inclusions of very soft chalk, and although they do not conjoin directly, they were almost certainly struck from the same pebble. CAT 2466 was recovered from the basal fill of Pit 23, and CAT 2469 from the middle fill of Pit 31, separated by Pit 25. CAT 2467 is a small specimen (GD 23mm), and it has its scraper-edge at the proximal end. The scraper-edge is damaged, and the unmodified distal end also displays use-wear from having been used for scraping. This piece has a notable sheen. All end-scrapers are based on either primary or secondary, hard percussion waste flakes, and they all have convex, steep scraper-edges.

End-/side-scraper CAT 2451 is based on a fairly small bipolar flake (20 x 17 x 7mm), and it has two straight to slightly convex, steep working-edges – one at the distal end, and one along the left lateral side. Three of the scrapers have been burnt (CAT 2451, 2452, 2469) and three are clearly used specimens (CAT 2451, 2452, 2467).

Truncated pieces: All three truncated pieces appear to be expedient implements, and their modification is generally very fine. CAT 2453 has a concave truncation, whereas the truncation of CAT 2454 is oblique, and that of CAT 2458 straight. The blanks are either small flakes (CAT 2458 has a GD of 12mm) or small blades (CAT 2454 measures 19 x 8 x 4mm), and these pieces are most likely small knives, where one edge was rubbed slightly to blunt it and protect the user's fingers.

Pieces with edge-retouch: Seven lithic artefacts display various forms of lateral modification. Three are based on flakes, two are blades, one is a microblade, and the blank of one is indeterminate. These pieces differ considerably in shape and size (GD 12-34mm), and it is thought that this tool group includes artefacts, or fragments of artefacts, with different functions. The modification of CAT 2457 may be hafting retouch, and CAT 2449 and CAT 2450 may be broken off scraper-edges.

TECHNOLOGICAL SUMMARY

This technological summary is based on information presented in the raw material, debitage, core and tool sections above. Generally, the assemblage appears very homogeneous, and this, in conjunction with the fact that the finds were recovered from a small number of closely situated features, with refits between those features, suggests that the flints were left at the location within a short space of time, and most likely by the same group of people (see distribution and dating sections).

Procurement: The recovery of unworked, but burnt, pebbles, and the character and size of various cores, crested pieces and blades, indicate that raw flint was procured in pebble form, most likely from the nearby North Sea shores, c. 12km from the coast and several kilometres from the River Don which may have functioned as the area's main transport route along which the pebbles must have been brought. The abraded character of the flints' cortex, as well as the curvature of the outer surfaces, support the suggestion that flint pebbles were collected at a secondary source, as well as the proposed size of these nodules (40-70mm).

Opening: The shape of the cores, and the nature of the cores' mostly plain surfaces, make it likely that, instead of creating a platform by detaching a primary 'opening flake', the nodules were opened by simply splitting them across. This is supported by a number of factors, such as the shape and character of the cores and their platforms, but first and foremost by the fact that it has been possible to conjoin two cores platform-to-platform, re-establishing most of the original pebble. Combined, core rough-out CAT 2428 and single-platform core CAT 2448 form a pebble with a length of 61mm. This approach made it unnecessary to shape or adjust platforms, as the splitting of a pebble created two core preforms with immediately usable striking platforms.

Heat treatment?: A number of factors makes it possible that heat treatment was carried out at the location, possibly in one or more shallow pits nearby (Olausson & Larsson 1982; Griffiths et al. 1987; Eriksen 1997; Coles 2009, 2011). The two burnt and split/exploded pebbles recovered from Pits 23 and Pit 25 may be 'roasted' nodules which were over-heated and subsequently disintegrated. It is unlikely that the settlers at Site 3B would transport pebbles up the Don, and then over land to the site, to use them as 'pot boilers' (for example in vessels of organic matters, like wood or bark), when erratic nodules of quartzite would have been better and more durable. It is also interesting to note that many cores and flakes have shiny surfaces, which is usually considered an indicator of heat treatment (ibid.). However, these shiny, 'greasy-looking' pieces should be tested scientifically, as these surfaces could have been affected by other factors, or the shiny appearances could be due to residue rather than surface alteration. The main argument for the use of heat treatment is that this approach would allow more blades and microblades to be detached from the small flint pebbles available to the settlers (pers. comm. Mike Cook, distinguished American knapper).

Core preparation: The cores generally seem to have received little or no core preparation before the initiation of blank production, as shown by the two core rough-outs CAT 2428 and CAT 2445. In both cases, blank production started with trimming of the platform-edges but without forming any crests (guide ridges), and in both cases the rough-outs were abandoned shortly after commencement of production, as the cores did not perform as the knapper(s) had hoped. A number of crests were recovered during the excavation, but they all appear to be crests created during the reduction process to adjust core shape between blade series rather than to prepare the early-stage cores. No platform rejuvenation was carried out, as indicated by the character of the platforms and the absence of core tablets. This is probably largely a function of the small size of the nodules and the cores.

Blank production: Two sets of blanks were produced, namely squat, mainly hard-hammer flakes (357 pieces) and elongated regular soft-hammer blades/microblades (469). Most likely, some hard-hammer flakes are waste from the decortication of the cores, although some may be blanks (for example for scrapers) produced on cores which were subsequently 'tossed' out of the site in connection with 'preventive site maintenance' (Binford 1983, 189). However, the fact that 40% of the flakes were produced by the application of soft percussion indicates that many flakes may be failed blades, which simply turned out slightly shorter than intended. Apart from dual-platform core CAT 2439, all surviving cores are single-platform cores, and predominantly (15 of 16 pieces) neat conical microblade cores.

There is little doubt that the purpose of the lithic reduction at Site 3B was to produce microblades and narrow macroblades (widths c. 3-11mm), most likely for the manufacture of microliths.

Tool production: The tools include two main groups, namely microliths and microlith-related implements (63 pieces, supplemented by 59 microburins) and scrapers (six pieces). Three truncated pieces are relatively 'flimsy' expedient knives, and seven pieces with edge-retouch are probably fragments of pieces with varying functions; two of these (CAT 2449, 2450) may for example be broken off scraper-edges.

The microliths are generally based on regular soft-hammer microblades or narrow macroblades. As indicated by the approximate numerical parity between microliths and microburins, at Site 3B most microliths were clearly manufactured by the application of microburin technique (using either the notch or the lamelle a cran approach; see above), although a small number may have been produced either by simply snapping off the proximal end or by retouching obliquely through the bulbar area. The resulting microliths were either geometric scalene or crescentic forms or simpler edge-blunted pieces, as well as Krukowski pieces, supplemented by a handful of backed bladelets.

Apart from one end-/side-scraper, all scrapers are based on robust cortical hard-hammer flakes with a convex, steep scraper-edge at one end.

DISTRIBUTION AND ON-SITE ACTIVITIES

The lithic assemblage was almost entirely recovered from features within an area measuring roughly 3 x 3m, centred on Hollow 7. In total, the area within the features measures slightly less than 4 x 4m (Fig. 10).

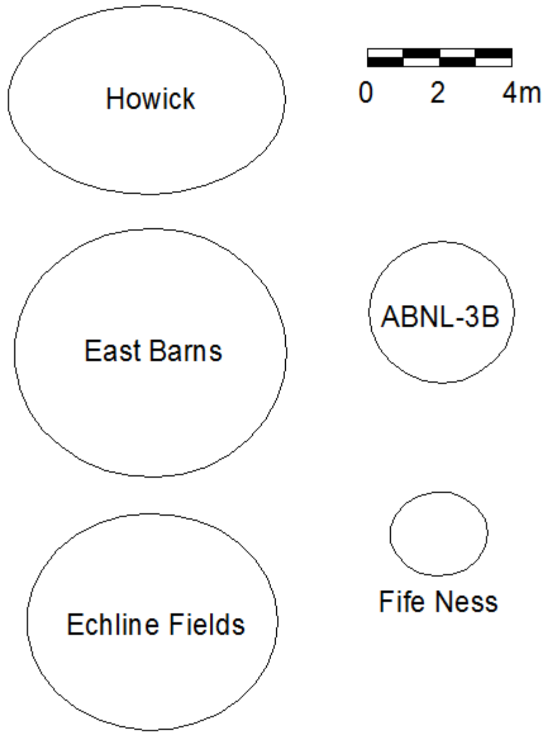
The dense concentration of the lithic artefacts, and the homogeneous nature of the lithic assemblage, makes it highly unlikely that these pieces were not deposited at Site 3B by the same group of people. The composition of the assemblage, with its heavy dominance of microliths, suggests that hunting may have been the main reason for these people settling at the location, probably to replace damaged microliths in composite hunting gear (cf. Lidén 1942) with new ones, most of which were produced at the site. The small number of scrapers, as well as the expedient knives (truncated pieces and unmodified blades) may relate to the processing of killed prey and/or subsistence-related activities.

The features: The site's features (Fig. 10) include:

The fill of a shallow hollow (Hollow 7). It is thought that this fill may be the remains of an originally more extensive spread representing the surface of a workshop, dwelling or shelter. This now truncated spread was recorded as Deposits 8 (NW), 9 (SE), 18 (SW) and 19 (NE). The hollow was irregular in plan, with an uneven base and gently sloping sides, and it measured 1.9 x 1.7 x 0.13m. There were no signs of in-situ burning in, around or below the hollow, but the reddish hue of the fill, and presence of charcoal and burnt lithics, suggests that burning had taken place.
Eight pits, set in a horseshoe-shape. The pits were generally sub-circular or oval cuts with flat bases and steeply sloping or near vertical sides, which appeared to have been intentionally dug. They measured between c. 1.3m and 0.4m across. The pits towards the north were up to 0.6m deep, whereas those towards the south were considerably shallower, between c. 0.1m and 0.3m deep. The relationship between some of the features and Hollow 7 is indicated by conjoining lithic artefacts.
A number of shallow, less well-defined hollows. For more details on these features, see elsewhere in this volume.

In Fig. 11, the space defined by the features is compared to that of a number of well-known Mesolithic structures from Scotland and north-east England, such as Howick, Northumberland (Waddington 2007); East Barns, East Lothian (Gooder 2007); Echline Fields, Fife (Robertson et al. 2013); and Fife Ness, also Fife (Wickham-Jones & Dalland 1998). The former three relatively complex structures are generally interpreted as houses, whereas the more 'flimsy' structure from Fife Ness is thought to be a shelter. These and other Mesolithic structures were discussed in detail in Robertson et al. 2013.

Fig. 11. The Site 3B structure and four other well-known Mesolithic structures – Howick, East Barns, Echline Fields, and Fife Ness.



Due to the regular horseshoe-shape of the pits, the present analyst finds it most likely that they represent a structure of some form. Compared to the other structures shown in Fig. 11, and taking into account the limited floor space of the area encircled by the pits, it is more likely that the Site 3B structure was a temporary shelter (cf. the light structures presented in Binford 1983, Fig. 115) than a more sedentary or semi-sedentary house.

In connection with the analysis of the site and its finds, other interpretations were considered, such as hazelnut roasting (eg, Duvensee 8; Bokelmann 1983; Bokelmann et al. 1981) and heat treatment of flint (Olausson & Larsson 1982; Griffiths et al. 1987; Eriksen 1997; Coles 2009, 2011). Both activities require the digging of pits, but it is generally accepted that, in both cases, the required roasting pits tend to be shallower than the ones investigated at Site 3B. It is possible that the location's pits were dug to provide sand for either hazelnut or flint roasting (sand being a good medium for spreading heat evenly; Coles 2009), but: 1) in most cases, sand would probably be provided by digging the pit into which hazelnuts or flint pebbles were to be placed; 2) the semi-circular setting of the pits is almost too regular to be associated merely with sand-taking; and 3) refitting of flints suggests that at least three of the pits (Pits 23, 25 and 31) were open all the way to the bottom at the same time (see below), suggesting that they may have been dug to hold stakes or poles in connection with the construction of a form of shelter.

Vertical distribution (stratigraphy): As indicated above, the typo-technological homogeneity of the assemblage suggests that the assemblage may have been deposited over a very short span of time by the same people, either during one visit to the site, or by returning to the site several times over a season, or possible over a period of a few years (see dating section).

The stratigraphy of the lithic artefacts, as interpreted during the excavation, indicated a basic three-step sequence of events, namely: 1) the establishment of a knapping floor with much debris, pre-dating the pits; 2) the digging of the pits, which were subsequently filled with debris from the first knapping floor; and 3) the establishment of a second knapping floor, represented by the finds of Hollow 7, which covered the pits.

However, a number of conjoining artefacts shed light on the relationship between the various features (for a discussion of refitting as an analytical tool, see Cziesla et al. 1990; Ballin 2000), and the initial interpretation of the stratigraphy had to be be reconsidered. In some cases, it was possible to refit breakage fragments of the individual flakes, blades, or microblades found within the same feature, but the following refit complexes are the most revealing:

Refit Complex 1: Overpassed blade CAT 381 and conical microblade core CAT 2427. Although these two pieces do not conjoin directly, the character of the flint suggests with a high degree of probability that they are from the same original pebble. Both were retrieved from Context 8 in Hollow 7 (NW).
Refit Complex 2: Split pebble CAT 2441-2 (five frags). The fragments of this pebble, which may represent unsuccessful heat treatment (see above), was recovered from Contexts 27 and 28, the basal fill of Pits 23 and 25.
Refit Complex 3: Core rough-out CAT 2428 and conical microblade core CAT 2448. These two pieces conjoin platform-to-platform, re-establishing most of the original parent pebble. They were retrieved from Contexts 8 and 33, linking Hollow 7 and Pit 31.
Refit Complex 4: Short end-scrapers CAT 2466 and 2469. Although these two pieces do not conjoin directly, the character of the flint suggests with a high degree of probability that they are from the same original pebble. They were recovered from Contexts 27 and 32, respectively (Pits 23 and 31).

Fig. 12. Refit connections between features on Site 3B.

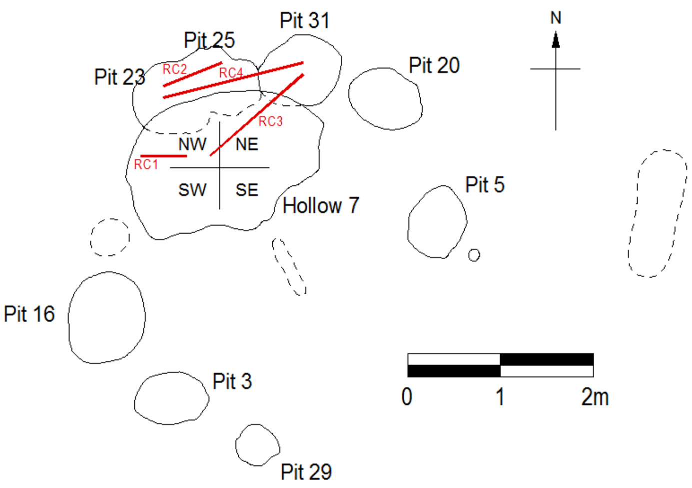


Fig. 12 shows in diagrammatical form the refit connections between a number of features across Site 3B. These connections suggest (contradicting the original interpretation regarding Hollow 7 as being later than the pits) that the lithic artefacts from the features form a unit, indicating that the assemblage was deposited over a very short time-span. In Spanou (2015, 27) it is suggested that the fill of Hollow 7 may originally have covered a larger area, and the refitting indicates that – despite the impression in the field of the Hollow 7 fill masking the pits – the pits may have been dug through this initial fill/knapping floor, whereby some flints from the knapping floor entered the pits, resulting in refitting parts being recovered from the pits and the Hollow 7 fill.

It is highly likely that knapping took place after the erection of the shelter, and that the knapping floor continued to develop and build up around the shelter's structural parts. If the shelter later disintegrated, or the stakes/posts were pulled up, the latest knapping debris may then have covered the pits explaining why the Hollow 7 fill may have been interpreted in the field as covering (and being later) than the pits.

Horizontal distribution: Assessment of the horizontal distribution of lithic artefacts is hampered by the fact that the of the shelter's knapping floor has been removed by ploughing. Had this surface survived, it would have been much simpler to analyse the site's spatial structures, and more detailed information could have been obtained (eg, Cziesla 1990; Ballin 2013b). Now only flint from the surviving eight pits and Hollow 7 provides information on the spatial organization of the site.

Data on the distribution of the individual artefact categories is available in Tables 3 and 6-9, and although there are slight variations in the distribution of the categories, a general picture emerges. Basically, most of the lithics were recovered from Hollow 7 and Pits 16, 20, 23, 25 and 31 towards the north, with Pits 3, 5 and 29 towards the pit arc's opening towards the south containing relatively few finds.

In the site report (Spanou 2015, 34) it is proposed that Hollow 7 (which probably represents a once more extensive knapping floor) may either be the remains of a natural hollow or the result of repeated re-use. The concentration of lithic finds indicates that the hollow may represent the centre of the site, and that this is where a hearth would have been. Commonly, knapping would take place by a site's central fireplace. The lower density of finds in Pits 3, 5 and 29 suggests that these features were dugg at the periphery of the knapping floor.

The presence of burnt hazelnut shells at Site 3B informs us that hazelnuts were roasted at the site, and there are indicators in the lithic material that flint may have been heat-treated at Site 3B. Both activities require the digging of shallow pits, which may have been located outside the excavated parts of the site. The roasting of hazelnuts suggests that the site may have been visited in the autumn.

DATING

The flint assemblage from Site 3B comes across as a coherent chronological unit, and its typo-technological composition – in conjunction with the fact that it was recovered from a very small area (c. 3m across) – suggests that it may have been deposited within a relatively short span of time. The distribution of the finds, and the refitting of lithic artefacts, indicates that an open-air knapping floor developed, followed by the erection of a small shelter, and that, as part of the construction work, pits for stakes or posts were dug through the knapping debris. It is quite likely that the knapping floor then continued to develop after the erection of the shelter.

Typology: The only diagnostic artefact types recovered from the site are microliths and microburins. The microliths are all narrow-blade forms, including scalene triangles, crescents and edge-blunted pieces, and as such they suggest a date in the Late Mesolithic period. Generally, the Scottish Mesolithic is subdivided into two main parts which, as a rule of thumb, are defined by early sites including isosceles triangles based on broad blades (W > 8mm), and later sites scalene triangles based on microblades (W ≤ 8 mm). However, as sites on the Scottish west-coast are generally considerably narrower than those from the east-coast (due to the availability of flint pebbles in different sizes) it is suggested to make the dominance of either isosceles or scalene triangles the key defining early and late diagnostic types. In Saville's (2008) analysis of the lithic finds from Cramond, Edinburgh, he demonstrated that the transition between the Early and Late Mesolithic periods may be as early as c. 8500 cal BC.

At Garvald Burn in the Scottish Borders (Ballin & Barrowman 2015, 21) a radiocarbon date was obtained from a Mesolithic site with a potential windbreak, the assemblage of which included a scalene triangle. The date suggested that the site was settled around 4350-4000 cal BC (AA-51537-38). The association of Scottish scalene triangles with a very late Late Mesolithic radiocarbon date is potentially important. Studies of the British Late Mesolithic in general suggests that, towards the Mesolithic-Neolithic transition, the composition of microlith assemblages changed, with the inclusion of higher numbers of so-called 'rods' and 'quadri-laterals' at the expense of scalene triangles (eg, Myers 1989, Fig. 9.4; Spikins 2002; French et al. 2007). Such very late Mesolithic assemblages are still relatively rare, and it is uncertain whether the microlithic repertoire of this period entirely excluded scalene triangles (see for example Bishop 2008).

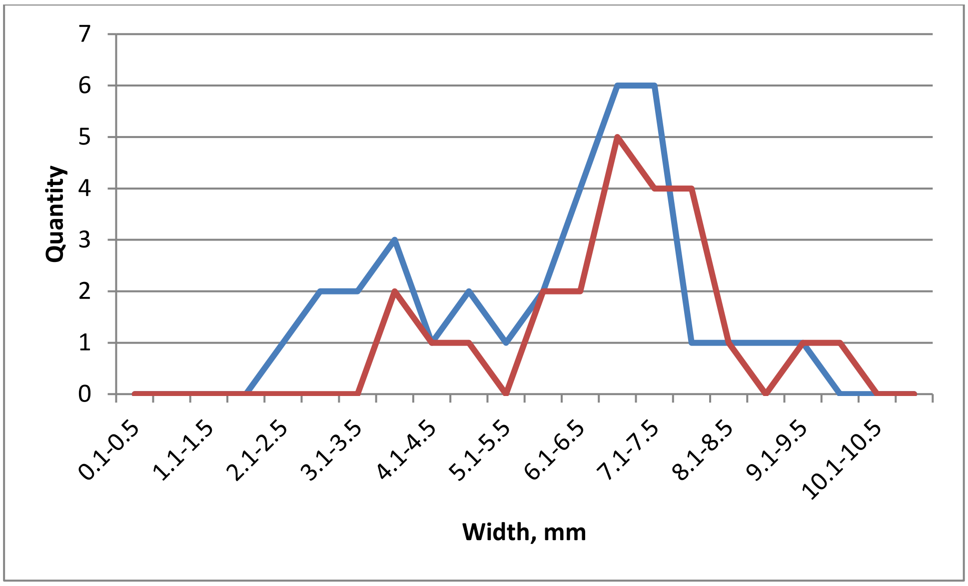
However, even if the latest Mesolithic assemblages in middle and southern England are characterised mainly by 'rods' and 'quadri-laterals', the question is whether this typo-chronological framework has validity north of the Anglo-Scottish border? Although assemblages dating to the very latest part of the Scottish Late Mesolithic are admittedly rare (Saville 2004; Finlay et al. 2004), 'there is no indication thus far of any specifically 'Late' or 'Terminal' Mesolithic element in the form of rod-dominated microlithic assemblages [...] among the Scottish finds' (Saville 2004, 205). With scalene triangles possibly forming part of Scottish lithic assemblages through the entire Late Mesolithic period, the typological repertoire of the assemblage from Site 3B therefore only allows a very broad date within the Late Mesolithic framework, from c. 8500-4000 cal BC.

Although the shapes and sizes of the microliths and microburins do not allow the occupation at the site to be dated more precisely within this period, they do provide important evidence relevant to the question of whether Site 3B may be a single-occupation site or a dual- or multi-occupation site. As mentioned above (Figs 8-9), the microliths are fairly narrow, and the curve showing the widths of the pieces is single-peaked, whereas the microburins are considerably broader, and the curve showing the widths of these pieces is double-peaked. The different relative widths of the microliths and microburins is due to the fact that the width of the microburins generally correspond to the width of the original microblade blanks, whereas the microliths have lost between one-third and one-half of the original microblades' widths through modification (cf. Ballin 2013a). However, in dating terms, the question is whether the double-peaked nature of the microburin curve may indicate several visits to the site?

Many of the microliths are probably damaged microliths which were removed from composite hunting implements and replaced at the site. The discarded microliths may to some extent have been manufactured elsewhere, whereas new microliths were produced at Site 3B, and the microburins represent on-site production. This replacement of microliths is partly demonstrated by the fact that the microliths (55 pieces) have a higher burnt ratio (16.4%) than the microburins/preforms (61 pieces) representing on-site production (9.8%). Some of the former group may have entered the hearth shot into prey and they were subsequently roasted with the meat, whereas the burnt microburins were only burnt when they accidentally fell into the fireplace during production.

Above, it was suggested that the production of microburins may have aimed to produce two different forms of microliths – narrow and broad ones – for different purposes (different prey?). To test whether the two types of microliths could have been produced during different visits to the site, Fig. 13 was produced (microburins from the pits and from Hollow 7). This diagram shows the same dual-peaked pattern within both groups of microburins, thus indicating the same possible activity pattern – the production of two different size categories of microliths. The fact that the dual-peaked pattern is found within both sub-assemblages – that from the pits and that from Hollow 7 – supports the suggestion above that the assemblage represents one visit to the site. The reason why this pattern is not repeated amongst the microliths (Fig. 8) may simply be that many of the site's microliths are discarded pieces which were manufactured elsewhere and possibly meant for general-purpose use.

Fig. 13. The widths of microburins from the pits (red: 24 pieces) and Hollow 7 (blue: 34 pieces).



The likelihood that, at Site 3B, different sizes of microblades were selected for the production of different sizes of microliths is supported by the fact that, although the microburins form a dual-peaked curve, the site's microblades form a neat single-peaked curved (Fig. 3), consistent with interpretation of the site as representing one visit to the site.

Technology: Technologically, the assemblage from Site 3B clearly represents a microblade industry, where microblades and narrow macroblades were produced from conical single-platform cores. The reduction of these cores followed a strict, but relatively simple operational schema (described in this report's technology section), and a number of idiosyncratic details (such as the apparent absence of initial cresting) indicates the deposition of the assemblage within a very narrow chronological band.

Technological approaches related to the one defined for Site 3B (usually involving initial cresting) characterizes other parts of the Late Mesolithic period, but also the earliest part of the Early Neolithic, with the main aim of these industries being the production of regular microblades and narrow macroblades (cf. Garthdee Road, Aberdeen; Ballin 2016). Within the region, similar approaches were identified in connection with the analysis of the mainly Late Mesolithic site at Nethermills Farm on the Dee (527 microlith-related implements and 620 microburins; Ballin 2013a), but this site also includes a significant Early Mesolithic sub-assemblage, as well as some later finds, and it was not possible to associate any parts of the assemblage with any of the site's radiocarbon dates.

Radiocarbon dates: Two relevant radiocarbon dates were obtained from the site (both based on burnt hazelnut shells), namely one from Hollow 7 (SUERC-57937) and one from the burnt basal layer of Pit 25 (SUERC-57938). Based on 2σ, the dates are: 7036-6831 cal BC and 6685-6614 cal BC, suggesting that visits to the site in the Late Mesolithic may have taken place on two occasions, separated by a period of several hundred years. Based on 1σ, the dates are: 7047-6780 cal BC and 6743-6614 cal BC, and in this case the two dates almost meet. It should also be borne in mind that burnt hazelnut shells may easily survive in the ground for hundreds of years, and that dates based on burnt hazelnut shells may not be the 'silver bullet' it was once believed to be. A date (SUERC-49726) from a pit in the same field (Pit 103) returned a date of 7060-6836 cal BC (2σ) or 7071-6816 cal BC (1σ) corresponding roughly to the date obtained from Hollow 7. This date is also based on a burnt hazelnut shell.

More radiocarbon dates are expected to be made available in the near future.

SUMMARY AND DISCUSSION

As explained above, Site 3B is thought to be the remains of a short-term specialised hunting camp. The site includes a number of features, which may represent a light structure, such as a wind-break.

This structure would have been considerably smaller and 'flimsier' than the now well-known oval houses from Scotland and north-east England (Fig. 11), but only slightly larger than the almost identical structure identified at Fife Ness (Wickham-Jones & Dalland 1998, Illus 2).

The site and its assemblage have been dated by diagnostic artefacts (scalene triangles and microburins) to the Late Mesolithic period, a date supported by technological elements, such as soft-hammer microblades and narrow macroblades, as well as conical microblade cores. A more precise date was provided by radiocarbon dating, which suggested a date around, or slightly after, 7000 cal BC.

A number of factors shed light on the site's 'internal chronology'. Observations made in the field seem to indicate a sequence of three stages, namely 1) the establishment of a knapping floor with much debris, pre-dating the pits; 2) the digging of the pits, which were subsequently filled with debris from the first knapping floor; and 3) the establishment of a second knapping floor, represented by the finds of Hollow 7, which apparently covered the pits. Although the 2σ dates seem to support this by returning dates separated by a several-hundred year gap between them (6685-6614 cal BC and 7036-6831 cal BC), the lithic evidence contradicts this.

Where some of the microliths may have been produced off the site and represent discarded damaged pieces, the microblades and microburins represent on-site production. Although the microburins' widths form a two-peaked curve (Fig. 9), the microblades form a neat single-peaked one (Fig. 3), and the analyst has interpreted this discrepancy as a suggestion of on-site production of two different sizes of specialized microliths (a mass of microblades were produced, but two different size categories of microblades were selected as blanks for microliths). These microliths may have been intended for the hunting of different forms of prey.

To test the three-stage scenario mentioned above, a diagram (Fig. 13) was produced to compare the width of the microburins in the pits and in Hollow 7, which appeared to form separate earlier and later stratigraphic units. The curves describing the microburins from the two contexts are both double-peaked, suggesting that the two contexts may represent contemporary levels. This is supported by the fact that the microburins from both contexts follow the same strict pattern, where proximal microburins all have their notches in the left lateral side, and all distal pieces in the right side (for a discussion of left-/right-handedness and motoric habits, see Andersen 1982).

This is also corroborated by refitting flints and flints which, due to raw material similarities, are almost certain to derive from the same parent nodules (Fig. 12). The refitting of artefacts from different contexts showed that Pits 23, 25 and 31 had been open top-to-bottom at the same time, and therefore dug at the same time, and that the flints from the pits and Hollow 7 may be contemporary. This suggests a slightly different sequence of events, where a light structure was erected on top of an existing knapping floor, with Hollow 7 possibly being a surviving part of this knapping floor. Knapping may have continued after the construction of the shelter, with new layers of lithic waste building up around its structural parts.

The typo-technological repertoire of Site 3B is exceptionally limited, being heavily dominated by knapping debris related to the production of microblades and narrow macroblades, numerous microburins from the production of scalene, crescentic and edge-blunted microliths, and a small number of scrapers and expedient truncated pieces. In comparison, the assemblage from the sturdy and probably more sedentary Howick house (Waddington & Pedersen 2007, 81) includes many more scrapers in relation to the microliths than Site 3B (microlith:scraper ratio 72:28% and 91:09, respectively).

Microliths are generally perceived as having been produced as tips and edges/barbs in composite hunting gear (hundreds of slotted bone points with in situ inserts have been recovered from southern Scandinavia and the Baltic region; eg, Lidén 1942), and the main activity taking place at the site is therefore likely to have been the production of microblades and new microliths, with the intention of replacing damaged microliths from used hunting equipment. The small number of scrapers and truncated pieces may represent either the processing of prey or subsistence-related activities.

However, although microliths were probably generally intended as inserts in composite bone tools, some of the pieces recovered from Site 3B are exceptionally small (the smallest intact scalene triangle [CAT 2538] measuring 9.9 x 2.4 x 2.2). It should be considered whether such pieces may have been used in a slightly different way, as the shaft into which they would have been inserted would have had to be correspondingly small. In terms of the production of microliths, at Site 3B, as well as Nethermills Farm 25km towards the south-west (Ballin 2013a), microburin technique was clearly the standard approach (both assemblages are characterized by approximate numerical parity between microliths and microburins), although small numbers were produced in different ways. The reason why some Mesolithic assemblages from Scotland are almost devoid of microburins may be that, in connection with the processing of the finds from Site 3B and Nethermills all chips were inspected rigorously by the use of a magnifying glass (8X), allowing the minuscule microburins (some as small as GD = 2mm) to be identified, whereas in other assemblages (particularly from older excavations) some microburins may still hide amongst the chips.

The presence of burnt hazelnut shells on the site is evidence that roasting of nuts took place at, or near, the site, and it has been suggested above that burnt flint pebbles and pieces with scorched cortex and shiny surfaces may indicate heat-treatment, possibly to increase the yield of microblades (pers. comm Mike Cook, distinguished American knapper) from the small nodules available along the Aberdeenshire North Sea shores. It was argued above, that the roasting of hazelnuts and flint would have required shallow pits, where the site's pits are too deep for this purpose, and the fact that these pits have been shown to have been open at the same time, makes it more likely that they relate to a structure rather than to any roasting event. Roasting of hazelnuts, as well as flint, may have taken place in the site's peripheral parts.

In the larger Scottish perspective, heat treatment of lithic raw materials is a phenomenon which ought to be shown some consideration. Although certain evidence of heat treatment in Scottish prehistory has not yet been made available, it is highly likely that it took place. Roasting of lithic raw material was undertaken for a number of reasons, such as, inter alia, to increase the yield of blades and microblades from small pebbles, allow the detachment of thinner flakes during bifacial production, and to improve the flaking properties of coarse or flawed lithic raw materials (Olausson & Larsson 1982; Griffiths et al. 1987; Eriksen 1997; Coles 2009, 2011), and as in some parts of Scotland only small pebbles or coarse/flawed raw materials were available, heat treatment should have been an attractive option in some places and at some points of time. We should begin looking for the evidence.

Although some house structures (eg, Waddington 2007; Gooder 2007; Robertson et al. 2013) and pits/pit clusters (eg, Murray et al. 2009) are now known from the Scottish Mesolithic period, Mesolithic structures are not common (Wickham-Jones 2004). The best comparative material for Site 3B and its assemblage is the Fife Ness site, Fife (Wickham-Jones & Dalland 1998), which closely resembles the present site on a number of points.

In terms of chronology, the two sites both date to the Late Mesolithic period, with the occupation of Fife Ness taking place up to a millennium earlier (7680-7080 cal BC [AA-25202-25215]; Waddington et al. 2007, Table 15.1) than that of Site 3B (7036-6614 cal BC), although the dates also allow the two sites to be almost contemporary. The sites are both associated with a semi-circular setting of pits or postholes, possibly relating to slight structures or shelters/wind-breaks with diameters of a few metres (Fig. 11; also see Wickham-Jones & Dalland 1998, Illus 2). Both assemblages are relatively small, with that from Fife Ness numbering 1,518 pieces and that from Site 1B 2,591 pieces. Most of the pieces are chips from the production of microblades, some of which were subsequently transformed into microliths. Both assemblages also include some scrapers and informal cutting implements (pieces with informal retouch, or blades and flakes used without modification). It is presently uncertain whether the dominance of the Fife Ness microliths by crescents and the dominance at Site 3B of scalene triangles relate to chronology, function or personal or regional preferences.

It is difficult to compare the two site layouts, as no actual floor survived at Site 3B, but further similarities include the fact that the sites are at least two-phased, in the sense that the pits for the structures' posts were dug through an existing knapping floor with debris from lithic reduction (Wickham-Jones & Dalland 1998, 4). Furthermore, at both sites the pits initially appeared to be sealed by an occupation layer, but as shown above by refitting and attribute analysis, this may not have been the case at Site 3B, nor at Fife Ness: 'The first impression, that the layer sealed the underlying cuts, could not be substantiated, and it is likely that the clues to this had been obscured by soil processes in the past' (Wickham-Jones & Dalland 1998, 4). At the present site, further refitting attempts may provide more refitting connections between Hollow 7 and the various fills of the pits.

An important difference between the two sites is the fact that Fife Ness is a coastal location and Site 3B an upland location c. 12km from the coast and several kilometres from the river Don (Spanou 2015, 109). Although the on-site activities at both locations focused on the production of microblades, and subsequently microliths, the settlers may have focused on different prey. At Fife Ness, sea birds or migrating birds may (among other animals) have been hunted, whereas at Site 3B this is unlikely. The possible manufacture at the latter site of different (specialized?) size categories of microliths suggest a more wide-spectred hunting strategy.

Nethermills Farm on the Dee, c. 25km towards the south, is a large lithic palimpsest (c. 30,000 flints were excavated by Kenworthy [1981]) covering more than 1,000 square metres in total (Ballin 2013a). A structure on the site is similar to the sturdier Mesolithic houses mentioned above, and it has been associated with that site's dominating Late Mesolithic element. Although it has not been possible to date the structure with certainty (Wickham-Jones et al. forthcoming), it may be a Mesolithic structure, relating to a favoured location in the landscape, visited again and again through the period. Although this site appears to have been less specialized, with more non-microscopic lithic tool forms, the main activity on the site was, as at Site 3B and Fife Ness, the production of microblades for microliths (527 microlith-related implements and 620 microburins; Ballin 2013a).

In the big picture, Site 3B is a valuable contribution to our knowledge of the Late Mesolithic of Scotland and, in particular, eastern Scotland. The site adds to the growing body of sites with structural remains of houses or shelters, which at the present can be subdivided into three groups (Fig. 11), namely: 1) Actual sturdy post-built houses of a semi-permanent nature (eg, Howick, Northumberland [Waddington 2007]; East Barns, East Lothian [Gooder 2007]; Echline Fields, Fife [Robertson et al. 2013]); 2) relatively 'flimsy' post- or stake-built structures, which have been interpreted as temporary shelters or wind-breaks (eg, the present site; Fife Ness, Fife [Wickham-Jones & Dalland 1998]; Garvald Burn, Scottish Borders [Ballin & Barrowman 2015]); and 3) potential dwellings or shelters surviving as hollows or turf-banked structures and which may or may not have been supported by posts or stakes (eg, Staosnaig, Colonsay [Mithen et al. 2000]; Littlehill Bridge, South Ayrshire [Macgregor & Donnelly 1994]; Glentaggart, South Lanarkshire [Ballin & Johnson 2005]). The latter group may include the poorly preserved remains of structures belonging to the former two categories. For a more detailed discussion of Scottish Late Mesolithic houses and dwellings, see Robertson et al. (2013).

The lithic assemblage from Site 3B represents a form of analytical baseline for the investigation of more complex sites, or palimpsests. To understand, and to be able to 'unlock', the more complex sites and their assemblages, it is necessary to know how assemblages from single-occupation sites appear (also see Ballin 2013b), and above it has been attempted to gain an understanding of Site 3B through attribute analysis of its lithic assemblage. Basically, simple diagrammatical and tabular representations indicate short-term single-occupation sites. In terms of 'unlocking' and gaining an understanding of the larger early prehistoric Site 2D from the Aberdeen Ring Road Project's southern leg, the approaches applied to the analysis of Site 3B were helpful (see elsewhere, this volume).

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Appendix-2.2.13 NL/006A and NL/006B Goval Lithics Analysis - Julie Lochrie

The Goval assemblage numbers 50 pieces of flint. The dating of three features to the Neolithic period are confirmed by associated pottery, these include [6A-0006], [6A-0036] and [6A-0041]. Seven of the lithics were found unstratified and the remainder of the assemblage was spread between ten features with a concentration in [6A-0006]. The most interesting aspect 0f the assemblage are the seven cores and the variety of reduction techniques they represent.

The assemblage is summarised in Table 1. For a detailed description of available local flint resources please refer to A2.2.8.

Table 1 Lithic assemblage summary

Feature	Chips	Flakes	Blades	Indeterminate Pieces	Cores	Tools	Total
6A-0000			2		2	2	6
6A-0006	21	5		3			29
6A-0016	1						1
6A-0018					1		1
6A-0036	3	1					4
6A-0041	1	2					3
6A-0049		1					1
6A-0132					1		1
6A-0134	2						2
6B-0003					1		1
6B-0010					1		1
Total	28	9	2	3	6	2	50

The flint is no different to what has been noted as locally available. The most common colour present is yellow-brown followed by a mottled mid grey or grey-brown and lastly a red-brown. Abraded pebble cortex is present on a few pieces but as most of the assemblage comprises chips there are not many primary or secondary pieces. The flint has very likely been sourced from local gravel outcrops or the side of riverbeds.

The assemblage is small but includes a collection of seven cores, accounting for 12% of the assemblage. The bulk of the assemblage is comprised of chips and indeterminate fragments which make up 62%. The chips cannot be analysed in detail but they have the benefit of indicating areas with nearby knapping. The only such context from Goval is pit [6A-0006] where over half of the assemblage was found. The small chips and flakes found here indicate nearby knapping and when combined with the high quantity of fragmented pottery point towards domestic occupation. The lithics from pit [6A-

0006] are not indicative of date but it is known that the pottery dates between c 3600 – 3300 BC. The small scattering of lithics from the other contexts do not reveal any other occupational information but do indicate that low levels of prehistoric activity were spread over a very large area. The two tools are unstratified and are not formal tool types. Their retouch comprises very small sections of removals to their lateral edge. In the case of 06-F004 the retouch is abrupt and fairly coarse, exaggerating a naturally concave part of the edge. The retouch to 06-F003 is incredibly fine and produces a shallow notch more similar to Mesolithic techniques of modification.

The cores demonstrate two different percussion techniques and numerous different approaches to reduction. Three of the cores show platform reduction with hard and soft percussion. There are two single platform cores, 06-F002 and 06-F046, the former is unstratified and the latter is from (6A-0132). Core 06-F002 has a single platform which shows soft and hard percussion characteristics, it is oval in plan, with one cortical critical and one reduced side. This core could broadly be termed conical and the blank removals would have comprised blades and some flakes. These types of cores are most commonly seen in the Mesolithic and early to middle Neolithic. Core 06-F046 has been reduced around 75% of its platform, at some point the apex has been removed and further flakes have been struck from the platform edge but these would have been very short, this may be an attempt to fashion the flint into a tool, most likely a scraper. The final core to show platform reduction is the most interesting the three, 06-F049. It is from the very north of the site, [6B-0003], and is made on fairly fine-grained, grey-brown flint, the best quality example of flint in the assemblage. Two platforms are identifiable and many orientations of removal can be seen. The generally shape of the core looks like a squat conical core but the apex is in fact the edge of a previous platform. The main platform, from which most of the removals have been made is sub-circular in plan and is covered in previous flake scars around a 360 orientation, the point of impact for most these no longer remains, having been removed by subsequent flakes although one section could be a third platform.

Bipolar reduction is present on two examples, 06-F037 from [6A-0018] and 06-F050 from [6A-0010]. Both of these cores have opposing two opposing axes of removals and in both case the removals are bifocal, much more so on 06-F037. The combination of platform and bipolar reduction is a very common assemblage characteristic from the middle Neolithic onwards as it is at this point that traditional platform techniques give way to bipolar reduction and levallois-like reduction. In fact the platform reduced core 06-F049 shows the emphasis during this period of orientating the core in specific ways to maximise yield. This very strategic method of reduction has a similar motivation to the more strictly levallois-like approach.

Appendix-2.2.14 SL/012 Blackdog Lithics Analysis – Julie Lochrie

Introduction

This report covers all lithics retrieved from the site during excavation and sample flotation. The assemblage is very small, totalling only 109 pieces.

Definitions used in the report are as follows: cortex: the outer skin of a rock; pebble: a small rounded stone smoothed by movement; core: raw material which has been used to detach pieces, will only show dorsal surfaces; debitage: all flaked waste material, including blades, flakes and chips; blade: a flake twice as long as it is wide; flake: any detached piece with a ventral surface; chip: all pieces below 10cm; fragment: the term fragment is used to indicate a broken piece; indeterminate/chunk: an indeterminate piece with no clear ventral surface; tool: any secondary modification (retouch). The end to be disposed of is snapped off after first weakening the break with a notch.

Technology

Assemblage is summarised in Table 1. All but the pitchstone scraper is of flint. The pitchstone has very few, small probable phenocrysts and is likely porphorytic. Pitchstone was not available locally and imported from the island of Arran in the Firth of Clyde. The trade and exchange of this stone was at its height in the early Neolithic period. The flint from Blackdog is present in a range of colours which is to be expected from the north east of Scotland. The flint found on other sites in the north east show that there is a wide variety in colour. Nethermills Farm near Banchory (Ballin 2013) produced a number of varieties, with the two largest groups being flint of the reddish-brown type and flint of a light-grey mottled type. The assemblage from the Carmelite Friary in central Aberdeen (Ballin 2001) is composed roughly in the same manner, but with the addition of some olive-coloured pieces. The site of Garthdee Road, Aberdeen (Ballin 2016), from the area near the mouth of the Dee, was dominated by a light-brown variety of flint, with reddish-brown pieces being fairly rare. It seems that sites along the Dee and further south in Aberdeenshire may include less flint of the reddish-brown forms than those further north which is reflected at the Middleton site.

Table 1. lithic assemblage summary

Debitage	
Chips	57
Flakes	32
Blades	8
Indeterminate pieces	4
Total debitage	*100*
Cores	
Bipolar	2
Flat uni-facial core	1

Single platform core	1
Total cores	*4*
Tools	
Circular scraper	1
Other Scraper	1
Scraper/ bifacial tool	1
Edge-retouch	1
Total tools	*5*
TOTAL	**109**

Debitage ratios are what is expected for a flake focussed industry with some blade production. The mix of platform and bipolar reduction is also borne out at several other early to middle Neolithic sites (Warren Fields, Warren 2009; Wester Hatton, A2.2.16). Scrapers are the dominant tool type and may relate to the types of activities taking place.

Distribution and Dating

Table 2 provides a summary of the assemblage by feature. Interestingly pit [12-0001] contained an almost complete early Neolithic bowl but some of the lowest quantity of lithics from the whole site. The greatest quantities were from buried soil [12-0022], and pits [12-0023] and [12-0031]. The buried soil and pit [12-0031] both contained small quantities of Neolithic pottery.

Table 2: Lithic Assemblage by feature

Feature	Chips	Flakes	Blade	Ind. Pieces	Cores	Scrapers	Pitchstone tool	Edge retouch	Total
12-0001		2		1					3
12-0002		1	1						2
12-0022	7	10			1	2	1	1	22
12-0023	38	10	3	2	1			1	55
12-0029		3			1				4
12-0031	11	7	2	1	1				22
12-0034	1								1

Total	57	33	6	4	4	2	1	2	109

Discussion

While both the site and lithic assemblage is small it certainly points towards domestic Neolithic activity. Interestingly however Ballin made a connection between small lithic assemblages and special sites (eg timber halls) when compared with the larger assemblages of domestic sites such as the sunken floored building at Garthdee Road. That certainly isn't reflected here. What is very similar is the presence of a spread of anthropogenic material and few accompanying features. As noted at Garthdee this type of scenario is exactly what would have been present had the site been truncated and unprotected by the hollow.

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Appendix-2.2.15 NL/013 Middlefield Lithics Analysis – Julie Lochrie

Introduction

This report covers all lithics retrieved from the Middlefield during excavation and subsequent sample flotation. The assemblage is small, totalling 122 pieces with the vast majority retrieved during soil sample flotation. Two pieces in the assemblage point towards a Mesolithic date.

The assemblage was retrieved from four small features which are interpreted as stone holes from site clearance [13-0007], [13-0009], [NL-2009] and [13-0011]. The small size of most of the lithics would not have been visible during excavation. The occurrence of Mesolithic archaeology in mainland Britain is most probably under represented due to a combination of this very ephemeral activity and modern archaeological prospection techniques. As such it was recognised, despite the small size, the site represented an opportunity to deepen our understanding of the period and the traces it leaves within the archaeological record. A complete catalogue can be found in the database.

Definitions used in the report are as follows: cortex: the outer skin of a rock; pebble: a small rounded stone smoothed by movement; core: raw material which has been used to detach pieces, will only show dorsal surfaces; debitage: all flaked waste material, including blades, flakes and chips; blade: a flake twice as long as it is wide; flake: any detached piece with a ventral surface; chip: all pieces below 10cm; fragment: the term fragment is used to indicate a broken piece; indeterminate/chunk: an indeterminate piece with no clear ventral surface; tool: any secondary modification (retouch); microlith: a range of small composite tools made during the Mesolithic; microburin: a waste product of microlith production. The end to be disposed of is snapped off after first weakening the break with a notch.

Lithic technology and dating

Assemblage quantity and composition is summarised in Table 1. Discounting a chalcedony microblade the assemblage is exclusively yellow-brown and red-brown coloured flint. The abraded character of the cortex of the site's primary and secondary flakes is indicative of local procurement of pebble flint. The cores have an average size of 36mm x 20mm, although three of the cores all measure 27mm maximum length. The largest core is 46mm in length and it is probable the original pebble size would not exceed a maximum dimension of 50mm.

The flint found on other sites in the north east show that there is a wide variety in colour. Nethermills Farm near Banchory (Ballin 2013) includes a multitude of varieties, with the two largest groups being flint of the reddish-brown type and flint of a light-grey mottled type. The assemblage from the Carmelite Friary in central Aberdeen (Ballin 2001) is composed roughly in the same manner, but with the addition of some olive-coloured pieces. The site of Garthdee Road, Aberdeen (Ballin 2016), from the area near the mouth of the Dee, was dominated by a light-brown variety of flint, with reddish-brown pieces being fairly rare. It seems that sites along the Dee and further south in Aberdeenshire may include less flint of the reddish-brown forms than those further north which is reflected at the Middleton site.

Table 1 Lithic assemblage summary

Debitage	

Chips	85
Flakes	21
Blades	2
Microblades	1
Indeterminate pieces	2
Total debitage	*111*
Cores	
Bipolar Cores	9
Total cores	*9*
Tools	
Edge retouched	1
Notched	1
Total tools	*2*
TOTAL	**122**

The composition of the assemblage shows a high percentage of chips (69%). This is likely due to the sampling strategy employed on the sites. As demonstrated in Ballin (1999), the chip ratio of sieved assemblages usually varies between *c.* 30% and 55%. Flakes are higher in quantity than blades although a small microblade with triangular cross-section is present.

The cores are bipolar and have usually been worked along one plane, with one face the focus of removals while the reverse still retains cortex. There is no evidence for the preparation of the cores in any way. There are two flakes with retouch. The edge retouched piece from [13-0007] is an atypical piece. This thick bipolar flake has a small section of abrupt retouch to the right of the distal, most likely to enhance a natural point. This type of non-formal tool could have been made for a specific purpose in the vicinity. The second retouched piece is more interesting but unfortunately very fragmentary. It has continuous fine retouch along the inverse right lateral which is concave, the remainder of the piece has snapped off across the medial. The character of the retouch and the soft hammer percussion all point towards a Mesolithic date. As well as the notched tool being Mesolithic in character, the small chalcedony microblade is also likely to be Mesolithic, both in terms of its technology and evidence for convenient use of local materials.

Assuming the assemblage is all broadly contemporary the most interesting aspect is the limited range of cores types. All cores are bipolar, in very similar sizes and reduction technique. At Standingstones and Milltimber (A2.2.12 and A2.2.8 respectively), as at other Mesolithic sites the cores are more commonly platform reduced. While there are certainly bipolar cores also present at these sites, they are in far lesser quantities. Comparing this with the nearby early to middle Neolithic site at Blackdog we actually begin to see the bipolar technique in greater numbers. This is unlikely to be a one-off as at early to middle Neolithic Blackdog (A2.2.14) there was a mixture of bipolar and platform reduction. At Warren Fields, an early Neolithic timber hall site, only bipolar cores were discovered. The middle Neolithic site at Wester Hatton (A2.2.16) was high in bipolar reduction and cores only second with Levallois-like technology for the reduction method of choice. Bipolar reduction certainly seems to become more popular in the north east during the Neolithic even though it is used in the Mesolithic. However a plausible explanation is that bipolar reduction was the particular choice of one person, or group of people using the camp for a short time.

Distribution and site function

The table below provides a summary of each context. In all instances chips are the most numerous find. When small flake and chips are present it shows that knapping has been occurring nearby. The presence of cores alongside this knapping debris points towards and are of low level knapping.

Feature	Chips	Flakes	Blades	Micro blade	Indeterminate Pieces	Bipolar cores	Edge retouch	notched	Total
13-0007	13	1					1		15
13-0009	25	7		1		3			37
NL-2009	31	11	2		2	5			51
13-0011	16	1				1		1	19
Total	85	21	2	1	2	9	1	1	122

Discussion

The site is a little too small to apply a detailed technological analysis and its dating may be from multiple periods. The lithic assemblage points towards some small-scale manufacture in the vicinity and it is likely this site was the location of a small camp.

The importance of these small sites from a time when mobility and structural building is poorly understood cannot be under estimated. While it may be impractical to focus an entire publication on such poorly preserved archaeology the opportunities presented by a road corridor of this scale mean this ephemeral evidence can be considered. These small sites represent the missing link in gaining a complete picture of people's interaction with the land.

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Appendix-2.2.16 AMA22 Wester Hatton, the Aberdeen Ring Road Project

The lithic assemblage

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INTRODUCTION

In connection with the construction of a ring road around the western periphery of Aberdeen, Headland Archaeology Ltd. carried out investigation of selected locations along the planned route (Spanou 2015; 2017). During this work, a number of prehistoric and later sites were examined by trial trenching and excavation, dating to various parts of the prehistoric period.

One of the sites investigated along the Aberdeen Western Peripheral Route/Balmedie-Tipperty (Northern Leg) was Wester Hatton (NGR NJ 9568 1505), from which an assemblage of almost 2,000 lithic artefacts was recovered. The topographical level of the location varied between 35m above O.D. to 44m above O.D. Due to access issues at Wester Hatton prior to the construction phase of the Ring Road Project, no non-invasive geophysical survey or invasive trial trench investigations had been undertaken. The construction phase eventually allowed for a programme of trial trenching to be conducted at the site as part the archaeological mitigation strategy. Fifteen trial trenches were excavated, covering 10% of the available area. The trial trenches identified a number of features including evidence of several structures (Structures A-E), as well as several pit clusters (Clusters E, NE, S and SW), of prehistoric date. These were confined to the southern half of the investigation area on the south facing slope of the rise. The results of the evaluation determined the size of the subsequent archaeological mitigation, culminating in an initial monitored topsoil strip of approximately 5500m² and the excavation of all encountered cut features.

The combination of lithic diagnostic material, diagnostic pottery styles and radiocarbon evidence suggests that Wester Hatton was visited briefly during the Late Mesolithic/Early Neolithic period, but that the vast majority of the lithic finds formed part of a number of later Neolithic and mainly Early Bronze Age knapping floors. These domestic scatters were then penetrated in connection with the construction of several Bronze Age houses and the digging of numerous pits, and the residual knapping debris became part of the fills of these features.

The purpose of this report is to characterize the lithic assemblage in detail and discuss general research questions, such as: the nature and date of the assemblage, lithic procurement and technology, as well as intra-site spatial patterns and site behaviour, and the site and its lithic material are compared with relevant contemporary sites and assemblages. During the initial assessment of the lithic artefacts from Wester Hatton, it was noticed (Spanou 2017, 117) that most of the finds derived from Structure B, and that this assemblage included sub-assemblages based on Levallois-like and bipolar reduction techniques. It was therefore decided to focus on Structure B, as well as on attempting to shed light on these different reduction techniques and their association with the different later Neolithic and Bronze Age occupations at Wester Hatton.

THE ASSEMBLAGE

From the excavation at Wester Hatton, 1,839 lithic artefacts were recovered. They are listed in Table 1. In total, 96% of this small assemblage is debitage, whereas 3% is cores and 1% tools.

Table 1. General artefact list.

	Str A	*Str B*	*Str C*	*Str D*	*Str E*	*E Cluster*	*NE Cluster*	*S Cluster*	*SW Cluster*	*Other*	*Total*
Debitage											
Chips	9	570	9	56	6	8		264	85	1	1,008
Flakes	12	364	7	57	3	9	3	143	41	1	640
Blades		30	1	2				17	2		52
Microblades		24		1		2		11	5		43
Indeterminate pieces		13		3		2	1	2			21
Crested pieces		7						3			11
Platform rejuvenation flakes								1			
Total debitage	*21*	*1,008*	*17*	*119*	*9*	*21*	*4*	*441*	*133*	*2*	*1,775*
Cores											
Single-platform cores, rough-outs		1									1
Single-platform cores		2						1			3
Levallois-like cores, rough-outs		3						1			4
Levallois-like cores		5						3			8
Split pebbles (early-stage bip. cores)		1									1
Bipolar cores	1	18		7				2	5		33
Total cores	*1*	*30*		*7*				*7*	*5*		*50*
Tools											
Leaf-shaped arrowheads									1		1
Short end-scrapers		1		1							2
Side-scrapers		1									1
Scale-flaked knives				1							1
Serrated pieces		4									4
Polished-edge implements		1									1
Edge-retouch		2						2			4
Total tools		*9*		*2*					*1*		*12*
TOTAL	**22**	**1,047**	**17**	**128**	**9**	**21**	**4**	**450**	**139**	**2**	**1,839**

RAW MATERIALS – TYPES, SOURCES AND CONDITION

Apart from three flakes in white milky quartz from Ditch 6238, all lithic artefacts from Wester Hatton are flint. The colour of the flint varies, with most being mottled-grey, and with relatively few belonging to the honey-brown variety known from many Aberdeenshire sites. As shown in the reports on other lithic assemblages recovered in connection with the construction of the Aberdeenshire Ring Road (for example 2D and 3B; this volume), prehistoric sites from the region include a substantial number of other colours than honey-brown and grey, such as buff, cream, beige, black and olive, and these colours are also present in the Wester Hatton assemblage.

However, the main difference between the present assemblage and for example Mesolithic (eg, Nethermills Farm on the Dee; Ballin 2013 [Neth]) and Early Neolithic (eg, Garthdee Road, Aberdeen; Ballin 2016 [Garth]) assemblages from Aberdeenshire is that the Mesolithic and Early Neolithic sites tend to be defined mostly by homogeneous, fine-grained, vitreous flint, whereas the present collection includes much medium- to coarse-grained, more opaque flint with impurities like chalk balls, fossils and clusters of micro-crystals. It is generally thought that the flint from the early prehistoric sites from the region was collected from beach walls along the North Sea shores, whereas it is likely that a proportion of the later Neolithic and early Bronze Age Wester Hatton material (see dating section) was procured from the later Neolithic flint mines in the Buchan Ridge area near Peterhead, just over 30km towards the north.

The flint from the Buchan Ridge Gravels includes different forms of flint, with some sources being dominated by one type and other sources by other types (Bridgland *et al.* 1997; Bridgland & Saville 2000 [Quat Banff]), such as fine-grained honey-brown forms and coarser varieties characterized by other colours. The impure medium- and coarse-grained flint from Wester Hatton is not unlike some of the flint from Stoneyhill Farm (Suddaby & Ballin 2010), which is situated on top of the Buchan Ridge Gravels, and Wester Clerkhill north of Peterhead (Ballin & Cameron forthcoming), which is thought to be based on glacially transported flint from the area around Den of Boddam.

The flaking properties of the flint from Wester Hatton is notably affected by the low quality (eg, grain-size and impurities) of some of the Buchan Ridge flint. Several of the Levallois-like cores from the site may have been abandoned at an early stage due the flint either being too dense (eg, CAT 1832) or too impure (eg, CAT 1833). One bipolar core (CAT 1795 with refitting flakes CAT 1796-99) clearly disintegrated completely when it was struck on an anvil, with some of the resultant flakes immediately breaking into proximal and distal segments due to the presence of internal impurities and weaknesses.

The mining operations at Den of Boddam and Skelmuir Hill are thought to have taken place during the later Neolithic period, a date supported by the recovery of a chisel-shaped arrowhead during the excavations at Den of Boddam (Bridgland 2000, Fig. 53), and the waste material from the mining area is characterized by numerous Levallois-like and bipolar cores (Saville 2005 [in Topping]; 2006 [flint techn]). The assemblage from Wester Hatton, as well as those from Stoneyhill Farm and Wester Clerkhill, is distinguished by the presence of the same types of cores, and these sites are probably contemporary with the Buchan Ridge mining operations.

Table 2. Reduction sequence of all unmodified and modified flakes and blades.

	Quantity					**Per cent**				
	B	*D*	*S Cluster*	*SW Cluster*	*Total*	*B*	*D*	*S Cluster*	*SW Cluster*	*Total*
Primary	102	15	11	7	135	14	24	6	15	13
Secondary	365	22	84	20	491	48	36	48	41	47
Tertiary	291	25	82	21	419	38	40	46	44	40
TOTAL	**758**	**62**	**177**	**48**	**1,045**	**100**	**100**	**100**	**100**	**100**

Table 2 shows that the flakes and blades are mostly cortical (*c*. 60%, with as much as 13% being primary flakes), and the cortex is generally smooth and abraded. The high cortex ratio, and the character of the cortex, suggest that flint may have been imported from the Buchan Ridge area in the form of raw pebbles, rather than prepared cores. This impression is supported by the retrieval of several abandoned early-stage core rough-outs at Wester Hatton (Table 1). Although relatively large pebbles and cobbles are available in the Buchan Ridge area – on top of the Gravels as well as below ground – the size of the Wester Hatton cores indicate that pebbles of up to *c*. 60mm were selected for transport.

In total, 139 pieces are burnt, with nine specimens being vitrified. The lightly burnt pieces show that a number of hearths were present in the area (see discussion of artefact distribution, below), but the vitrified pieces were probably affected by higher temperatures than those commonly experience in connection with domestic fireplaces, such as cremation pyres. Two vitrified pieces were found in Structure D and the SW Cluster, with most deriving from Structure B. Four of the vitrified specimens from the latter derive from the cremation pits 6266 and 6273.

STRUCTURE B

With 1,047 pieces, the sub-assemblage from Structure B is by far the numerically largest of the Wester Hatton sub-assemblages (57% of the total). In terms of typo-technological composition, it is mirrored by the sub-assemblage from the S Cluster approximately 10-15m towards the south-west. The flints from these two areas are both thought to date mainly to the later Neolithic, with the Structure B assemblage being supplemented by later artefacts. The collection includes 1,008 pieces of debitage, 30 cores, and nine tools.

Debitage

The 1,008 pieces of debitage embrace 570 chips, 364 flakes, 30 blades, 24 microblades, 13 indeterminate pieces and seven crested pieces. As shown in Table 3, the flakes and blades consist of roughly equal numbers of hard-hammer and bipolar pieces (44% and 41%, respectively), supplemented by some soft-hammer specimens (6%). A total of 29 flakes, blades, microblades and crested pieces have finely faceted platform remnants, showing that they were detached from Levallois-like cores. In Scotland, the Levallois-like technique was in use during the Middle and Late Neolithic periods (Ballin 2011 [Brit Mus]). Thirteen flakes (4%) display *Accident Siret* ('split-bulb fractures'), testifying to the application of robust reduction techniques.

Fifty-four pieces (3% of the assemblage total) are burnt, with seven of these being vitrified or 'borderline vitrified'. The lightly burnt pieces may be objects which accidentally fell into domestic fireplaces, whereas the more heavily burnt ones may relate to 'special events' like cremations – four of the seven vitrified pieces are from Cremation Pits 6266 and 6273.

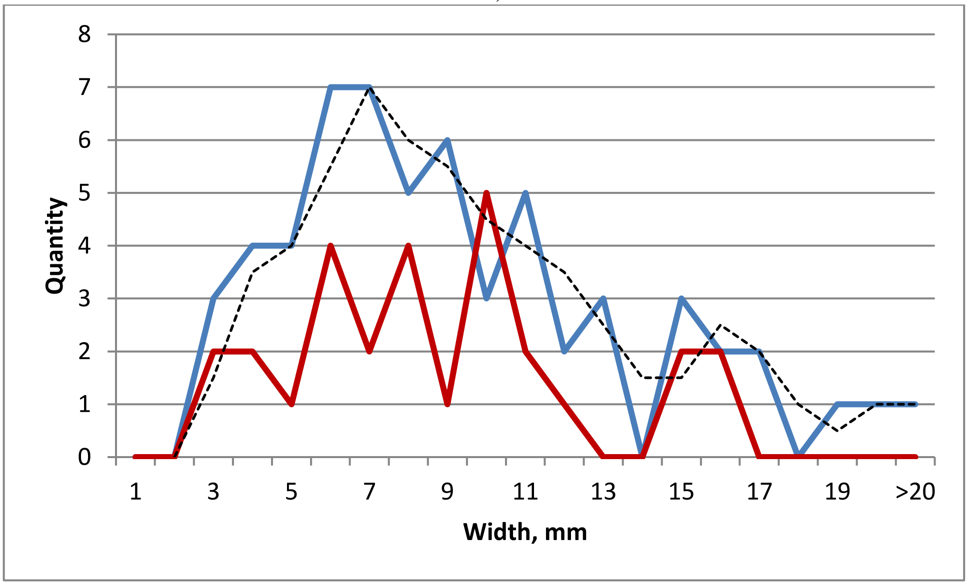
Table 3. Applied percussion techniques: definable unmodified and modified flakes and blades from the four main areas within Wester Hatton.

	Quantity	Per cent

	B	D	S Cluster	SW Cluster	Total	B	D	S Cluster	SW Cluster	Total
Soft percussion	17		15	2	34	6		13	7	7
Hard percussion	131	5	74	11	221	44	12	64	38	46
Indet. platf. technique	13		11		24	4		9		5
Platform collapse	14	3	10	1	28	5	7	9	3	6
Bipolar technique	121	35	6	15	177	41	81	5	52	36
TOTAL	**296**	**43**	**116**	**29**	**484**	**100**	**100**	**100**	**100**	**100**

The sub-assemblage includes too few intact blades to display those in a typical XY-diagram (length:width), but Fig. 1 gives an impression of the width and thus general size of the blades and microblades from the area. The width of the largely contemporary pieces from the S Cluster are shown for comparison. The microblades and broadblades clearly form a continuum of specimens with widths of *c*. 3-13mm, with the curve peaking at *c*. 6-10mm. Compared to other later Neolithic assemblages, such as Stoneyhill Farm and Midfield in Aberdeenshire (Suddaby & Ballin 2010; Ballin 2010 [Midfield]), the blades from Wester Hatton are quite small and include a fair number of microblades. However, the blades as well as the microblades include Levallois-like pieces, and most of these are clearly contemporary. There is a tendency for the larger blades to have pronounced bulbs of percussion, whereas the smaller ones have more discrete bulbs. Two delicate soft percussion microblades (probably produced by the application of pressure-technique) form a small separate group (CAT 1045, 1763) – they probably date to the Late Mesolithic/Early Neolithic period.

Fig. 1. The width of all unmodified blades and microblades from Structure B (blue) and the South Cluster (red) (59 and 28 pieces, respectively). A trendline (moving average) has been inserted to even out some of the random statistical fluctuations caused by the relatively low number of blades (stippled line).



The 13 indeterminate pieces are generally fragments of objects which disintegrated either due to exposure to fire (one-third of these pieces are burnt) or due to internal impurities. One piece

(CAT 1798), for example, was conjoined with other bits of debris and a bipolar core (Refit Complex 1795-99), and the original pebble simply fell apart when it was placed on an anvil and struck.

Seven crested pieces were recovered from the site, but no core rejuvenation flakes. Two (CAT 1839-40) are bilateral, with small flakes detached to either side of the dorsal ridge, whereas five (CAT 1804, 1814, 1817, 1837, 1841) are unilateral, with small flakes detached to one side of the ridge only. The former may relate to the initial shaping of the Levallois-like cores, and the latter to adjustments made during blank production. CAT 1814 is a blade (37 x 18 x 12mm), whereas the others are elongated flakes (av. dim.: 30 x 18 x 8mm). CAT 1804 has retained parts of the corner where a faceted platform meets the lateral crest, showing that this piece was detached from a Levallois-like core.

Cores

In total, 30 cores were recovered during the excavation at Wester Hatton. They include the following core types: Three single-platform cores (incl. one rough-out); eight Levallois-like cores (incl. three rough-outs); and 19 bipolar cores (incl. one split pebble).

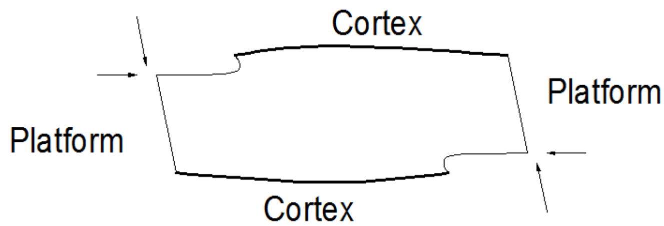
The dimensions (L x W x T) of cores are measured in the following ways: in the case of platform cores, the length is measured from platform to apex, the width is measured perpendicular to the length with the main flaking-front orientated towards the analyst, and the thickness is measured from flaking-front to the often unworked/cortical 'back-side' of the core. In the case of bipolar cores, the length is measured from terminal to terminal, the width is measured perpendicular to the length with one of the two flaking-fronts orientated towards the analyst, and the thickness is measured from flaking-front to flaking-front. More 'cubic' cores, like cores with two platforms at an angle and irregular cores, are simply measured in the following manner: largest dim. by second-largest dim. by smallest dim.

Single-platform cores: CAT 1812 is a rough-out for a single-platform core (34 x 33 x 24mm). It had a primary flake removed at one end to create a platform, followed by the detachment of a single flake. The removal of this flake revealed a relatively large internal cavity, and the core was immediately discarded.

Two 'proper' single-platform cores include a relatively cubic piece (CAT 1827), measuring 32 x 31 x 32mm, and a broad piece (CAT 1816), measuring 27 x 41 x 37mm. The former has a plain platform and the latter a faceted platform, and they are both untrimmed, with a cortical 'back-side'. They were discarded when the development of deep hinge- and step fractures dug into the flaking-front, making further systematic blank production impossible. Incipient circular impact scars on the platforms show that both cores were reduced by the application of hard percussion.

Levallois-like cores: This category includes three rough-outs (CAT 1824, 1832-33), and five smaller exhausted specimens (CAT 1813, 1829, 1835-36, 1843). CAT 1824 is a highly irregular rough-out, which was abandoned when internal impurities made the piece flake in an uncontrolled manner (GD 40mm). CAT 1832 and CAT 1833 have surviving cortex on either face, showing that these pieces are based on flat pebbles. The former is a relatively large specimen (59 x 53 x 30mm). It has a neat faceted platform at one end, and a small number of flakes were detached in an attempt to shape the first lateral crest and the flaking-front, but without completing these tasks. It is difficult to say why this piece was abandoned, but the flint appears to be impure and dense and may have been difficult to control. CAT 1833 is slightly smaller (47 x 42 x 23mm) and has a faceted platform at either end. It was attempted to develop a flaking-front on either face, by detaching flakes from either platform, but this rough-out was also abandoned, possibly due to impurities and the development of deep hinge fractures.

Fig. 2. The unsuccessful attempts to prepare a Levallois-like core (CAT 1833) by first shaping a platform at one end and developing a flaking-front, and then shaping a platform at the other end, and developing a flaking-front across the opposite face.



The five Levallois-like cores embrace three single-platform variants (CAT 1835-36, 1843) and two opposed-platform variants (CAT 1813, 1829). They all have either one single or two opposed faceted platforms, and they all have a domed cortical lower face. The sizes of the various sub-categories – rough-outs, single-platform and opposed platform variants – are shown in Fig. 3 and Table 4. Table 4 shows how the Levallois-like cores from Structure B gradually grew smaller as they developed from rough-outs to single-platform variants, and then finally to opposed-platform variants.

Fig. 3. The length and width of the intact Levallois-like cores from Structure B: Roughouts (black); single-platform variants (red); and opposed-platform variants (blue).

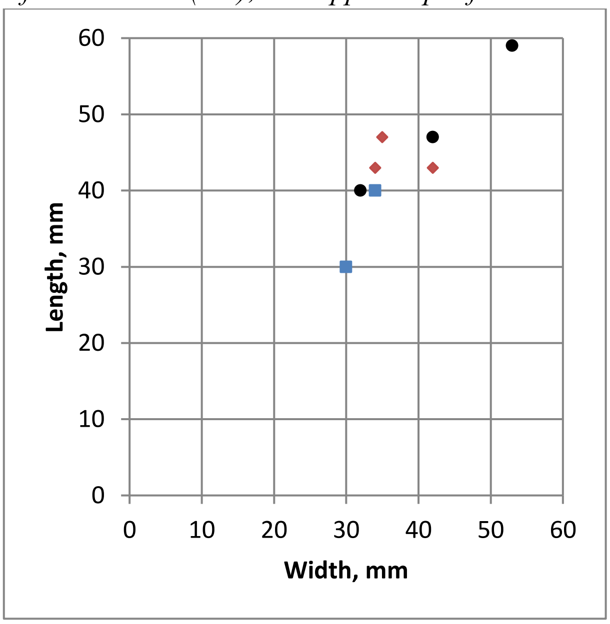


Table 4. The average dimensions of the various sub-categories of the Levallois-like cores from Structure B.

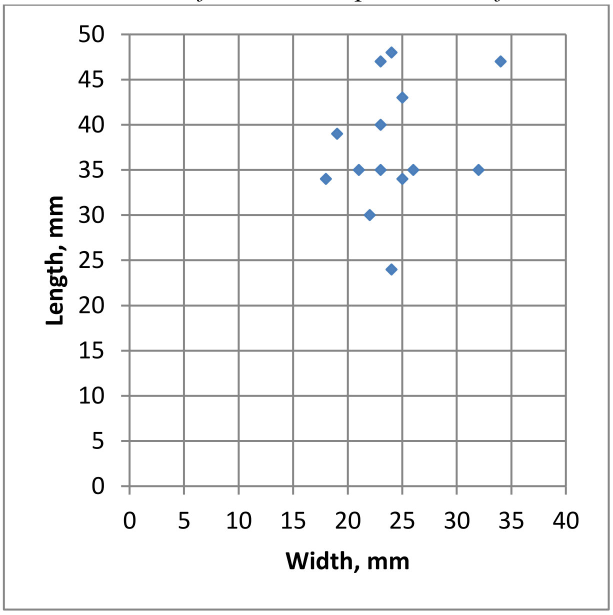
	Length	*Width*	*Thickness*
Rough-out	49	43	24

Single-platf.	44	37	20
Opposed-platf.	35	32	20

Single-platform core CAT 1835 was simply abandoned when it became too small (thin) for further reduction to take place, whereas all the other Levallois-like cores were discarded due to the development of deep hinge- or step-fractures.

Bipolar cores: The 19 bipolar cores include a number of different sub-types. One piece (CAT 1815) is a small pebble (33 x 31 x 22mm) from which one flake was removed by bipolar technique; eight pieces are unifacial cores (with one cortical face); whereas 10 are bifacial cores (with two opposed flaked faces). Seventeen of the cores have one reduction axis (one set of opposed terminals), whereas only one has two (two sets of opposed terminals). The average size of the seven cores is 37 x 24 x 13mm (Fig. 4). The bipolar cores from Structure B are considerably larger than those from Structure D (Fig. 5), which may reflect the application of different operational schemas. At Structure D, the reduction clearly focused on bipolar technique, and although some platform flakes are present, it appears that flakes were mainly produced by reducing pebbles entirely by anvil technique. In contrast, some of the bipolar cores from Structure B may represent the final exhaustion of Levallois-like cores by bipolar technique. This hypothesis is supported by the cores from the S Cluster, where Levallois-like technique was also practiced. Two bipolar cores from this area have average dimensions of 41 x 34 x 19mm.

Fig. 4. The dimensions of the intact bipolar cores from Structure B.



It was possible to conjoin a number of bipolar cores and bipolar flakes, shedding light on several interesting issues.

<u>Refit Complex 1793-94</u>: This complex consists of one bipolar core and one orange-segment flake and, when conjoined, it is obvious that both were created at the same time, namely when a pebble was held on an anvil and violently struck with a hard hammerstone. This process is demonstrated more clearly by a fully refitted original pebble from Lundevaagen 21

from SW Norway (Figs 5-6). Fig. 5 shows the refitted pebble from Lundevaagen 21, and Fig. 6 the exploded pebble (Ballin 1999). In this case, two of the pieces were initially defined as unifacial bipolar cores, and the other two as bipolar orange-segment flakes. Philosophically speaking, it could be claimed that all four pieces are cores or that all are orange-segment flakes. In the greater picture this means, that the classification of bipolar cores and flakes may vary from analyst to analyst. Refit-complex 1793-94 corresponds to half of the complex from the Norwegian site.

Fig. 5. Refitted anvil-struck pebble from Lundevaagen 21, SW Norway.

Fig. 6. The exploded pebble shown in Fig. 5.

Refit Complex 1795-99: This complex consists of one bipolar core (CAT 1795), and a number of flakes fragments and indeterminate pieces. Combined, these pieces almost make up the entire original pebble. This complex demonstrates the poor quality of some of the flint used at Structure B, characterized by internal weaknesses like chalk balls, fossils, micro crystals, fault planes, etc. In the present case, these weaknesses simply caused the pebble to disintegrate the moment it was placed on an anvil and struck.

Refit Complex 1805-06: This complex consists of one bipolar core (CAT 1805) and one bipolar blade (CAT 1806). As in the case of Refit Complex 1795-99, this complex collapsed due to internal impurities and irregular flaking properties.

Tools

During the archaeological investigations of the Wester Hatton site, nine tools were retrieved (Table 1): Two scrapers, four serrated pieces, one polished-edge implement and two pieces with edge-retouch.

Scrapers: This category includes one short end-scraper and one side-scraper. The end-scraper (CAT 1911) is based on a relatively large bipolar core (36 x 27 x 11mm), and it has a surviving bipolar terminal at one end, whereas the opposed terminal was transformed into a convex, steep scraper-edge. The side-scraper (CAT 1821), on the other hand, is based on a large indeterminate broadblade (50 x 17 x 8mm), and it has a straight to slightly convex, steep scraper-edge along either lateral side.

Serrated pieces: The serrated pieces form a heterogeneous group, with the blanks including one large bipolar flake (CAT 1823), two blades (CAT 1825, 1838) and one microblade (CAT 1819). Size-wise, the two extremes are CAT 1823 (51 x 33 x 10mm) and CAT 1819 (24 x 7 x 3mm). The serration usually only covers part of one lateral side, but that of CAT 1823 covers the entire left lateral side. In two cases (CAT 1823, 1825) the teeth are so worn that it was not possible to calculate a 'teeth-per-centimetre' ratio, but CAT 1819 has six teeth per cm, and CAT 1838 has 16 teeth per cm. It was possible to refit the serrated microblade CAT 1819 dorsal-ventrally with another microblade (CAT 1820). The blank of CAT 1825 is a Levallois-like blade.

Serrated flints ('micro-denticulates') are generally relatively rare in Scottish prehistoric assemblage, and most seem to be Neolithic. The best comparison for the serrated pieces from Wester Hatton are those from the Neolithic settlements at Stoneyhill Farm in Aberdeenshire (Suddaby & Ballin 2010), where several finely serrated narrow blades were recovered (up to 17 teeth per cm). Several of these pieces were found in Middle Neolithic contexts.

Polished-edge implements: One polished-edge implement was retrieved from the site (CAT 1828). It is based on an elongated indeterminate flake (48 x 28 x 8mm), and it has notable abrasion along both lateral sides, proximal end. The abraded areas are associated with edge-retouch. The abrasion corresponds more to the rough abrasion noticed on many pieces from the Mesolithic Zone 5 scatter (Site 2D; this volume) than to the smooth, mirror-like polish noticed on pieces from the later Neolithic sites Overhowden and Airhouse in the Scottish Borders (Ballin 2011 [BAR]).

Pieces with edge-retouch: This category comprises two pieces. They differ considerably in shape and size (av. dim.: GD 22-37mm). This tool group probably includes artefacts and fragments of artefacts with different functions.

Technological summary

This technological summary is based on information presented in the raw material, debitage, core and tool sections above. The diagnostic lithic and ceramic material (Table 5) indicates that the finds may mainly date to the later Neolithic. However, a radiocarbon-sample from Ditch 6238 returned an Early Bronze Age date (1747-1566 cal BC; SUERC-73583), suggesting that the structure and possibly some of the lithics might date to this period. This is supported by the distribution patterns, where the finds from Ditch 6238 and from the entrance area towards the east differ notably in typo-technological terms. It is suggested that the finds from the entrance area may largely be of a Middle Neolithic date, whereas those from Ditch 6238 may largely be of an Early Bronze Age date (see dating section). Most other parts of the structure and its surroundings were almost entirely devoid of lithic artefacts.

The entrance area: This part of Structure B is characterized by a combination of reduction techniques, such as 'standard' single-platform technique, Levallois-like technique, and bipolar technique. As suggested by the finds from later Neolithic sites like Stoneyhill Farm (Suddaby & Ballin 2010) and Wester Clerkhill (Ballin & Cameron forthcoming), these three techniques were commonly used during the later Neolithic, and to a degree combined within different operational schemas. These schemas include:

1. Production of flakes from single-platform cores by the application of hard percussion; these cores were then exhausted completely by the application of bipolar technique.
2. Production of flakes and blades from Levallois-like cores, which would then be exhausted by bipolar technique. The Levallois-like cores appear to have been worked partly by hard percussion and partly by soft percussion, where the hard:soft ratio of the site's Levallois-like flakes is 77:23, and that of the Levallois-like blades/microblades 43:57.
3. The reduction of pebbles by bipolar technique only.

The Levallois-like technique included the production of crests along both lateral side, and most of Structure B's crested pieces are thought to derive from Levallois-like cores. This approach is dealt with further in the discussion section.

Ditch 6238: As shown in Table 5, the finds from the southern ditch includes no Levallois-like cores or flakes/blades, and the lithics are almost entirely bipolar cores and flakes/blades (see below). Evidence from Bronze Age sites in Aberdeenshire (such as the Kingfisher Industrial Estate, Aberdeen; Ballin 2008 [Kingf]) suggests that, in this part of Scotland, Bronze Age knappers preferred to produce flakes by bipolar technique rather than flakes and blades from platform-cores.

Distribution

It is thought that Structure B is the remains of a Bronze Age house, with the two ditch segments indicating the position of a wall-line. The opening between the two ditch segments towards the east may indicate the position of an entrance area. The inner part of the structure is characterized by the presence of two larger pits, whereas the entrance area is characterized by the presence of a large number of pits and postholes. It is uncertain exactly how (or if) the various features relate to each other and to Structure B.

Table 5. The distribution of contexted diagnostic elements across Structure B.

	C Pit	S Ditch	N Ditch		Entrance area											Total
	6240	*6238*	*6243*	*6294*	*6252*	*6254*	*6258*	*6264*	*6265*	*6266/73*	*6269*	*6278*	*6282/84*	*6287*	*Surf/top*	
Debitage	7	279	16	1	8	5	1	37		166	15	99	332	18		984
Crested pieces		1						1		1			4			7
Single-platform cores								1	1	1						3

Levallois-like cores								1		1		1	4		1	8
Levallois-like flakes		1								8		6	8	1		24
Bipolar cores		11						1		2		2	1	1	1	19
Serrated												3	1			4
Polished-edge imps										1						1
Burnt		8	3							12	2	8	14	3		50
Vitrified										4		1	2			7

Table 5 shows the distribution of diagnostic lithic elements, as well as elements important to the interpretation of the structure and its surroundings. There are two main concentrations of lithics, namely one from the entrance area (711 finds) and one from the southern ditch (291 finds). Both groups of finds are notably dominated by debitage and in both cases the debitage is heavily dominated by minuscule chips, suggesting that both concentrations consist mainly of residual knapping debris which generally entered the features with the backfill.

On the basis of the presence of burnt bone, it was suggested (Spanou 2017, 104) that Pits 6266 and 6273 may be cremation pits. This interpretation is supported by the presence in these features of vitrified (superficially glazed) flint, indicating fires reaching higher temperatures than one would expect from a domestic hearth (cf. Ballin 2012 [Skilm]), but although these pieces of flint may have been in contact with a funeral pyre, they do not necessarily represent grave goods and deliberate deposition. All vitrified pieces from Structure B are simple flakes or flake fragments, and they are more likely simply to be residual pieces present at the site of the pyre, thus predating the cremation pits.

The composition of the sub-assemblages from the entrance area and the southern ditch differ considerably. The former includes eight Levallois-like cores and 19 bipolar cores (including the solitary split pebble), reflecting the combined technological approach one would expect from a later Neolithic site (cf. Suddaby & Ballin 2010; Ballin & Cameron forthcoming). In addition, this area also includes a number of likely later Neolithic implements, such as a side-scraper on a very large blade; four serrated pieces (cf. Suddaby & Ballin 2010); and a polished-edge implement (cf. Ballin 2011 [BAR]). In contrast, all 11 cores from the southern ditch are bipolar cores, and the technologically definable blanks from this feature are heavily dominated by bipolar specimens: 85% of the flakes are bipolar; 89% of the blades are bipolar; and 100% of the microblades are bipolar. This sub-assemblage includes no formal tools.

The most sensible interpretation of events at this location is that there were two knapping floors in this area – a later Neolithic one towards the east (‘the entrance area’) and a Bronze Age one towards the west (‘southern ditch’) – and that at a later stage a Bronze Age house was built at the location and some pits (including cremation pits) were dug, with residual Neolithic and Bronze Age flints (as well as some pottery; see elsewhere in this volume) entering the features of the house with the backfill. Two microblades from the northern ditch, produced by pressure-technique, probably represent a very brief visit to the site in Late Mesolithic/Early Neolithic times.

The sub-assemblage from the S Cluster (below), situated 10-15m south of Structure B, is composed very much like the sub-assemblage from Structure B's entrance area. As no features were found and investigated between the S Cluster and Structure B, it is uncertain whether these two later Neolithic knapping floors may have formed part of one very large scatter, or whether they represent different visits to the site at different times during this period.

Dating

As touched upon above, the sub-assemblage from Structure B may include finds from the later Neolithic as well as the Early Bronze Age, with later Neolithic artefacts concentrating in the structure's entrance area, and Early Bronze Age finds in the southern ditch (distribution section). The dating evidence includes typological and technological elements, as well as radiocarbon dates and associated pottery.

Typology: The only strictly diagnostic types recovered at the structure are eight Levallois-like cores, which are all datable to the later Neolithic (the Middle or Late Neolithic periods) (see immediately below). Apart from the polished-edge implement (CAT 1828), none of the tool types is strictly diagnostic. Polished-edge implements are generally found in later Neolithic contexts (cf. Ballin 2011 [BAR]). So far, the only exception from this rule is the concentration of heavily abraded flints recovered from Zone 5 at Site D (see elsewhere in this volume), where they were associated with Late Mesolithic finds. At Site D the concentration of polished-edge implements had the exact same distribution as the Mesolithic objects.

Four finely serrated pieces ('micro-denticulates') were also retrieved from the entrance area (CAT 1819, 1823, 1825, 1838), and although in Scotland individual serrated pieces may be found throughout the post Mesolithic period, they are most commonly found in later Neolithic contexts. At Stoneyhill Farm (Suddaby & Ballin 2010), six serrated pieces were recovered from four different areas, but it was only possible to date two of the areas safely: Cairn 7/17 deposit 7183 and Trench 1/Grid J were both dated to the later Neolithic period by the presence of Levallois-like cores and flakes/blades. Side-scraper CAT 1821, also from the entrance area, is not typologically diagnostic, but the fact that it is based on a very large blade suggests that it may form part of this group of later Neolithic objects.

Technology: It is significant that it is possible to subdivide Structure B into two chronological zones, the entrance area and the southern ditch, characterized by different technological approaches. The former area is associated with a combined approach, Levallois-like technique and bipolar technique, whereas the latter is characterized by the almost exclusive use of bipolar technique. In connection with the analyst's processing of lithic assemblages from eastern Scotland, Table 6 was produced, suggesting a sequence of techno-complexes within this region. This model should be perceived as a working model in need of corroboration and adjustment.

Table 6. The techno-complexes of East of Scotland and their diagnostic lithic elements (Ballin 2008 [Kingf]; 2010 [Midmill]; 2013 [Neth]; Ballin 2016 [Garth]; Suddaby & Ballin 2010; Ballin et al. 2017 [Blackdog]). This generalized model was produced in connection with an investigation of lithics from museums in Moray (Ballin 2014# [Moray]).

Techno-complex	*Period*	*Raw material*	*Target blanks*	*Percussion technique*	*Diagnostic microliths/arrowheads*	*Key Aberdeenshire sites*
1	Early Mesolithic	Local flint	Broad blades	Soft/practically no bipolar	Broad microliths	Nethermills, Banchory

2	Late Mesolithic	Local flint	Microblades	Soft/practically no bipolar	Narrow microliths	Nethermills, Banchory
	Early Neolithic	Local flint	Microblades/ broad blades	Soft/practically no bipolar	Leaf-shaped points	Garthdee Road, Aberdeen
3	Middle Neolithic	Exotic light-grey/local flint	Broad blades	Hard (Levallois-like)/bipolar	Chisel-shaped points	Stoneyhill, Peterhead
	Late Neolithic	Exotic dark-grey/local flint	Broad blades	Hard (Levallois-like)/bipolar	Oblique points	Midmill, Kintore
4	Early Bronze Age	Local flint	Flakes (schematic operational schema)	Bipolar/hard	Barbed-and-tanged points	Kingfisher Est., Aberdeen
5	Later Bronze Age	Local flint	Flakes (unschematic operational schema)	Bipolar/hard	None	Blackdog, north of Aberdeen

The finds from the entrance area fit Table 6's Techno-complex 3, that is, an approach based on the production of flakes and blades from Levallois-like technique. The applied percussion technique may mainly have been hard percussion, but some of the finer blades were produced by the application of soft percussion (probably punch technique rather than the pressure technique applied throughout most of Techno-complex 2), and bipolar technique was also used, partly to exhaust the Levallois-like cores completely and partly to reduce smaller pebbles. The finds from the southern ditch fit Techno-complex 4, that is, practically all flakes were produced by the application of bipolar technique. The Early Bronze Age form of bipolar technique is well-controlled compared to the more unschematic form of bipolar technique experienced in connection with later Bronze Age assemblages (eg, Blackdog, a few kilometres south of Wester Hatton; Ballin *et al.* 2017) and Early Iron Age assemblages (eg, Burland, Trondra, Shetland; Ballin 2014# [Burl]). This spatial sub-division of Structure B into technological zones is further supported by the radiocarbon-dates, with a sample from the entrance area returning a Middle Neolithic date and a sample from the southern ditch an Early Bronze Age date (see below).

Two soft percussion microblades (CAT 1045, 1763) were probably produced by the application of pressure technique and may represent a brief visit to the area during the Late Mesolithic/Early Neolithic period. One is a stray find and the other is one of the exceptionally rare lithic finds from the northern ditch (Feature 6243).

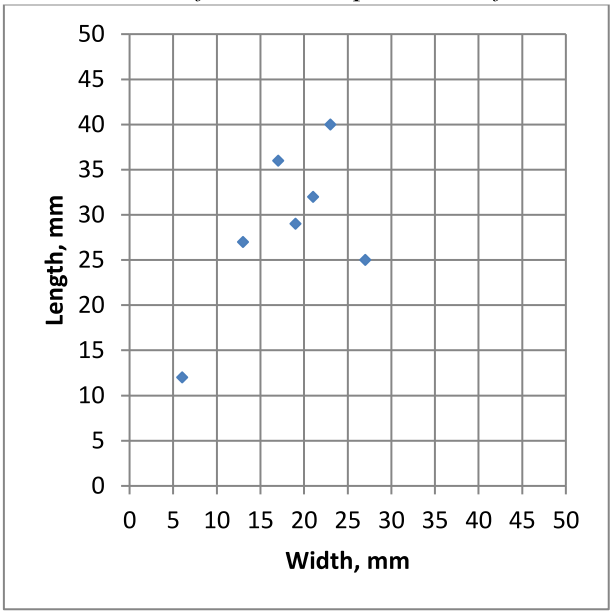
Radiocarbon-dates: As briefly touched upon above, two radiocarbon-dates were obtained from Structure B, one from Pit 6269 in the entrance area, and one from the southern ditch, Feature 6238. The sample from Pit 6269 suggested activity in the area in the Middle Neolithic (3312-2920 cal BC; SUERC-74399), and the sample from the ditch indicated activity during the Early Bronze Age (1747-1566 cal BC; SUERC-73583).

Dating summary: Combined, the dating evidence suggests the following sequence of events: A brief visit to the area (northern ditch) during the Late Mesolithic/Early Neolithic period was followed by, first, a substantial knapping episode (entrance area) during the Middle Neolithic, and, then, a substantial knapping episode (southern ditch) during the Early Bronze Age. The latter two knapping floors may have overlapped slightly. Finally, a probably Bronze Age house was built on top of the knapping debris, and a significant number of pits (including cremation pits) and postholes were dug through this debris. The exact chronological relationship between the various ditches, pits and postholes is uncertain.

STRUCTURE D

A modest sub-assemblage of 128 pieces was recovered from Structure D, including 119 pieces of debitage, seven cores, and two tools. The debitage includes 56 chips, 57 flakes, two blades, one microblade, and three indeterminate pieces. Most of the flakes are bipolar specimens, whereas five are hard-hammer flakes. Two of the latter are Levallois-like pieces, indicating a later Neolithic presence at the location. Only one of the two blades was technologically definable, and it is a bipolar piece.

Fig. 7. The dimensions of the intact bipolar cores from Structure D.



The seven cores are all bipolar specimens. Three pieces are unifacial cores, whereas four are bifacial cores. Six of the cores have one reduction axis, whereas one has two. The average size of the seven cores is 29 x 18 x 9mm (Fig. 7).

In addition, this sub-assemblage includes two tools, namely one short end-scraper (CAT 1770) and one scale-flaked knife (CAT 1844). CAT 1770 is the broken-off scraper-edge of a vitrified implement (24 x 20 x 8mm), and its working-edge is highly regular, convex and steep. Overhanging areas along this edge indicates that the piece is well-used. The vitrification of this tool implies that it might have formed part of a package of grave goods following a deceased person onto the funeral pyre. Although CAT 1770 was found within the general fill of Ditch 6030 (Fill 6028), a cremation burial had been inserted into the ditch (Pit 6155), and it is possible that the scraper former part of this context, but was redeposited (bioturbation?). Pottery from the ditch suggests a Middle Neolithic date for the ditch and its knapping debris, but it can not be ruled out that the cremation is later.

Scale-flaked knife CAT 1844 is an oval bipolar flake (32 x 22 x 5mm) with cortical blunting along the left lateral side, whereas semi-invasive retouch along the entire right lateral side forms a cutting-edge. This piece is unstratified, and its date is uncertain. The scale-flaking only indicates a date within the Early Neolithic – Early Bronze Age period (Clark 1936, 47).

Two flint-bearing parts of Ditch 6030 were radiocarbon-dated to the Middle to Late Bronze Age period. One sample provided the date 1210-1015 cal BC (SUERC-73585) and and another sample the date 1260-1047 cal BC (SUERC-73386).

SOUTH CLUSTER

The sub-assemblage from the S Cluster is relatively large (450 pieces) and its composition, in conjunction with its location 10-15m south-west of Structure B, suggests that it may be contemporary with parts of this site (discussed below and in the Structure B section).

The collection embraces 441 pieces of debitage, seven cores, and two tools. The debitage includes 264 chips, 143 flakes, 17 blades, 11 microblades, two indeterminate pieces, three crested pieces, and one platform rejuvenation flake. As shown in Table 7, the sub-assemblage is dominated by hard-hammer flakes, supplemented by soft-hammer specimens, with bipolar flakes being rare. Seventeen of the flakes (12%) are Levallois-like pieces with finely faceted platform remnants. Five flakes (4%) display *Accident Siret* ('split-bulb fractures'), testifying to the application of robust reduction techniques.

Table 7. Applied percussion techniques: definable unmodified and modified flakes and blades from the South Cluster.

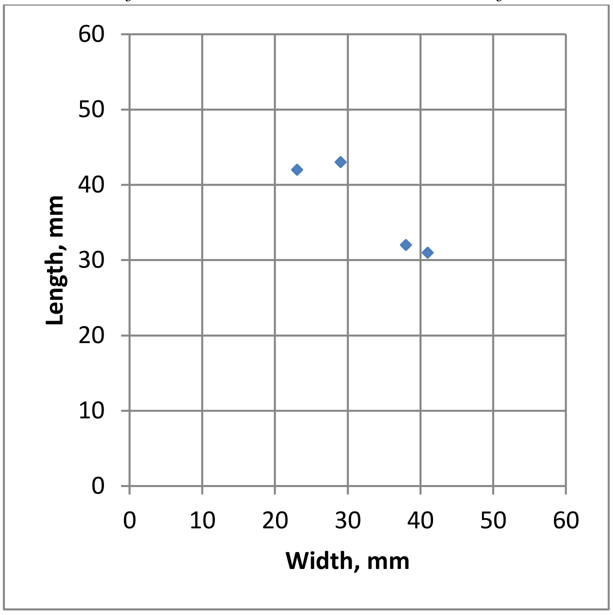
	Quantity	*Per cent*
Soft percussion	15	13
Hard percussion	74	64
Indet. platf. technique	11	9
Platform collapse	10	9
Bipolar technique	6	5
TOTAL	**116**	**100**

The 28 blades and microblades include soft-hammer and hard-hammer specimens (soft:hard ratio *c.* 1:2), showing that more delicate approaches were generally applied when detaching these blanks than when flakes were manufactured. The three crested pieces include two intact specimens with an average size of 23 x 15 x 5mm. Crested flake CAT 1787 is a broad, probably failed piece, and the type of flint (very dark, fine-grained, small-dotted flint) suggests that it may have been part of the same nodule as single-platform core CAT 1784. Core tablet CAT 1792 was initially classified as a crested piece, but it was conjoined to the apex of single-platform core CAT 1784, and it is clearly a detached platform (see below). CAT 1784Only one burnt piece was recovered.

The seven cores embrace five platform cores and two bipolar cores. The former are one single-platform core (CAT 1784) and four Levallois-like cores (CAT 1780-81, 1785-86). CAT 1784 is a medium-sized core (38 x 31 x 23mm) with a plain, untrimmed platform, and a cortical 'back-side'. On its own, this piece has all the attributes defining a single-platform core, such as a well-defined platform at one end, and a flaking-front characterized by flake and blade scars which all have their negative bulb-of-percussion below the edge of this platform. However, a platform rejuvenation flake (CAT 1792) was conjoined with the apex of this single-platform core, demonstrating that it was once an opposed-platform core

The Levallois-like cores (Fig. 8) form a heterogeneous group, including one rough-out (CAT 1781), two single-platform variants (CAT 1780, 1785), and one opposed-platform variant (CAT 1786). They all have a domed cortical lower face.

Fig. 8. The dimensions of the intact Levallois-like cores from the South Cluster.



The roughout is based on a relatively flat flake, which had its proximal end modified into a faceted platform, and attempts were made to form crests along both flanks. Like the rough-out, CAT 1780 is clearly based on a flake blank. It was abandoned after a solitary flake was detached from its flaking-front. Although it has had a faceted platform formed at one end, it does not appear to have had any crests made, and this piece may be a rough-out rather than a single-platform core. CAT 1785 is a broad, short piece and it shows similarities with traditional single-platform cores with cortical 'back-sides'. However, its relative flatness, combined with its neatly faceted platform, defines it as a Levallois-like core. CAT 1786 is a completely exhausted specimen, with a faceted platform at either end. The four Levallois-like cores have an average size of 37 x 33 x 15mm (Fig. 8).

The two bipolar cores include one unifacial piece (CAT 1783) and one bifacial piece (CAT 1782). The former has one reduction axis, whereas the latter has two. The fact that CAT 1782 has spots of cortex on either main face shows that this piece is based on a flat pebble. CAT 1783, on the other hand, has the remains of a faceted platform at one end (most of which has been crushed by bipolar 'bashing'), showing that during the later Neolithic of eastern Scotland some Levallois-like cores were indeed exhausted by the application of bipolar technique, with these two core types, at least occasionally, forming parts of a common operational schema. The two bipolar cores are relatively large, having an average size of 41 x 34 x 19mm. Two flakes with edge-retouch (CAT 1788, 1791) could not be defined more precisely.

All finds derive from three roughly equally sized pits (length x width *c.* 0.5 x 0.5m, and with depths of *c.* 0.1-0.4m), namely Pits 6228, 6232, and 6234. Almost the entire sub-assemblage (95%) was recovered from Pit 6234, including all the cores and tools. As almost 60% of all finds from the latter pit is in the form of minuscule chips, it is almost certain that the flint is residual knapping debris, and that it entered the features with the backfill. Considering the large number of finds retrieved from Pit 6234, including seven cores (four of which are Levallois-like), it is beyond doubt that the knapping floor dug through by the pit diggers was of notable magnitude.

The Levallois-like cores, flakes and blades are all datable to the later Neolithic period. This date is corroborated by pottery from Pits 6228 and 6234, with some sherds being defined as deriving from vessels identified as Modified Carinated Bowls (specifically North-Eastern modified Carinated Bowls or CBNE) and Impressed Ware.

For a more detailed discussion of the Levallois-like technique and its products, see the Structure B section and the discussion section.

SW CLUSTER

With 139 pieces, the sub-assemblage from the SW Cluster is numerically comparable to the one from Structure D, and it has a similar composition. The lithic collection includes 133 pieces of debitage, five cores, and one tool. The debitage embraces 85 chips, 41 flakes, two blades, and five microblades. However, where the flakes from Structure D were almost entirely bipolar (hard-hammer:bipolar ratio 07:87), those from the SW Cluster include roughly equal number s of hard-hammer and bipolar specimens (ratio 42:58). The debitage from the SW Cluster also includes two soft percussion microblades, both of which are thought to date to the Late Mesolithic/Early Neolithic period. In contrast to the sub-assemblages from Structure B, Structure D, and the S Cluster, the one from the SW Cluster contains no Levallois-like flakes at all.

The five cores (CAT 1771-73, 1775-76) are all bipolar specimens, two of which are fragmented. Three are unifacial, and one bifacial, and they all have one reduction axis. The average size of the three intact pieces is 31 x 18 x 10mm.

In addition, this sub-assemblage includes one tool, namely the basal fragment of a leaf-shaped arrowhead (CAT 1774), which was recovered from Pit 6066. The arrowhead broke into two halves, and the fact that the recovered fragment (13 x 18 x 3mm) has a tiny surviving part of a lateral angle allows the original piece to be identified as a kite-shaped arrowhead with a pointed base. Kite-shaped arrowheads are generally dated to the latest part of the Early Neolithic period, but it is possible that some are contemporary with early elements of the Scottish Middle Neolithic, such as Modified Carinated Bowls and early Impressed Ware, as well as the first imported Yorkshire flint and Levallois-like technique (discussed further below). It is quite possible that the flint used to make CAT 1774 is from north-east England.

The SW Cluster can be subdivided into a western and an eastern group of pits, but the worked flint in the features is the same throughout the area. A number of the pits only contained one, two or three pieces of debitage (Pits 6057, 6059, 6069, and 6075), whereas others contained 10-20 pieces of debitage (Pits 6051, 6055, 6061, and 6073; Pit 6061 also contained a bipolar core). Pit 6053 contained 27 pieces of debitage and two bipolar cores, and Pit 6066 contained 34 pieces of debitage, two bipolar cores, and one leaf-shaped point. A few fragments of highly regular microblades were recovered from the eastern as well as the western cluster.

Apart from the small number of probably Late Mesolithic/Early Neolithic microblades, both pit clusters within the SW Cluster yielded Modified Carinated Bowls and Impressed Ware, and it is possible that the kite-shaped arrowhead is contemporary with this pottery (see dating section). This suggests that most of the flint (apart from the microblade fragments) may date to the Middle Neolithic period (a radiocarbon sample from Pit 6051 returned a date of 3341-3095 cal BC; SUERC-74400), but that no Levallois-like knapping took place, as no Levallois-like cores or flakes were recovered. As most of the debitage is in the form of minuscule chips, the debitage is most likely to represent a knapping floor which predates the pits and which entered the features with the backfill.

THE NUMERICALLY SMALL SUB-ASSEMBLAGES

As shown in Table 1, only four areas yielded notable amounts of worked flint, namely Structure B (1,047 pieces), Structure D (128 pieces), S Cluster (450 pieces), and SW Cluster (139 pieces). All other areas (Structures A, C, and E, and the E and NE Clusters) only yielded four to 22 pieces each.

Structure A: The 22 finds from Structure A include nine chips, 12 flakes, and one bipolar core (CAT 1777). The flakes are mostly bipolar pieces, supplemented by one soft-hammer flake and one hard-flake. Most of the finds were found in Ditch 6096.

Structure C: This small sub-assemblage includes 17 pieces, all of which are debitage. The finds embrace nine chips, seven flakes and one blade. The flakes are roughly evenly distributed across hard-hammer and bipolar specimens, and the solitary blade is bipolar. All finds are from Ditches 6179 and 6193. A radiocarbon sample from the northern ditch, Feature 6179, returned a date of 1376-1121 cal BC, or the Middle Bronze Age period (SUERC-73584).

Structure E: Only nine flints were recovered from this structure, namely six chips and three flakes. Two of the flakes are bipolar and one is a hard-hammer flake. The finds were mostly from Pit 6038, with two deriving from Gully 6026, and one from Posthole 6040. The structure (Pit 6050) was radiocarbon-dated to 1112-927 cal BC, or the Late Bronze Age period (SUERC-73587).

E Cluster: This sub-assemblage includes 21 pieces, all debitage. Eight pieces are chips, supplemented by nine flakes, two microblades and two indeterminate pieces. The flakes are dominated by bipolar specimens, but one hard-hammer flake was also retrieved. One of the microblades (CAT 325) is a highly regular medial fragment (W – 4.8mm), and it may date to the Late Mesolithic or Early Neolithic period. All the finds were recovered from the large pit Feature 6188, and three-quarters of the pieces are burnt, suggesting that the feature may be a cremation pit. However, as most of the flints are minuscule chips, the finds are most likely residual pieces which were burnt accidentally in connection with the activities taking place in or around the pit. Burnt bone and Middle Neolithic pottery were found in the pit fills, but a radiocarbon sample returned a date of 1526-1421 cal BC (SUERC-74401), or the Middle Bronze Age period, supporting the suggestion of most of the lithic and ceramic finds being residual pieces, which entered a Bronze Age pit with the backfill.

NE Cluster: This is the numerically smallest sub-assemblage from Wester Hatton, and it includes three flakes and one indeterminate piece. Only one of the flakes was technologically definable and it was classified as a bipolar flake. The finds were recovered from Pits 6163 and 6167.

As the finds from these areas are almost exclusively small-sized debitage (apart from bipolar core CAT 1777), the lithic material is likely to be residual material – probably representing waste from knapping floors – which entered the pits with the backfill. It is generally not possible to say whether the flints predate the cut features by days, years, centuries or millennia. The only exception is the likely Late Mesolithic/Early Neolithic microblade CAT 325 from the E Cluster, which predates the probably Middle Neolithic Pit 6188 by centuries or millennia.

SUMMARY AND DISCUSSION

As all the lithic finds from Wester Hatton are from cut features, and as *c*. 55% of all the lithics are minuscule chips, most of the 1,839 pieces is probably residual knapping debris. Some vitrified pieces from cremation pits (eg, from Pits 6266 and 6273 in the entrance area of Structure B) may have been affected by the high temperatures of funeral pyres, but as these pieces are also plain knapping debris, rather than more 'special' pieces which might possibly have been selected for intentional deposition, these flakes are probably also residual pieces. Their association with the cremation pits may simply be that a funeral pyre was built on top of residual flint debris, and that some of these flakes then entered the cremation pits with the backfill.

The entire area appears to have been affected by prehistoric activity (Table 8), with lithic and pottery evidence covering the Late Mesolithic/Early Neolithic period (a handful of microblades), the Middle Neolithic period, and the Early Bronze Age, but most of the site's structures and pit clusters only yielded a few pieces of flint. Only four areas offered larger assemblages of flint artefacts, namely Structure B (1,047 pieces), S Cluster (450 pieces), Structure D (128 pieces), and SW Cluster (139 pieces). The radiocarbon dates support the dates suggested by and for the lithic evidence, but a string of Early, Middle and Late Bronze Age radiocarbon-dates may indicate that most of the structures (B-E) were built during the Bronze Age period.

Table 8. Summary of the dating evidence.

	Lithic and pottery evidence			Radiocarbon-dates				
	LM/EN	*Later Neo*	*Bronze Age*	*MN*	*EBA*	*MBA*	*MLBA*	*LBA*
Str. B				x	x			
Str D							x	
S Cluster								
SW Cluster				x				
Str A		Uncertain						
Str C		Uncertain				x		
Str E		Uncertain						x
E Cluster		Uncertain				x		
NE Cluster		Uncertain						

Although most of the lithic material is clearly plain knapping debris, these finds do shed light on a number of issues, such as raw material procurement, general technological developments through the prehistory of eastern Scotland, the Levallois-like technique, and kite-shaped arrowheads in relation to developments around the Early/Middle Neolithic transition.

Raw material procurement: Through most of Aberdeenshire prehistory, flint was procured from local beach walls and transported inland along the region's rivers. During the Mesolithic (eg, Nethermills Farm on the Dee; Ballin 2013) and Early Neolithic (eg, Garthdee Road, Aberdeen; Ballin 2016 [Garth]) periods this was probably the only flint source available in this part of the country. This changed during the later Neolithic period. At the transition between the Early and Middle Neolithic periods, flint was imported into Scotland from north-east

England, and during the Middle and Late Neolithic periods, assemblages in the Scottish Borders, Lanarkshire, and the Lothian counties are almost entirely in this type of flint (Ballin 2011 [BAR]). This form of flint has also been noticed in assemblages from eastern Scotland (eg, Midmill, Kintore; Ballin 2010). In eastern Scotland, an additional flint source was made available, when, during the Middle Neolithic period, quarrying of the Buchan Ridge Gravels began (Bridgland *et al.* 1997; Bridgland & Saville 2000 [Quat Banff]). These mining operations near Peterhead (the best-known centres being Den of Boddam and Skelmuir Hill) produced tonnes of flint cores and blanks, probably intended for settlements in the surrounding landscape.

Most of the flint from prehistoric sites in the region is fine-grained probably coastal material, and it has generally been difficult to quantify the use of Buchan Ridge flint on sites in eastern Scotland. However, a small number of later Neolithic assemblages include notable proportions of medium- and coarse-grained, somewhat flawed flint, and it is thought that this material may be Buchan Ridge flint. The present assemblage most likely consists of a mixture of coastal and Buchan Ridge flint, and the assemblage from Midmill near Kintore (Ballin 2010) is thought to include not only local and Buchan Ridge flint, but also notable proportions of Yorkshire flint (in Area 1 the latter is estimated at *c.* 35% of the sub-assemblage). Wester Hatton is located just over 30km from Den of Boddam, and Midmill *c.* 40km. Wester Clerkhill just north of Den of Boddam is based almost entirely on Buchan Ridge flint, but in this case the flint was probably collected in the vicinity of the site, having been scooped up by a north-moving glacier and 'dumped' in the area around Peterhead (Ballin & Cameron forthcoming).

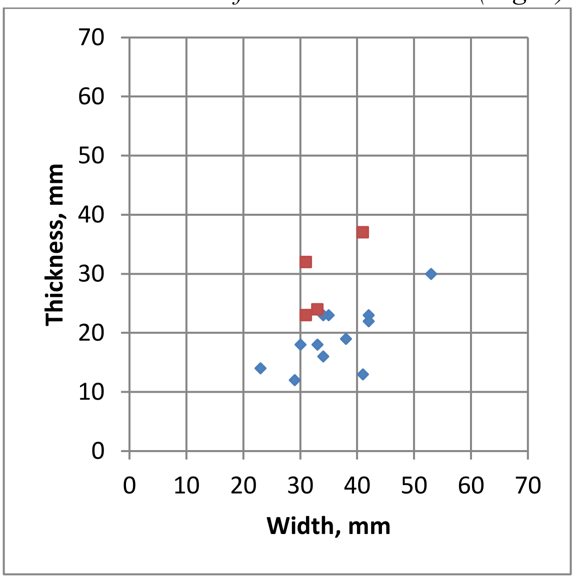
General technological developments in eastern Scotland: In connection with the analyst's processing of other lithic assemblages from eastern Scotland, a chronological model was produced (Table 6), based on his impressions of these assemblages and their raw material and typo-technological composition. The suggested sequence of industries should be perceived as a working hypothesis in need of corroboration. Table 6 includes five lithic techno-complexes, covering the Mesolithic-Bronze Age period. Late Upper Palaeolithic material is also present in eastern Scotland (Ballin forthcoming [Brit Arch]), but this material has not been incorporated into the model, as it is not yet possible to determine whether this group of assemblages represent one techno-complex or several.

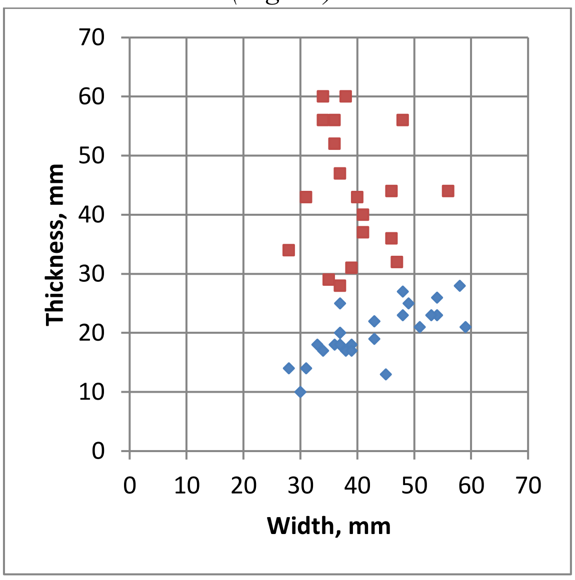
Some key sites are listed in Table 6, but the finds from Wester Hatton add additional supporting evidence. Particularly the assemblages from Structure B (entrance area) and S Cluster add to the understanding of the mixed Levallois-like/bipolar approach practiced during the Middle and Late Neolithic periods, and the finds from Structure B (southern ditch) is a typical Early Bronze Age assemblage characterized by the almost exclusive use of schematic bipolar technique. An assemblage from the recently excavated later Bronze Age site of Blackdog, a few kilometres from Wester Hatton, shows a different form a bipolar approach, which is less schematic, and which could be described as simple 'bashing'. The later Bronze Age operational schema was aptly described by Herne (1991, 47): *'There were no stages of reduction to follow, nor were there any standardised products to create. The commonly held view of flintworking as a learned tradition, often implicitly assumed in British studies, would seem to be inappropriate in this context. Equally hard to apply would be a cognitive, or 'mental template', model of flintknapping, as for instance that proposed by Bonnichsen (1977). If any model is a useful one in this instance it might simply be that which is given by the notion of 'following a rule', the rule perhaps being: 'rotate the core to find a [pointed end; re-phrased by this author] and hit it'.*

The Levallois-like technique: In a Scottish context, the later Neolithic Levallois-like technique has been dealt with primarily by Ballin (2011 [BM]; Suddaby & Ballin 2010) and Saville (2006), but over the last decade newly excavated sites have added new later Neolithic assemblages which have shed additional light on this approach. The most important of these collections include: Midmill near Kintore; Wester Clerkhill near Peterhead; Kingfisher Estate near Aberdeen; and now Wester Hatton. The Levallois-like cores, crested pieces, and flakes/blades from these locations allow the following general characterization of the approach to be suggested:

Levallois-like cores are usually defined by having been prepared by finely faceting the cores' platforms, rather than trimming the platform-edges in the traditional single-platform manner (Ballin 2011 [Levall]; Suddaby & Ballin 2010), but some Levallois-like cores have plain platforms, and some of the region's later Neolithic single-platform cores have faceted or finely faceted platforms. The absence of faceting on some Levallois-like cores, however, may be due to these cores being heavily exhausted specimens and they may have had their platforms rejuvenated. The main difference between Levallois-like cores and 'standard' single-platform cores is shape, with the single-platform cores being thick and the Levallois-like cores flat (Figs 9-10), possibly indicating the use of different pebble blanks (thick and flat), as well as different ways of preparing the core rough-outs.

Figs 9-10. The width and thickness of the Levallois-like cores (blue) and single-platform cores (red) from Wester Hatton (Fig. 9) and Wester Clerkhill (Fig. 10).





The evidence suggests that traditional single-platform cores may have been produced either by splitting pebbles across or simply detaching a primary 'opening flake', whereas Levallois-like core rough-outs may have been formed by splitting a pebble along the long axis, providing a flat core blank, or selecting already flat pebbles. These core blanks were then equipped with two lateral crests. Much further research is needed before we can say that we fully understand why later Neolithic people produced two different forms of single-platform cores ('standard' single-platform cores and Levallois-like cores). The analyst has previously suggested (Ballin 2011 [Levall]; Suddaby & Ballin 2010) that the main function of the Levallois-like cores may have been to allow the production of two different blank forms from the same cores, namely squat flakes from the cores' broad-sides (for chisel-shaped and oblique arrowheads) and elongated blanks from the lateral sides under and along the crests (for cutting implements).

The Wester Hatton material sheds light on the development of the Levallois-like cores during the reduction process, from rough-outs, over single-platform variants, to opposed-platform variants (Fig. 11; Table 9). The most notable effect of the redefinition of a Levallois-like core, from one form to another, is a drop in length of *c.* 15-20% between the different stages. Bipolar core CAT 1783 from the S Cluster furthermore links Levallois-like cores and bipolar cores within one common operational schema. This relatively large bipolar core (41 x 37 x 22mm) has a crushed terminal at either end, but at one end it also retains a small part of an original faceted platform.

Fig. 11. The length and width of the intact Levallois-like cores from Structure B and South Cluster: Roughouts (black); single-platform variants (red); and opposed-platform variants (blue).

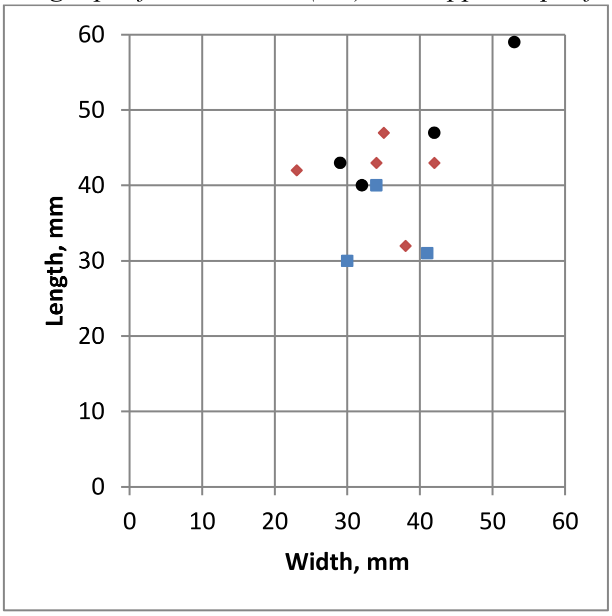


Table 9. The average dimensions of all Wester Hatton's Levallois-like rough-outs, single-platform variants, and opposed-platform variants.

Levallois-like core variants	*Length*	*Width*	*Thickness*
Rough-outs	47	39	21
Single-platform variants	41	34	19
Opposed-platform variants	34	35	18

In terms of fully understanding the Levallois-like approach, it would be necessary to find a suitable, chronologically unmixed later Neolithic assemblage, which is numerically big enough to be representative, but not so big that for example refitting (hopefully linking different core types and tools forms sequentially) became overly difficult or time-consuming/expensive (a 'goldilocks scenario'). It would also be helpful if the parent site was excavated completely in gridded squares, and not only in the form of cut features, as this would allow a spatial element to be added, in case the different stages of the operational schema took place in different parts of the site.

Kite-shaped arrowheads: The solitary leaf-shaped (kite-shaped) point (CAT 1774) from the SW Cluster is interesting in the sense that, in Britain, leaf-shaped arrowheads are generally associated with the Early Neolithic period (eg, Waddington 2004; Butler 2005). However, there is no other evidence at Wester Hatton suggesting Early Neolithic settlement in the area, with the lithic material generally indicating later Neolithic and Bronze Age activity, and the pottery Middle Neolithic (modified Carinated Pottery and Impressed Ware) and possibly Bronze Age activity (Coarseware). The radiocarbon-dates support this pattern, suggesting activity in the Middle Neolithic and throughout the Bronze Age period.

Table 10. Simplified schema of the main lithic and ceramic elements of the Neolithic period.

	Lithic diagnostic elements	*Ceramic diagnostic elements*
Early Neolithic period	Leaf-shaped points	Carinated Pottery
Middle Neolithic period	Chisel-shaped points	Impressed Ware
Late Neolithic period	Oblique points	Grooved Ware

This problem may not necessarily be a problem but might simply show how lithic and pottery specialists use different forms of 'boxes', different forms of 'short-hand'. Table 10 shows the main diagnostic elements used by the two groups of specialists, and the true problem might simply be that the boxes of the two groups of specialists are 'out of sync', that is, the switch from typical Early Neolithic points to typical Middle Neolithic points does not happen at the same time as the switch from typical Early Neolithic pottery to typical Middle Neolithic pottery.

CAT 1774 is not only a leaf-shaped point, but a kite-shaped point, and these points are generally accepted as being late within the Early Neolithic period (Green 1980). At the same time, the pottery from the SW Cluster belongs to the group of Modified Carinated Pottery/Impressed Ware found across the Wester Hatton site, and this style may represent a form of transitional Early/Middle Neolithic pottery. British leaf-shaped points (or other Neolithic/Bronze Age lithic points) have not been dealt with in any detailed general studies since Green's work from 1980, and the precise dating of the points and their sub-types is still uncertain.

However, and illustration (Fig. 12) of most leaf-shaped points from the main prehistoric sites in the Biggar area, South Lanarkshire, is informative, in the sense that it suggests a relationship between sub-type and raw material: The chert arrowheads are apparently all drop-shaped, whereas the flint arrowheads include a significant number of kite-shaped pieces. The flint seems to be mottled grey Yorkshire flint, and as Yorkshire flint is generally associated with the Scottish Middle and Late Neolithic periods (Ballin 2011 [BAR]), this again links the kite-shaped points to the latest part of the Early Neolithic period. Finally, CAT 1774 was recovered from Pit 2066, which also included Modified Carinated Pottery/Impressed Ware.

Fig. 12. A selection of chert and Yorkshire flint arrowheads from the Biggar area, South Lanarkshire, recovered from various sites by Biggar Archaeology Group (courtesy of Tam Ward, BAG).

In summary, the lithic finds from Wester Hatton appear to date predominantly to the Middle Neolithic period, with a supplement of mainly Early Bronze Age lithic material. These sub-assemblages generally have a domestic appearance, representing knapping floors disturbed by the construction of later Bronze Age houses and pits in the area.

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Appendix-2.2.17 AMA09 Milltimber Coarse Stone Analysis - Julie Lochrie

Saddle Quern

A broken edge from a saddle quern, in two conjoining parts, was retrieved from pit [AMA09-2089]. The two pieces conjoin and make up the edge fragment of a large saddle quern. The original dimensions and shape are impossible to know but measuring 29.5mm x 14.5mm x 97mm it would not have been an easily portable object.

Saddle querns are large stones used as the surface for grinding of cereal crops and this example was the only one found at the Milltimber site. Dating the saddle quern is not an easy task as they have a long period of use with no fixed date upon which they become obsolete. They are used from the Neolithic into the Iron Age. As the site is clearly multi-period, visited throughout this time bracket, it is not possible to be certain of its date. It is likeliest to be early to middle Iron Age as it was found in a pit where charcoal was radiocarbon dated to 358 – 105 cal BC (SUERC-74402).

The quern fragments are heavy and are unlikely to have been carried far from where they were used, even less likely when the quern would have been complete. The grinding surface shows the quern is well-used and would have performed an essential domestic function that indicates likely occupation in the vicinity. The deposition of querns is often discussed in terms beyond discard but in how quernstones embody a wider meaning to the household and community. They are often theorised as being an embodiment life cycle and of seasonal changes since they are such an essential component of food production (Culduthel, Inverness, McLaren forthcoming; North Kessock, Inverness, Lochrie pers comm; and Kintore, Aberdeenshire, Engl 2008. However strong evidence for the Milltimber deposit being deliberately structured is scant. The context the saddle quern fragments were found in is isolated as it cannot be phased alongside any other features. There were also several other large but natural stones in the deposit could just as likely point towards small scale area clearance. If Iron Age in date comparative examples of structured deposition from this period can be found at Birnie (ScARF 2012) and Kintore (Engl 2008, 223-224).

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Appendix-2.2.18 SL/004 Gairnhill Coarse Stone Analysis - Julie Lochrie

This report covers all coarse stone artefacts retrieved from the northern area of Gairnhill, SL/004D. The coarse stone finds number two saddle querns, two polishers and a pounder/hammerstone. Two natural stones have been omitted from the analysis. The coarse stone assemblage was found in Gairnhill 3 and Gairnhill 5 with an unstratified quern laying in topsoil near Gairnhill 2. All artefacts are complete and in good condition although a flake has fractured from the edge of the unstratified quern. Measurements are in millimetres (mm) and grams (g) unless otherwise stated. The following abbreviations have been used: length (L), width (W) and thickness (Th). Dimensions provided are maximum measurements.

Table 1 Coarse Stone Summary

Area	Feature	Context	Object type
In Topsoil near Gairnhill 2	Surface Find	-	Saddle quern
Gairnhill 3	Pit 4D-0392	4D-0388	two polishers
Gairnhill 5	Post-hole 4D-0192	4D-0195	pounder/hammerstone
	Ditch 4D-0151	4D-0101	Saddle quern

The querns are both saddle type and would have been used for grinding foodstuffs, primarily grain although the multiple possibilities for a grinder cannot be forgotten. These querns require a secondary stone, a rubber, to be ground against them but none of these artefacts were present. The two querns are both very similar in manufacture and use, both could be termed 'slug' querns. They are both broadly plano-convex in shape and are dressed. Peckmarks remain visible around the convex underside. The overall plan of each is a little different, one is sub-oval the other is sub-triangular, likely reflecting the original shape of the stone. The grinding surface of each is fairly flat with grinding occurring right to the edge which must have pushed whatever was being ground off the edge of the stone. In fact, on the sub-oval stone from Gairnhill 3 the smooth wear is greatest at one edge where the wear carries round and down its edge. The sub-triangular quern has a similar feature but is much more pronounced with a raised edge upon which the smooth wear continues up and over. No satisfactory explanation can be made for the wear on the sub-triangular quern other than the stone may have either been re-modified in in its life or may have been used as a rubber; at 370mm maximum length this is not wholly unreasonable. These type of planoconvex 'slug querns' were found at Kintore where wear extending to their edges was also noted (Engl 2008, 215). Engl also makes the point that these stones are more portable than other querns (*ibid*, 215). In the case of the querns from Gairnhill they could certainly could be managed short distances but at 12.8 and 14.8kg each they are at the heavier side of portability.

The polishers are unmodified hand-sized, sub-spherical and sub-ovoid cobbles. They are a stone which is already naturally fine-grained and very smooth, both stones have a naturally flatter face and upon this face is a dark black brown stain. The most likely explanation for the use of these stones is that they have been used in leather working. The pounder/hammerstone has seen much use, almost 90% of its entirety is covered in pitmarks. It fits in the hand but is a little larger than the polishers and would have had a bit more weight. The type of action that must have caused the pit-like marks would be a steady pounding, with occasionally movement of the stone for better grip, resulting in larger areas of wear on the surface. What the activity is cannot be said with certainty but is likely to be the grinding down of something hard or the use of the hammer against an intermediate percussor. One small circular section of the stone has deeper wear and it is likely this was repeated, stronger force in the same localised position. This is more akin to the type of wear expected from hammering and the strength of force applied suggests the purpose was to drive one object into another.

Coarse stone was not spread across site and other artefacts were few so it is most likely the inhabitants cleared the site before abandonment. Small and portable stone tools were likely taken if they were of value and left if not. Stone will be available in most places and none had undergone particularly advanced manufacture to justify their retention. It is unlikely that larger stationary querns were favoured over the smaller querns as none were found and these are difficult to transport, although they may have been removed during modern agricultural development. The presence of two polishers in a pit together is not quite enough to be termed a cache but these tools are likely to have been stored together for similar purpose. This strongly suggests that the activity or the person using them were located very close by.

The stone tools give a small but tantalising glimpse into what must have been a small bustling community or a thriving family unit. The finds that remain are the debris which has been forgotten or abandoned and as such must be viewed as a very partial representation of the craft and food processing activities that were being undertaken.

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Appendix-2.2.19 NL/001C Chapel of Stoneywood Coarse Stone Analysis - Julie Lochrie

This report summarises the form, function and deposition of two saddle querns from Chapel of Stoneywood. Measurements are in millimetres (mm) and grams (g) unless otherwise stated. The following abbreviations have been used: length (L), width (W), thickness (Th). A complete catalogue can be found in the finds database.

One of the querns has been deliberately shaped while the other is an unworked natural stone. The worked quern has been pecked to a roughly plano-convex shape and is oval in plan. The grinding surface is gently convex and deepest at the centre suggesting a short movement with most pressure applied halfway through the action. The unworked quern is wedge-shaped and sub-rectangular in plan. The grinding surface is naturally concave with much of its natural irregular texture remaining, pointing towards non-intensive use. The focus for most of the wear on the unworked quern is towards one end, suggesting it was positioned near the body and the natural angle and wedge shape was used to advantage.

Quern stones would have been an essential step in the agricultural process and could have been used to grind, mash and crush many foodstuffs but primarily grain. They were found in Structure A amongst other large stones, infilling ovoid pit [1C-0114]. The stones appear to be deliberately levelling the ground, suggesting the presence of human or animal traffic. The building has been interpreted as likely to be a byre and not domestic in use. It is worth noting that the combined weight of the stones is 27.6kg, a substantial quantity to have carried to the building. This could suggest that the stones have not travelled far and there are domestic structures in the area or it was so important to include them in them in the buildings construction that they were carried despite their weight. This type of meaningful addition has been discussed at other sites including Culduthel, Inverness (McLaren forthcoming), North Kessock, Inverness (Lochrie pers comm) and Kintore, Aberdeenshire (Engl 2008). In these examples it is usually theorised that the querns imbue the new home with 'luck' in successful agriculture and plentiful food. The construction of the roundhouse has been radiocarbon dated to the middle Bronze Age (1377-1231 cal BC SUERC-49725 and 1395 – 1291 cal BC SUERC-57933) and the querns similarly date to this period.

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Appendix-2.2.20 AMA22 - Wester Hatton Coarse Stone Analysis - Julie Lochrie

The coarse stone assemblage numbers 12 items, which includes seven saddle querns, a rubber, a grinder, a pounder/hammerstone, a possible hammerstone and a grooved stone. Most of the saddle querns are particularly large and heavy and would have been intended as stationary. The exception to this are two smaller slug querns from Wester Hatton 4 ditch [AMA22-6030].

The dating of coarse stone is usually reliant on contextual dating as there is no clear chronological typology and unlikely to ever be one. The reason for this is that coarse stone, and saddle querns in particular, do not change much throughout their period of use from the Neolithic into the Iron Age. The range of quern types found here from the Bronze Age can be compared to the range from Kintore, which include large stationary querns, portable 'slug' querns and saucer querns (Engl 2008).

Table 1 Coarse stone assemblage

Area	Feature	Context	Quantity	Weight (g)	Summary
PC 2	AMA22-6075	AMA22-6004	1	28800	Saddle quern, 06-CS12
PC 4	AMA22-6234	AMA22-6235	1	176	Pounder/Hammerstone, 06-CS7
WH 4	-	AMA22-6025	1	287	Grooved stone, 06-CS1
WH 4	AMA22-6030	AMA22-6028; AMA22-6029	5	63566	Four saddle querns and one rubber 06-CS2, 06-CS3, 06-CS4, 06-CS9 and 06-CS10
WH 4	AMA22-6144	AMA22-6149	2	900	Grinder and possible hammerstone. 06-CS5 and 06-CS6
WH 1	AMA22-6096	AMA22-6097	1	31700	Saddle quern, 06-CS8
WH 1	AMA22-6115	AMA22-6116	1	10000	Saddle quern, 06-CS11

Pit Cluster 2 and Post-Hole Cluster 4

This area has no associated radiocarbon dates but from the pottery evidence is thought to be middle Neolithic. A saddle quern was found in pit [AMA22-6075] which is a long, flat, sub-oval stone at a slight incline. It has the largest surface area than any of the saddle querns, measuring 582mm x 310mm, but is one of the thinnest at 45-121mm. Its underside has been roughly dressed and its grinding surface is smooth with very slight central dishing.

Post-hole Cluster 4, Post-hole [AMA-6234] contained an ovoid cobble that has been used as both a pounder and a hammerstone (06-CS7). It has bifacial flaking at one end and a pounding facet, measuring 7mm x 2.5mm on the other. As the tool has been found in a post-hole it could have either been used as packing or fallen in after the post was removed/rotted.

Wester Hatton 4

The four saddle querns from WH4 were all retrieved from ditch [AMA22-6030]. Two are small portable slug querns and the other two are large stationary querns. The large querns are both roughly wedge shaped, one natural (06-CS10) and the other roughly shaped (06-CS9). The wedge shape helps it two ways, it can allow the user to rest their knees under the quern if they wish and whether they did or not the natural angle allows an easier downward thrust when grinding. The small slug querns (06-CS2 and 06-CS4) are typical of their type, both being plano-convex in shape, the grinding surface being almost flat to the very edges. The broken one has a dressed concave side and the complete one is natural. A rubber was also found in this group which is not much larger than the slug querns. The difference between the slug querns and rubber is that the ground face on the rubber is convex.

A fragmentary grinder (06-CS5) and a large fractured, soot stained cobble possibly used as a hammerstone (06-CS6) was also found at Wester Hatton 4.

Wester Hatton 1

Two of the saddle querns came from Wester Hatton 1, one is partial, of an unknown form and the other is a large saucer quern. The saucer quern (06-CS8) is sub-circular in plan with a deep central dish, it appears that it hasn't been shaped but the base has worn a little smooth. The base is slightly convex but is stable enough it doesn't rock on its base. The fragmentary quern is shaped, with peckmarks along one edge but the very base of it is also exceptionally smooth, the grinding surface on this quern is very deep and well-used.

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Appendix-2.2.21 Milltimber, Aberdeenshire (ABSL13 SL002B)

Report on metalworking evidence

AOC project no. 23241

22nd November 2016

AOC Archaeology Group

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Milltimber, Aberdeenshire (ABSL13 SL002B)

Report on metalworking evidence

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Date of Report:	**22nd November 2016**

This document has been prepared in accordance with AOC standard operating procedures.

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Contents

The vitrified material from Milltimber (Headland Project Code: ABSL-002B)

Dawn McLaren

Overview

A small assemblage comprising a limited quantity (782.3g) and range of vitrified material was recovered during excavations at Milltimber, Aberdeenshire. With the exception of two small fragments of low-density fuel ash slag, the assemblage is dominated by waste indicative of ferrous metalworking activities, specifically blacksmithing. All of the waste identified is residual material that was recovered from secondary contexts, including the fill of a Roman or later oven, an isolated undated post-hole and soils within a natural palaeochannel. None of the ironworking slags recovered are chronologically distinctive but they could be Iron Age or later in date.

Classification

The material was subject to macroscopic examination to enable classification based on morphology, density and colour. The total quantity of debris by type is summarised in Table 1.

Overall, this is a small quantity of vitrified debris which provides limited evidence for iron working, probably smithing. A summary of the vitrified material is presented below and a full catalogue of the material is given in the archive report (see Appendix A[1]).

Type	Mass (g)
Plano-convex slag cake (PCSC)	656
Hammerscale (HS)	1.1
Unclassified iron slag (UIS)	111.3
Low-density fuel ash slag/vitrified ceramic (FAS)	13.9
Total	*782.3*

Table 1: summary of vitrified material by type

Diagnostic ferrous metalworking waste
Only two types of diagnostic ferrous slag types were present; these consisted of two plano-convex slag cakes (PCSC) and a limited quantity of hammerscale (HS).

Plano-convex slag cakes are typically sub-circular or oval accumulations of slag formed during ironworking. These can survive in a range of sizes and can vary considerably in weight and density making it difficult to be sure whether they were produced during smelting or smithing based on visual examination alone (McDonnell 1994, 229; Bayley *et al* 2001, 14).

[1] Appendix A not recommended for publication.

Two plano-convex slag cakes (SF 1 & 2) were recovered from the fill of palaeochannel [2b-2650]. Their dimensions, texture, weight and form is consistent with smithing hearth bottoms from Iron Age and later sites in Scotland (e.g. McDonnell 1994, 230; McDonnell 2000, 219). These smithing hearth bottoms are recognisable by their characteristic plano-convex form, having a rough convex base with frequent small charcoal impressions and a smoother, vitrified, upper surface; they are formed as the result of high temperature reactions between iron, hammerscale and silica from the hearth lining or flux, which accumulate at the base of the smith's hearth (McDonnell 1994, 230; Starley 2000, 338). Both examples from Milltimber are substantially complete compact cakes of small dimensions. They are 85.5mm and 88.5mm in diameter, 38mm to 76mm in thickness and are 229.8g and 426.2g in weight respectively. One cake, SF 1, is a particularly thick and heavy example and appears to be comprised of a series of small cakes superimposed on top of one another, suggested by the traces of at least two layers observed on the external curving edges of the cake. A similar amalgam was recovered from an Iron Age hearth at Seafield West, Inverness where chemical and microstructural analysis confirmed that the cake consisted of two superimposed hearth bottoms indicative of distinct but sequential phases of smithing within the same hearth (Heald *et al* 2011, 21-22). Layered smithing hearth bottoms, such as the example from Milltimber and from further afield at Seafield West, are thought to occur when sequential episodes of smithing take place prior to the hearth being cleaned out, allowing a hearth bottom to form and fuse to an existing cake at the base of the forge hearth (*ibid*, 22). The second slag cake from Milltimber, SF 2, appears to represent only a single phase of metalworking activity. As the methods of blacksmithing within a simple forge saw little change from the Iron Age onwards, it is impossible to closely date hearth bottoms simply on the basis of their form alone.

Further evidence of smithing activities was recovered in the form of a limited amount of magnetic hammerscale flakes (1.1g) from post-hole [2B-0080]. Hammerscale flakes and spheres are produced during the forging and welding of iron alloys; when the oxidised surface of a red-hot iron object is struck during smithing, plates or flakes of iron on the surface of the bloom or object are expelled. Similarly, spheroidal hammerscale consists of small droplets of solidified slag which are expelled from a bloom during primary smithing or during welding (Bayley *et al* 2001, 14; Dungworth & Wilkes 2009). Micro-debris of this form is usually found in the immediate vicinity of the smithing hearth and anvil and, where found in significant quantities, can indicate precisely the focus of the blacksmithing activity (Starley 1995; Heald 2002, 71). No *in situ* metalworking features or hearths were noted in the vicinity of post-hole [2B-0080] but the presence of diagnostic micro-debris implies that blacksmithing took place in the area.

In addition to these classifiable, diagnostic, ironworking slags already described are small quantities (111.3g) of unclassified iron slag (UIS). These are amorphous, small and fractured pieces of iron-rich vitrified material which, although likely to be debris from ironworking, are not possible to assign to a particular stage in the ironworking process (Crew & Rehren 2002, 84). These are likely to represent rake-out from an iron smelting furnace or smithing hearth. The pieces from Milltimber came from upper soils within Oven F17 [2B-2123] and post-hole [2B-0080].

Other vitrified materials

A small amount of material from Milltimber (13.9g) is a low-density slag characterised by its vitreous and vesicular nature, low density and friability. This type of slag is typically called fuel ash slag and is formed when material such as earth, clay, stones or ceramics are subjected to high temperatures, for example in a hearth (Bayley 1985, 41-43; Bayley *et al* 2001, 21). These can be formed during any high temperature pyrotechnic process and are not necessarily indicative of deliberate industrial activity. This material was recovered from the fill of post-hole [2B-0080] and is likely to be domestic hearth waste. Similar material was recovered with fuel debris and hearth sweepings associated with later prehistoric roundhouses at Oldmeldrum, Aberdeenshire (McLaren 2010, 19).

Discussion

Slags produced from ferrous metalworking are rarely intrinsically datable and as a result any chronological information about the craft activities that this material represents must derive necessarily from any associated stratigraphic evidence, datable artefacts or directly datable organic material, such as charcoal. As with many multiperiod sites such as this, the vitrified material from Milltimber was residual and was recovered from secondary contexts, including the upper soils within a Roman or later oven, the fill of an undated post-hole and soils within a natural palaeochannel.

Small quantities of unclassified iron slag came from upper soils within Oven F17 [2B-2123]. Although the majority of the ovens excavated in this area were found to be Roman in date, the macroplant remains from this feature were inconsistent with those investigated across the site as a whole and a later, possibly Early Historic, date for construction and use has been postulated. The soils containing the unclassified iron slag fragments post-date the use and abandonment of this structure, indicating that the metalworking activities that the slag represents are likely to be Roman or later in date. Vitrified material, resulting from both metalworking and other, non-metalwork related pyrotechnic activities, were recovered from the fill of Roman ovens at Forest Road, Kintore, Aberdeenshire (Heald 2008, 209). Like that seen at Milltimber, much of this waste was secondary and intrusive within the ovens and did not relate directly to the use of the features themselves.

The recovery of hammerscale, indicative of blacksmithing, alongside fragments of unclassified iron slag and fuel ash slag from post-hole [2B-0080] suggests that ironworking was taking place in the vicinity but the date of this activity cannot be determined from the available evidence. Similarly, the residual smithing hearth bottoms that came from the palaeochannel [2B-2650] attest to blacksmithing activities but the lack of close dating makes it difficult to draw any useful comparisons.

Conclusions

The small assemblage of vitrified material from Milltimber is dominated by ferrous metalworking waste indicative of blacksmithing activities. All of the debris was recovered from secondary contexts within prehistoric to Roman or Early Historic features but all is residual and cannot be closely dated. Despite the lack of close dating and *in situ* metalworking structures, the ironworking waste from Milltimber provides an interesting glimpse of craft activities taking place in the area.

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APPENDIX A: THE ARCHIVE SLAG CATALOGUE

Site code	Context	Feature	SF	Sample	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/ impressions?	Notes
ABSL13 002B	2138	Fill of oven F17 [2b-2123]	7		UIS	Three angular fractured fragments of unclassified iron slag, red-brown in colour, vesicular with frequent small air bubble voids and charcoal impressions. The slag is molten in appearance in restricted small areas of the fragment's surfaces. Magnetic.	3	Y	44.8	36	24	23	Small charcoal impressions	Dimen-sions recorded for largest piece only
ABSL13 002B	2138	Fill of oven F17 [2b-2123]			UIS	Angular fractured nodule of dark purple-brown, dense vitrified unclassified iron slag. The nodule is broken suggesting it fractured from the edge of a larger piece. The surface are coated in a red-brown sandy crust. The texture is dense with occasional air bubble voids but no clear charcoal impressions. Slightly magnetic.	1	Y	39.2	44.5	38.5	26	No	

Site code	Context	Feature	SF	Sample	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/ impressions?	Notes
ABSL13 002B	2655	Fill of palaeo-channel [2B-2650]	2		PCSC	Intact sub-circular cake of iron-rich, dense slag, plano-convex in section and rich red-brown in colour. The upper surface has a smooth depression towards one curving edge from the downwards pressure of the bellows on the slag when viscous. This portion of the edge is damaged, probably from removal from the hearth after cooling. The lower surface is convex and far more angular and uneven than the face previously described. This surface has frequent small sub-rectangular charcoal impressions and patches of heat-affected sandy soil adhering.	1	Y	229.8	88.5	75	38	Small charcoal impressions on base	

Site code	Context	Feature	SF	Sample	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/ impressions?	Notes
ABSL13 002B	2655	Fill of palaeo-channel [2B-2650]	1		PCSC	Possible superimposed slag cake. Very thick, dense piece of red-brown slag, sub-circular in plan with a layered profile suggesting superimposed series of at least two thin plano-convex sectioned cakes. The uppermost surface is dished with an uneven central hollow filled in with oxidised, rust-stained sandy crust. There is a short curved projection of slag at one edge which is broken; this may be where the cake adhered to the edge of the hearth. The lower surface is convex and angular with small sub-rectangular charcoal impressions. The edges of the piece are obscured by adhering patches of heat-affected sandy soil.	1	Y	426.2	85.5	69	76	Small charcoal impressions on base	

Site code	Context	Feature	SF	Sample	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/ impressions?	Notes
ABSL13 002B	81	Fill of post-hole [2B-0080]		1038	HS	Small quantity of dark grey/purple hammerscale flakes averaging 2-3mm in diameter with occasional slag spheres, 1mm in diameter, mixed with small quantities of heat-affected stone (mostly quartz) and amorphous dark brown vitrified residues (possibly bloom or unvitrified roasted ore).	See mass	Y	1.1				Hammerscale flake and spheres	
ABSL13 002B	81	Fill of post-hole [2B-0080]		1038	UIS	Multiple small fractured angular fragments of red brown/silvery grey dense slag, some pieces molten-looking in apperance, frequent small air bubble voids and occasional charcoal impersssions. No significant inclusions noted. Majority of pieces are small prill-like nodule fragments.	Multiple	N	27.3	35	23.5	8	Occasional small charcoal impression	

Site code	Context	Feature	SF	Sample	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/ impressions?	Notes
ABSL13 002B	81	Fill of post-hole [2B-0080]			VC/ FAS	Two small sub-rounded nodules of low-density vitrified material; light and brittle; glassy in texture and vesicular. Slight grey-blue tint suggests element of vivianite staining	2	N	13.9	30	22.5	17	N/A	Dimen-sions recorded for largest piece only

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Appendix-2.2.22 Netherbeanshill, Aberdeenshire

Assessment of the vitrified material

AOC project no. 23240

26th July 2016

AOC Archaeology Group

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Netherbeanshill, Aberdeenshire

Assessment of the vitrified material

On Behalf of:	**Julie Lochrie** Headland Archaeology Ltd Jane Street Edinburgh EH6 5HE
AOC Project No:	**23240**
Prepared by:	**Dawn McLaren**
Date of Report:	**26th July 2016**

This document has been prepared in accordance with AOC standard operating procedures.

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Contents

Abstract

A small quantity of heat-affected and vitrified material from excavations at Netherbeanshill, Aberdeenshire was submitted for assessment to determine whether any of the fragments derive from prehistoric metalworking activities.

The majority of the waste was found to be a heat affected material known as cinder or clinker which although indicative of high temperature pyrotechnic processes is not diagnostic of metalworking. Despite this, a very small number of fractured pieces of prill-like magnetic vitrified residues were present indicative of ferrous metalworking. These include two fragments of micro-debris – known as slag spheres – that are considered to be diagnostic of bloom- or black-smithing activities. No 'bulk' ferrous slags were present, nor were any fragments of magnetic vitrified residue suggestive of iron smelting activities.

The quantities of potential ferrous metalworking waste from Netherbeanshill is too limited to suggest it derived from *in situ* metalworking features but does imply, at the very least, that small scale ironworking was taking place in the vicinity of the excavated features. This metalworking waste is not chronologically distinctive by form and could well represent intrusive later residues.

Overview

A small quantity of heat affected and vitrified material (43.5g) from excavations at Netherbeanshill, Aberdeenshire was submitted for assessment to determine whether any of the fragments derive from prehistoric metalworking activities and identify the archaeological significance of the assemblage.

The majority of the material was found to be a heat affected material known as cinder or clinker which although indicative of high temperature pyrotechnic processes is not diagnostic of metalworking. Despite this, a very small number of fractured pieces of prill-like magnetic vitrified residues were present indicative of ferrous metalworking. These include two fragments of micro-debris – known as slag spheres – that are considered to be diagnostic of bloom- or black-smithing activities. No ‘bulk’ slags were present, nor were any fragments of magnetic vitrified residue suggestive of iron smelting activities.

The quantities of potential ferrous metalworking waste from Netherbeanshill is too limited to suggest it derived from *in situ* metalworking features but does imply, at the very least, that small scale ironworking was taking place in the vicinity of the excavated features. Whether this represents later, intrusive, or contemporary activity will require contextual analysis to determine.

To aid assessment and serve as an archive record, a brief inventory of the assemblage has been compiled and is included here as Appendix A.

Methodology

Each fragment was examined macro- and microscopically with the aid of a binocular microscope and scanned with a magnet to determine the material’s magnetic qualities. A brief inventory of the finds, by sample number and context, was compiled (see Appendix A) which provides a spot identification, brief description of the material’s colour, morphology and weight. No detailed cataloguing was undertaken and the dimensions of individual pieces were not measured.

Classification

In general, assemblages of vitrified material or slag can be split into two broad categories: those which include diagnostic waste which can be attributed to metalworking and those which comprise non-diagnostic waste which could have been produced as the result of a range of high temperature processes and are not necessarily indicative of metalworking. The Netherbeanshill assemblage is summarised in Table 1.

Short description	Weight (g)
Magnetic Vitrified Residues	2.95
Non-magnetic Vitrified Residues	1.7
Clinker etc.	38.85
Total	*43.5*

Table 1: summary of the Netherbean assemblage

A very limited quantity (2.95g; 7%) of the material is indicative of ironworking. It is present in the form of small magnetic globular ‘prills’ and fractured fragments of larger magnetic vitrified residues. These derive from contexts 28, 37, 61, 64, 71, 190, 220, 223 and 248. Although these pieces are suggestive of waste produced during ironworking and are often found amongst assemblages of blacksmithing debris, this type of waste is not considered to be diagnostic of a particular stage in the ironworking process. Amongst this small group of ferrous slags is a single magnetic slag sphere from context 165 and a single prill which has a slag sphere embedded in one surface from context 220. A further fragmentary sphere comes from 242. It is considered to be ‘atypical’ in structure and may be an unusual type of fuel ash slag rather than metalworking waste; microscopic examination demonstrates that it is homogeneous and glassy and is not magnetic. Slag spheres, when found in quantity and association with hammerscale flakes, are typically considered to be waste diagnostic of bloom or blacksmithing.

During smithing small fragments of iron slag are expelled from the cooled surface of the billet or forged object either as the result of hammering or from flaking within the hearth during heating. These small residues, often referred to as hammerscale and slag spheres, consist of a shiny, dark grey, magnetic waste product usually encountered as small plates or flakes, typically only a few millimetres across and less than a millimetre thick, and as small molten-looking spheres (Dungworth & Wilkes 2009, 33). In the hearth these residues fuse together forming small prills and eventually, if the hearth is not raked out regularly, hearth bottoms. The presence of slag spheres at Netherbeanshill is of interest but the absence of accompanying hammerscale flakes would be unusual for a blacksmithing site and the spheres could well be intrusive.

The bulk of the assemblage (38.85g; 89%) comprises a heat affected material commonly referred to as cinder or clinker. This is a low-density heat affected material which is dark brown/grey/black in colour and its texture resembles that of volcanic pumice in that it is porous and brittle with frequent bubbles and voids. It is a material that has become affected by heat but is not truly vitrified. It is not diagnostic of metalworking of any kind but is the product of various high-temperature pyrotechnic processes. It is commonly found in large quantities with later, medieval and post-medieval blast furnace waste assemblages (Bayley et al 2008, 60).

Also present are very low quantities of non-magnetic vitrified residues (1.7g; 4%), probably a type of fuel ash slag unconnected with metalworking.

Chronology

None of the material is chronologically distinctive.

Significance

A very limited quantity and restricted range of ironworking waste is present amongst the Netherbeanshill assemblage, consisting only of small fragments of magnetic vitrified residues or prills and slag spheres suggestive of bloom or blacksmithing of iron. No iron smelting waste was present and no waste suggestive of non-ferrous metalworking was recognised.

The recovery of small fractured pieces of ironworking slag from a Bronze Age site is of potential importance as ferrous metalworking would not be anticipated from a site of this date. Some evidence for ironworking has been found in British contexts that are culturally assigned to the Late Bronze Age (e.g. Hartshill Copse, West Bedfordshire: Collard et al 2006) and the LBA/Early Iron Age transition period (e.g. Broxmouth, East Lothian and Welham Bridge, East Yorkshire: McDonnell 2013; Halkon & Miller 1999). Yet, the low quantities of magnetic micro-debris recovered within soil samples from the excavation at Netherbeanshill suggest that this material represents a residual scatter of waste rather than *in situ* debris within a metalworking feature where far greater quantities and concentrations would be expected. The absence of any hammerscale flakes to compliment the slag spheres, as would be anticipated on a blacksmithing site, is noteworthy in this context. The key issue is to determine whether this is a) a residual spread of material contemporary with the datable Bronze Age features excavated; b) a residual spread of material representing a later phase of activity, or c) intrusive later material within Bronze Age features. This should be determined by investigation of the context of recovery of the magnetic vitrified material. Only in scenario A would this waste be considered archaeologically significant.

Recommendations for further work

- Context of Ironworking waste: As a priority, the feature type/deposit type and stratigraphy of the contexts from which Magnetic Vitrified Residues have been recovered should be assessed. This should allow determination of whether the material is likely to be intrusive or contemporary with the dated Bronze Age features.
- Future analysis of ironworking waste: There is little scope for further analysis of the ironworking waste itself. Future macroscopic analysis could capture a more detailed morphological description and record the dimensions of the individual pieces of ironworking slag but this is unlikely to add value to what has already been captured in Appendix A. Scientific analysis such as XRF or SEM could provide limited further information on chemical composition but, again, this is likely to have restricted overall value unless closely datable.
- Cinder: It would be of benefit to examine the contexts of recovery of the clinker to look for any concentrations or associations with features related to burning. This may help to determine whether this heat-affected material is associated with a particular domestic or craft activity. No further analytical work on the cinder is recommended.

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APPENDIX A

S. no	C. no	Material	Short description	Weight g	Magnetic
1094	220	Charcoal	Charcoal	0.05	N
1089	215	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.2	N
1109	263	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.3	N
1113	268	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.05	N
1127	295	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.1	N
1115	272	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.3	N
1123	292	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.05	N
1126	284	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.1	N
1128	280	Cinder	Dark-brown/black porous and brittle heat-affected material; morphous	0.3	N
1119	278	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.5	N
1118	276	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.3	N
1107	252	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.1	N
1100	234	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.05	N
1101	236	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.6	N
1108	232	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.1	N
1095	221	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	1.9	N
1098	226	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.5	N
1088	213	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	4.4	N
1090	217	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.1	N
1085	203	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.5	N
1086	205	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.05	N
1073	175	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.5	N
1075	183 & 184	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.9	N
1078	188	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	3.6	N
1067	154	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.4	N
1066	152	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.5	N

S. no	C. no	Material	Short description	Weight g	Magnetic
1068	168	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.05	N
1040	91	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.1	N
1092	112	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.5	N
1041	93 & 96	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.4	N
1060	141	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.5	N
1051	119	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.1	N
1093	113	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.5	N
1007	4	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.1	N
1006	22	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.05	N
1032	87	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.3	N
1033	81 & 82	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	3.3	N
1001	11 & 19	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.1	N
1022	42	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.7	N
1047	44	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.1	N
1036	46	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.05	N
1025	59	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	1.4	N
1024	53/55	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	3.1	N
1048	46	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.05	N
1027	64	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	1.7	N
1028	61	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.6	N
1079	190	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	2.7	N
1080	192	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.05	N
1094	220	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	2	N
1091	223	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.7	N
1062	149	Cinder	Dark-grey porous, brittle heat affected material	0.05	N

S. no	C. no	Material	Short description	Weight g	Magnetic
1104	246	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.05	N
1018	37	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	0.8	N
1105	248	Cinder	Dark-brown/black porous and brittle heat-affected material; amorphous	1.1	N
1072	173	Cinder & Coal	1 fragment of angular ?coal, laminar in structure, not obviously heat affected & 5 fragments of cinder	1.1	N
1009	23	Cinder & stone	1 amorphous nodule of dark-brown, porous and brittle cinder; 1 fragment of angular rock	0.1	N
1120	282	Coal	Small cuboidal laminated fragment of dark grey/black coal	0.05	N
1016	28	Magnetic vitrified residue	Small sub-rounded nodule of porous and vesicular dark-grey/brown vitrified material	0.1	Y
1018	37	Magnetic vitrified residue	Small amorphous accumulation of magnetic residue; does not incorporate any diagnostic micro-debris but is magnetic and almost certainly waste from ferrous metalworking	0.4	Y
1028	61	Magnetic vitrified residue	Small amorphous accumulation of magnetic residue; does not incorporate any diagnostic micro-debris but is magnetic and almost certainly waste from ferrous metalworking	0.2	Y
1027	64	Magnetic vitrified residue	Small prill-like fractured nodule of dark grey magnetic vitrified material	0.6	Y
1030	71	Magnetic vitrified residue	small fractured fragment of magnetic vitrified material; not diagnostic	0.1	Y
1079	190	Magnetic vitrified residue	Small fractured nodule of dark grey, molten-looking globule of magnetic iron-rich slag	0.5	Y
1094	220	Magnetic vitrified residue	1 prill-like amorphous nodule of magnetic vitrified material consisting of an conglomerate of small residues including a slag sphere embedded in one surface	0.1	Y
1091	223	Magnetic vitrified residue	Small prill-like nodule of magnetic vitrified residues	0.6	Y
1105	248	Magnetic vitrified residue	Two small fractured angular fragments of dark grey molten-looking globules of magnetic vitrified material	0.2	Y
104	246	Non-Magnetic vitrified residue	Amorphous vesicular and porous nodule of non-magnetic vitrified material	0.1	N
1105	248	Non-Magnetic vitrified residue	Single sub-rounded nodule of vesicular vitrified material; not diagnostic of metalworking; more aligned with Fuel Ash Slag or similar	1.6	N

S. no	C. no	Material	Short description	Weight g	Magnetic
1069	165	SS	Possible fractured slag sphere; glassy and brittle. Atypical; not necessarily metalworking	0.1	N
1103	242	SS	slag sphere; magnetic	0.05	Y

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Appendix-2.2.23 GAIRNFIELD
Client ID: ABSL13 SL004D
AOC project number 23243

Site summary

Excavation of a Bronze Age site located in the plateau region between the watershed of the Dee and Don Valleys, Aberdeenshire. Site encompasses a series of post-built timber roundhouses and associated features. A series of radiocarbon dates have been obtained for the site as a whole and demonstrate a broad date range of 1372 – 840 BC. No specific contextual information has been provided by the excavator so it is not possible to determine a specific C14 date for individual contexts or structures.

Summary of vitrified debris

Approx 1.5kg of vitrified and heat affected material was sent for analysis. The majority of this had been interpreted in the field as possible bronze working waste or extremely early ironworking slag. Macro and Microscopic examination reveals the majority of in situ material to be a low-density fuel ash slag with small quantities of cinder and magnetic residues. The magnetic residues were examined under magnification and are primarily heat-affected stone. A small quantity of unclassified and runned iron slag was present amongst the assemblage but this derives from unstratified/poorly stratified contexts and is considered to be later, undated, intrusive material and not directly associated with the excavated settlement evidence.

A single fragment of low density/fuel ash slag (36.1g) has been extracted from a larger sample from context 0120 for analysis to determine the composition of this material which might enable a better understanding of its formation process. Context 120 is the fill of Ring-ditch [4D-0240] from building 4 (4D-0240).

Examination of High Temperature Residue
Gairnfield
David Dungworth

Introduction

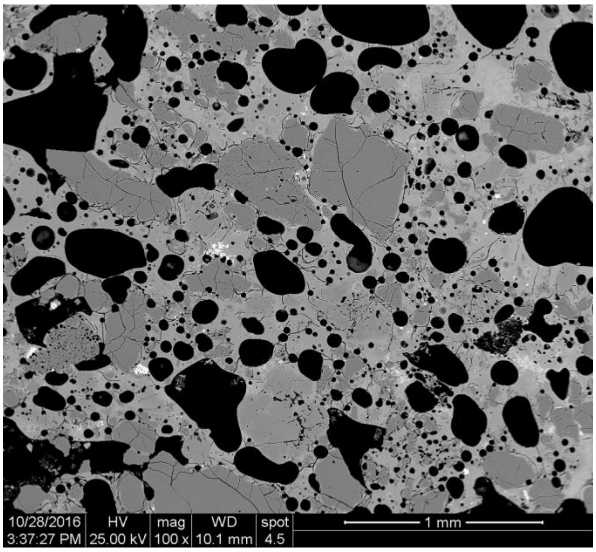
The archaeological excavation at Gairnfield recovered a small quantity of a high temperature residue which was submitted for examination and analysis in order to determine the processes that might have produced it. The residue consists of an amorphous, partially vitrified material which is somewhat porous and dark brown in colour. Visually, the material does not resemble any commonly known metalworking residues.

Methods

A single sample of the vitrified material was mounted in epoxy resin and ground to reveal a cross-section. This was then polished to a 1-micron finish using standard metallographic techniques. The polished sample was examined using a Scanning Electron Microscope (SEM) and the microstructure recorded using a back-scattered electron detector. The chemical composition of discrete areas of the sample was determined using an Energy dispersive X-ray spectrometer (EDS) attached to the SEM.

Results

The sample has a microstructure which comprises a series of fairly large inclusions in a highly vesicular vitreous matrix (Figures 1–4). The vesicular nature of the matrix suggests that it formed from carbonate rich salts (such as a plant ash) and that the material was never hot enough for the matrix to completely melt (in which case the gas bubbles would have escaped). The most abundant inclusions are quartz and most of these shows cracks probably introduced by exposure to high temperatures. Slightly less abundant are the larger alkali feldspar inclusions (Figure 3). A close examination of the vitreous matrix suggests that the inclusions (in particular the quartz) have been partially dissolved by the matrix (Figure 4).



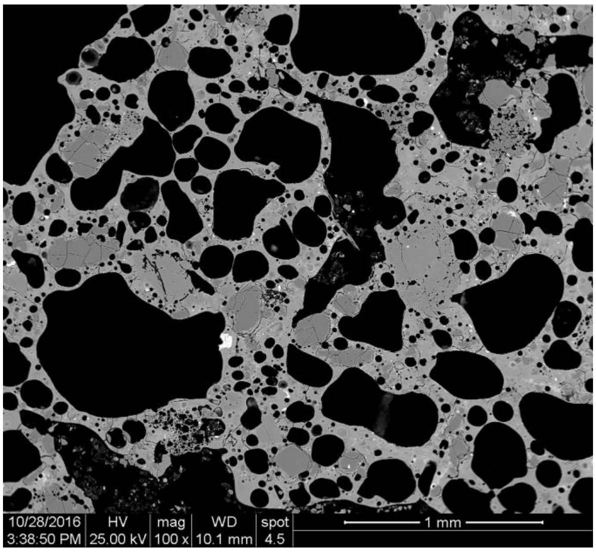


Figure 1. Gairnfield high temperature residue showing abundant quartz grains in a vesicular and vitreous matrix

Figure 2. Gairnfield high temperature residue showing abundant quartz grains in a vesicular and vitreous matrix

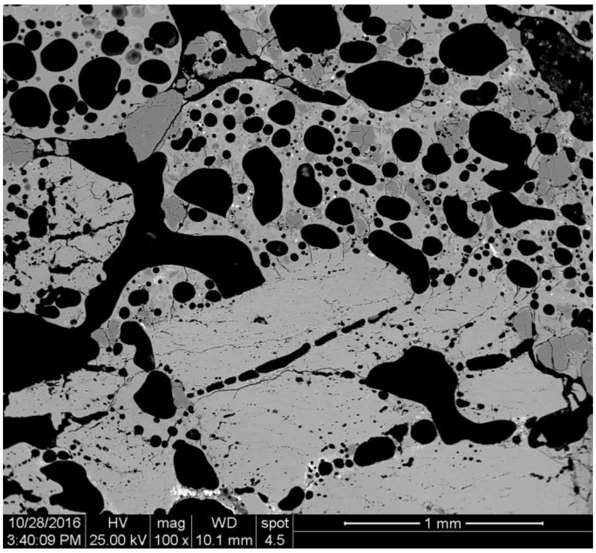


Figure 3. Gairnfield high temperature residue showing abundant quartz grains and large grains of alkali feldspar in a vesicular and vitreous matrix

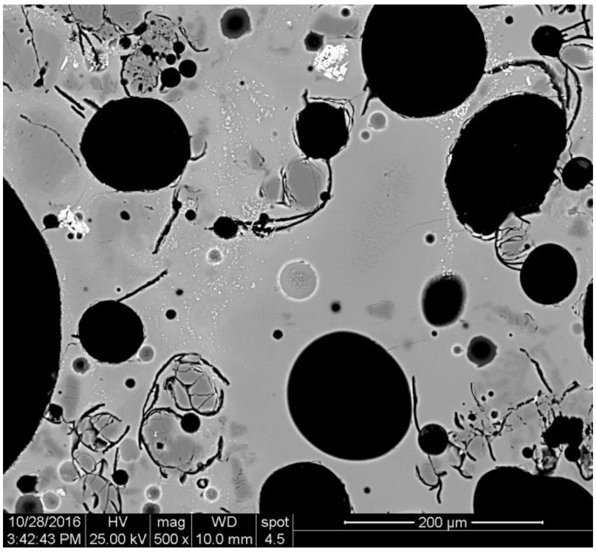


Figure 4. Gairnfield high temperature residue showing abundant the vesicular and vitreous matrix with partially dissolved quartz grains

The inclusions were analysed separately: the quartz were pure SiO2 and the Table 1 shows a representative selection of the feldspars.

Table 1. Chemical composition of the feldspar inclusions in the Gairnfield high temperature residue

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	Cl	K_2O	CaO	TiO_2	MnO	Fe_2O_3	BaO
1	2.2	<0.1	19.2	63.9	<0.1	<0.1	<0.1	13.8	<0.1	<0.1	<0.1	0.16	0.5
2	3.2	<0.1	19.6	64.4	<0.1	<0.1	<0.1	12.0	0.2	<0.1	<0.1	<0.1	0.5
3	2.1	<0.1	19.4	63.9	<0.1	<0.1	<0.1	13.9	<0.1	<0.1	<0.1	<0.1	0.5
4	3.2	<0.1	19.6	64.1	<0.1	<0.1	<0.1	11.4	0.4	<0.1	<0.1	<0.1	1.2
5	3.6	<0.1	19.3	64.8	<0.1	<0.1	<0.1	11.4	0.1	<0.1	<0.1	<0.1	0.6
6	2.4	<0.1	19.4	64.2	<0.1	<0.1	<0.1	13.4	<0.1	<0.1	<0.1	0.13	0.3
7	4.8	<0.1	19.6	65.2	<0.1	<0.1	<0.1	9.1	0.4	<0.1	<0.1	0.14	0.4
8	2.6	<0.1	19.2	63.9	<0.1	<0.1	<0.1	13.3	<0.1	<0.1	<0.1	0.15	0.6
9	8.7	<0.1	23.5	62.4	<0.1	<0.1	<0.1	0.6	4.2	<0.1	<0.1	0.18	0.1
10	10.5	<0.1	20.1	68.0	<0.1	<0.1	<0.1	1.2	<0.1	<0.1	<0.1	<0.1	<0.1

The heterogeneity of the residue made a bulk analysis impractical; however, the vitreous matrix was analysed (Table 1) by focussing the SEM on small areas that are free from inclusions (cf Figure 4).

Table 2. Chemical composition of the matrix of the Gairnfield high temperature residue

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	Cl	K_2O	CaO	TiO_2	MnO	Fe_2O_3	CuO	SnO_2	PbO
Matrix	4.6	0.6	20.5	65.1	0.2	<0.1	<0.1	5.6	1.5	0.3	<0.1	1.4	<0.1	<0.5	<0.2

The composition of the matrix provides more information on the processes that might have generated it, although the dissolution of some quartz and feldspar will have altered the composition to some degree.

Interpretation

The microstructure of the high temperature residue indicates that it was largely formed from rock (or possibly soil). The low levels of iron, copper and other metals suggest that it was not formed during the manufacture or fabrication of metals. The chemical composition of the matrix suggests that this was formed at least in part by the vitrification of plant ashes. Given the uncertain extent to which the composition of the matrix has been altered by the dissolution of quartz and feldspar there is no certain way to determine the identity of the plant ash.

While this material might represent the vitrification of rock, soil and/or plant ashes as a result of deliberate human action it could also have been produced unintentionally or even as the result of natural processes.

Gairnfield, Aberdeenshire (ABSL13 SL/004)

Report on the vitrified material

AOC project no. 23243

5th December 2016

AOC Archaeology Group

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Gairnfield, Aberdeenshire (ABSL13 SL004)

Report on the vitrified material

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AOC Project No:	**23242**
Prepared by:	**Dawn McLaren & David Dungworth**
Date of Report:	**5th December 2016**

This document has been prepared in accordance with AOC standard operating procedures.

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Contents

The vitrified material from Gairnfield (Headland Project Code: ABSL13 SL-004)

Dawn McLaren & David Dungworth

Introduction

A total of 1516.7g of vitrified and heat-affected material was recovered during excavations at Gairnfield in association with a series of late Bronze Age roundhouse structures. The majority of the assemblage is composed of low-density fuel ash slags, cinder and other heat-affected residues. These are not considered to be indicative of any form of deliberate craft process but rather appear to be components of domestic hearth debris which have become incorporated within the ditches, post-holes and pits relating to the roundhouse strutures. A small quantity of ferrous metalworking waste was also present but is likely to be secondary intrusive material post-dating the occupation of the roundhouses.

Categorisation

The assemblage was visually examined and categorised based on the morphology, density, vesicularity and colour of individual pieces. A single fragment of low-density vitrified material was selected for intrusive scientific analysis to clarify its composition and microstructure. The results of both macro- and microscopic examination are summarised below. A full catalogue of the material and methodologies for analysis used are given in the archive report.

Table 1: Summary of the vitrified material by type and weight

Type	Mass (g)
Metalworking waste	
Plano-convex slag cake fragment (PCSC)	108.4
Unclassified iron slag (UIS)	53.4
Runned slag (RS)	337.4
Magnetic vitrified residues (MVR)	1.51
Undiagnostic vitrified/heat-affected material	
Fuel ash slag/low-density slag (FAS)	882.8
Cinder	54.9
Magnetic residue	6.2
Stone (vitrified and non-vitrified)	72
Total	**1516.7**

Metalworking waste

A total of 501g of waste associated with ferrous metalworking was recovered comprising a single fragment of a plano-convex slag cake (108.4g), fractured pieces of runned slag (337.4g) and unclassified iron slag pieces (53.4g). In addition, a small quantity of magnetic residues came from sample processing (1.51g) which contained a very limited number of possible hammerscale flakes and slag spheres.

The plano-convex slag cake is incomplete but the size, density and texture is suggestive of smithing waste. This is also implied by the small number of hammerscale flakes and slag spheres recognised amongst the assemblage. The quantity of micro-debris is so limited that it is not possible to argue for *in situ* metalworking waste as these small flecks could be easily disturbed as the result of bioturbation and are likely to represent intrusive later material.

Undiagnostic vitrified and heat affected material

The bulk of the assemblage comprises amorphous fragments of partially vitrified, low-density material (882.8g) which are porous and friable, and range in colour from pale to dark brown. Some areas of the slags are heat-affected, brittle and fused, with a granular texture and pockets or inclusions of a light-grey/green, vesicular, glassy vitrified material. These glassy inclusions and patches are similar in appearance and texture to fuel ash slag or clinker (also known as cramp; Bayley 1985, 41-43; Bayley *et al* 2001, 21; Spearman 1997, 165; Photos-Jones *et al* 2007). This suggests a high silicaceous and organic content but lacks the porous structure expected of fuel as slag and the high-organic content typical of clinker/cramp.

A single sample of this low-density material was selected for further analysis to determine its chemical and structural composition. The mounted and polished sample was examined using a Scanning Electron Microscope (SEM) and the microstructure recorded using a back-scattered electron detector. The chemical composition of discrete areas of the sample were determined using an Energy dispersive X-ray spectrometer (EDS) attached to the SEM.

The sample has a microstructure which comprises a series of fairly large inclusions in a highly vesicular vitreous matrix (Figures 1–3). The vesicular nature of the matrix suggests that it formed from carbonate rich salts (such as a plant ash) and that the material was never hot enough for the matrix to completely melt (in which case the gas bubbles would have escaped). The most abundant inclusions are quartz and most of these shows cracks probably introduced by exposure to high temperatures. Slightly less abundant are the larger alkali feldspar inclusions (Figure 2). A close examination of the vitreous matrix suggests that the inclusions (in particular the quartz) have been partially dissolved by the matrix (Figure 3).

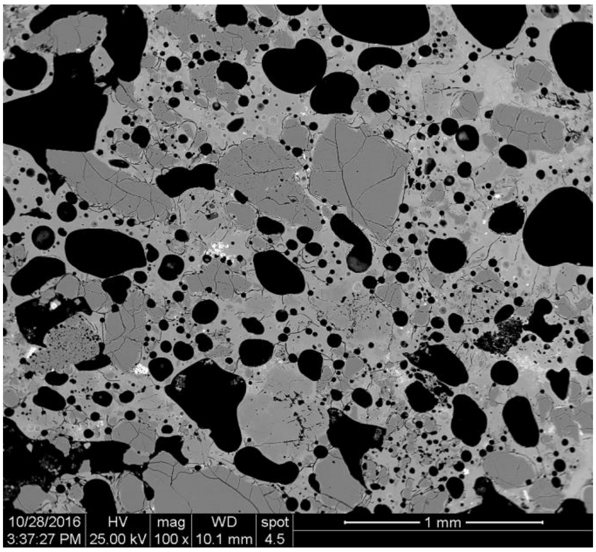

Figure 1. Gairnfield high temperature residue showing abundant quartz grains in a vesicular and vitreous matrix

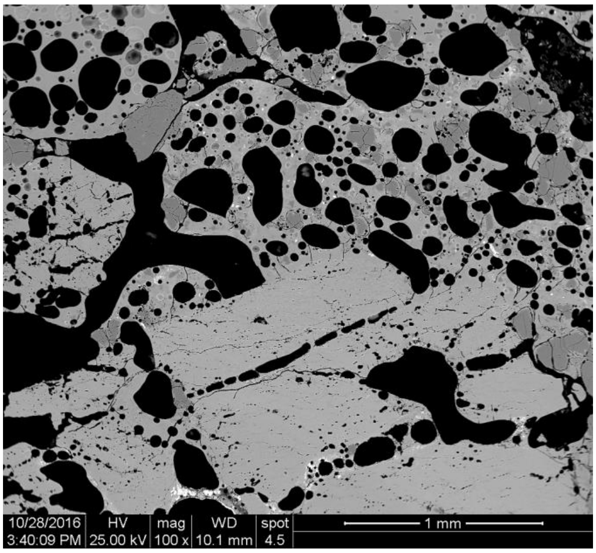

Figure 2. Gairnfield high temperature residue showing abundant quartz grains and large grains of alkali feldspar in a vesicular and vitreous matrix

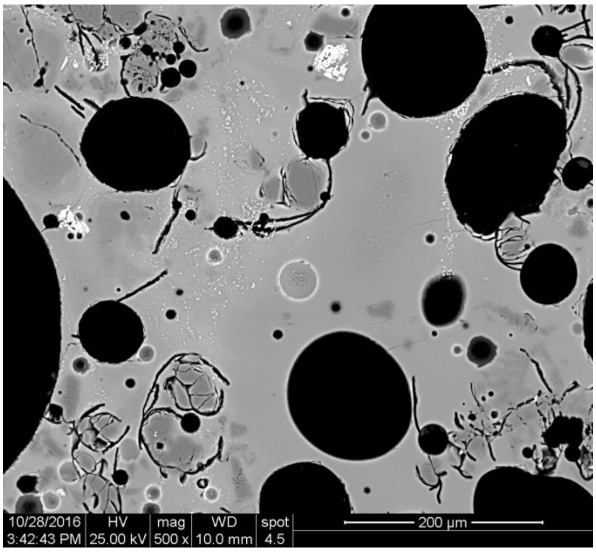

Figure 3. Gairnfield high temperature residue showing abundant the vesicular and vitreous matrix with partially dissolved quartz grains

The inclusions were analysed separately: the quartz inclusions were pure SiO2 and the Table 2 shows a representative selection of the feldspars.

Table 2 Chemical composition of the feldspar inclusions in the Gairnfield high temperature residue

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	Cl	K_2O	CaO	TiO_2	MnO	Fe_2O_3	BaO
1	2.2	<0.1	19.2	63.9	<0.1	<0.1	<0.1	13.8	<0.1	<0.1	<0.1	0.16	0.5
2	3.2	<0.1	19.6	64.4	<0.1	<0.1	<0.1	12.0	0.2	<0.1	<0.1	<0.1	0.5
3	2.1	<0.1	19.4	63.9	<0.1	<0.1	<0.1	13.9	<0.1	<0.1	<0.1	<0.1	0.5
4	3.2	<0.1	19.6	64.1	<0.1	<0.1	<0.1	11.4	0.4	<0.1	<0.1	<0.1	1.2
5	3.6	<0.1	19.3	64.8	<0.1	<0.1	<0.1	11.4	0.1	<0.1	<0.1	<0.1	0.6
6	2.4	<0.1	19.4	64.2	<0.1	<0.1	<0.1	13.4	<0.1	<0.1	<0.1	0.13	0.3
7	4.8	<0.1	19.6	65.2	<0.1	<0.1	<0.1	9.1	0.4	<0.1	<0.1	0.14	0.4
8	2.6	<0.1	19.2	63.9	<0.1	<0.1	<0.1	13.3	<0.1	<0.1	<0.1	0.15	0.6
9	8.7	<0.1	23.5	62.4	<0.1	<0.1	<0.1	0.6	4.2	<0.1	<0.1	0.18	0.1
10	10.5	<0.1	20.1	68.0	<0.1	<0.1	<0.1	1.2	<0.1	<0.1	<0.1	<0.1	<0.1

The heterogeneity of the residue made a bulk analysis impractical; however, the vitreous matrix was analysed (Table 3) by focussing the SEM on small areas that are free from inclusions (cf Figure 4).

Table 3 Chemical composition of the matrix of the Gairnfield high temperature residue

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	Cl	K_2O	CaO	TiO_2	MnO	Fe_2O_3	CuO	SnO_2	PbO
Matrix	4.6	0.6	20.5	65.1	0.2	<0.1	<0.1	5.6	1.5	0.3	<0.1	1.4	<0.1	<0.5	<0.2

The composition of the matrix provides more information on the processes that might have generated it, although the dissolution of some quartz and feldspar will have altered the composition to some degree.

The microstructure of the high temperature residue indicates that it was largely formed from rock (or possibly soil). The low levels of iron, copper and other metals suggest that it was not formed during the manufacture or fabrication of metals. The chemical composition of the matrix suggests that this was formed at least in part by the vitrification of plant ashes. Given the uncertain extent to which the composition of the matrix has been altered by the dissolution of quartz and feldspar there is no certain way to determine the identity of the plant ash.

While this material might represent the vitrification of rock, soil and/or plant ashes as a result of deliberate human action, it could also have been produced unintentionally or even as the result of natural processes.

Also present within the assemblage are small quantities of cinder (54.9g), non-diagnostic magnetic residues (6.2g) and fragments of vitrified stone (72g).

Distribution

Building 1
None of the 19.57g of vitrified and heat-affected material recovered from this structure was debris associated with metalworking and is likely to be domestic hearth debris. Small quantities of cinder (1.57g) and undiagnostic magnetic residues (0.4g) came from the fill of ditch [4D-0011] with further small quantities of cinder (2g), fuel ash slag (2.2g) and undiagnostic magnetic residues from hearth [4D-0013]. A small quantity of cinder (12g) came from (4D-0056).

Building 2
A single small fragment of unclassified iron slag (0.4g) came from ditch [4D-0148]. It is likely that the small fragment of iron slag is intrusive within this context. *there is supposed to be vit material from posthole [4D-0469] but no trace of this was found amongst the received assemblage.

Building 3
A total of 28.35g of material was associated with this structure but less than 3g is classified as metalworking waste. This comprises 2.4g of small fragments of unclassified iron slag from the fill of ring ditch segment [4D-0433], a single flake of hammerscale amongst undiagnostic magnetic residue (0.1g) from ring ditch segment [4D-0386] and a single small slag sphere from amongst undiagnostic magnetic residue (0.6g) from feature [4D-0444]. The small size and restricted mass of this material suggests that it is possible that this is intrusive residual later waste incorporated within earlier negative features.

Other vitrified and heat-affected material from this structure appears to represent fuel/hearth debris and includes 6g of cinder from pit [4D-0392]; 0.5g undiagnostic magnetic residue from ring-ditch segment [4D-0433]; 3.1g of fuel ash slag from post-hole [4D-0245]; 0.2g of schist from pit [4D-0381]; 0.13g cinder, 15.4g fuel ash slag, 0.02g albertite and 0.1g of undiagnostic magnetic residue from ring-ditch segment [4D-0386]; 1.8g of fuel ash slag and 0.8g of magnetic residue from ring-ditch segment [4D-0468]; 2.5g of fuel ash slag from feature [4D-0444] and 0.1g of magnetic residue from ring-ditch segment [4D-0386].

Building 4
A single small fractured fragment of unclassified iron slag (34.5g) came from the fill of drainage ditch [4D-0151) alongside a small quantity (0.2g) of undiagnostic magnetic residue. The other 606g of vitrified and heat-affected material associated with this structure consists of fuel or hearth

debris in the form of 1.8g of cinder, 599.53g of fuel ash slag and 0.6g of undiagnostic magnetic residue from the fill of ring-ditch [4D-0240]; 0.24g of cinder from drainage ditch [4D-0065]; 2.4g of fuel ash slag from ring-ditch [4D-0074] and 1.6g of vitrified stone from post-hole [4D-0089].

Building 5
The largest quantity of vitrified debris (708.3g) recovered at Gairnfield was associated with this structure, consisting of both metalworking waste and fuel/hearth debris. The presence of small quantities of ferrous metalworking debris (316.71g) is notable, yet none of the bulk slags appear to be securely stratified and it is likely that these, as well as the extremely restricted quantity of magnetic micro-debris (0.81g) represent later, intrusive material rather than debris contemporary with the use of the roundhouse.

Small fractured fragments of unclassified iron slag (15.2g) and runned slag (300.7g) came from (4D-0026) whilst 30.9g of unclassified iron slag was unstratified. Small quantities of magnetic vitrified material included a single small slag sphere amongst undiagnostic vitrified residues (0.1g) from post-hole [4D-0083] and 0.71g of undiagnostic vitrified residues from post-holes [4D-0138] and [4D-0338].

Fuel or hearth debris (408.4g) represented by small fragments of cinder, low-density fuel ash slag and undiagnostic magnetic residues came from twelve contexts including the fills of various post-holes, ring-ditch segments and the drainage ditch. These comprise small quantities of cinder (0.13g), fuel ash slag (3.9g) and undiagnostic magnetic residue (0.02g) from the fill (4D-0370) of the ring-ditch; 0.12g of cinder from post-hole [4D-0138]; cinder (1g) and undiagnostic magnetic residues (0.4g) from the fill of drainage ditch [4D-0017]; 3.9g cinder, 6g of fuel ash slag, 70g stone, 0.2g undiagnostic residue from context (4D-0026); 11.8g of cinder from post-hole [4D-0083]; 13.8g of cinder and 215g of fuel ash slag from context (4D-0098); 0.3g and 0.06g of undiagnostic magnetic residue from post-holes [4D-0139] and [4D-0196]; 31g of fuel ash slag from context (4D-0215); 0.2g cinder and 0.1g of undiagnostic magnetic residue from post-hole [4D-0232] and 2.57g of cinder and 0.2g of stone from post-hole [4D-0236].

Building 6
Only 1 fragment of metalworking waste was found in the vicinity of this structure consisting of an unstratified fragment of a plano-convex slag cake (108.4g). This fragment is suggestive of blacksmithing activities taking place in the area but the date and provenance of this material is unknown and unlikely to relate to the prehistoric building. More securely stratified waste consists of small quantities (3.6g) of burnt and vitrified fuel/hearth debris including 2.6g of cinder and 0.01g of magnetic residue from feature [4D-0554] and less than 1g of magnetic residues from pit [4D-0512], post-holes [4D-0539], [4D-0537], [4D-0523].

Four-post structure
A small quantity (0.5g) of cinder came from post-hole (4D-0005) of structure [4D-0021].

Discussion

Although it is fairly common for small fractured pieces of fuel ash slag and non-metalwork related vitrified materials to be recovered from later prehistoric structures associated with hearths, kilns and other pyrotechnic activities, the formation processes that lead to the creation of this material are not always well understood. Small quantities of similar material are known from other late Bronze Age settlements, such as those at Oldmeldrum, Aberdeenshire (McLaren 2010), Kirtaraglen, Isle of Skye (McLaren 2013, 47) and Northton, Harris (Heald 2006, 171). These fuel ash slags and other low-density slags are typically thought to represent debris from domestic hearths but the fact that not every hearth of later prehistoric date produces fuel ash slag indicates that specific constituents, in terms of fuel type, soil type, temperature and perhaps other materials added to the fire while lit, are key components in the formation of this partially vitrified material.

The recovery of non-metalwork related low-density slags from Gairnfield is, therefore, not unexpected but the quantity and size of the fragments is notably large. In total, over 800 grammes of this waste was found and survives in fractured amorphous lumps measuring up to 90mm in diameter. The pieces are distributed in a light scatter across negative features (e.g. pits and post-holes) in the interior of buildings 1, 3, 4 and 5, including a concentration of 599.53g from the ring-ditch of building 4. Many of the pieces of low-density slag were found alongside pieces of cinder, emphasising their association with domestic hearth debris. Scientific analysis of the chemical composition of a sample of this waste demonstrates that the constituent materials are vitrified rock or soil and plant ashes.

At the late Iron Age farmstead (mound 1) at Bornish, South Uist, none of the slags recovered during excavation appeared to derive from metallurgical processes but instead were thought to be a product of reactions between iron-bearing peat ash, the calcareous sands of the machair and, in some instances, fragments of rock, within hearths and ovens (Young 2012, 289). This material comprised friable, sintered waste, but also included pockets of denser material, which was more heavily fused and vitrified, like the material from Gairnfield. Young's analysis of the Bornish material suggests that the slags were produced as the result of high temperatures within a hearth that was maintained for an extended period of time, allowing slags to be generated through the sintering of sand into which the features were cut, as well as through reactions with peat fuel (*ibid*, 289). The peat ash from the fuel would have provided a source of silicates for the material and the peat ash would have contributed a fluxing effect leading to the partial vitrification of some of the sintered material (*ibid*, 294).

At Gairnfield, it was not possible to be as confident about the fuel type being used in association with the hearths through analysis of the vitrified material alone. Environmental analysis of fuel waste from the site by ** demonstrates that ** was the principal fuel used and the dominant source of plant ash that would have contributed to the formation of this heat-affected material.

Conclusion

The majority of the vitrified material from Gairnfield is not metalwork-related in origin but rather appears to be the bi-product of household hearths in use within and in association with the timber-built roundhouse structures. The formation processes that lead to the production of these slags is not well understood but may be the result of the fire within the hearths being continuously fed and maintained over an extended period of time allowing underlying soils, stones and ash from the fuel to partially melt and fuse together. The small quantity of ferrous metalworking waste amongst the slag assemblage from Gairnfield represents a spread of unstratified and intrusive later debris relating to metalworking activities of an unknown date and provenance.

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APPENDIX A: THE ARCHIVE SLAG CATALOGUE

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
26		n/a	Building 5 (4D-0025)	Cinder	3 sub-rounded, amorphous fragments of dark brown/black cinder.	3	N	3.9	19	14.5	10	no	no	n/a	dimensions record largest fragment only
67	44027	Drainage ditch [4D-0065]	Building 4 (4D-0024)	Cinder	4 fragments of dark-brown/black heat-affected material; porous and brittle in texture; non-magentic	4	n	0.2	10	5	5	no	no	n/a	dimensions record largest fragment only
370	125	Ring-ditch segments [4D-0433] [4D-0439] [4D-0444] [4D-0468]	Building 5 (4D-0025)	Cinder	Two small, fractured, angular pieces of dark brown, heat-affected material; low density and non-magnetic. The fragments are porous and brittle in texture with frequent air bubble voids and appears glassy under magnification.	2	N	0.13	11	8	5	no	no	n/a	dimensions record largest fragment only

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
4D-0018	40012	Drainage ditch [4D-0017]	Building 5 (4D-0025)	Cinder	9 fragments of dark-brown/black heat-affected material; porous and brittle in texture; non magnetic	9	N	1	12	7	6	no	no	n/a	dimensions record largest fragment only
4D-0094	40032	Ditch [4D-0011]	Building 1 (4D-0019)	Cinder	Small, fractured, amorphous fragment of dark brown/black heat-affected material; low-density. The piece is porous and brittle in texture with frequent air bubble voids and appears glassy under magnification.	1	N	0.27	13.5	10	8.5	no	no	n/a	
4D-0134	40049	Drainage ditch [4D-0065]	Building 4 (4D-0024)	Cinder	4 fragments of glassy cinder, black in colour with frequent air bubbles	4	N	0.04	9.5	6.5	3.5	no	no	n/a	dimensions record largest fragment only

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
4D-0161	40060	Post-hole [4D-0138]	Building 5 (4D-0025)	Cinder	Two small fractured, sub-angular fragments of dark brown/black heat affected material; low density; non-magnetic. The fragmetns are porous and brittle in texture with frequent air bubble voids and appears glassy under magnification	2	N	0.12	9	6	3.5	no	no	n/a	dimensions record largest fragment only
40396	40140	Ring-ditch segment [4D-0386]	Building 3 (4D-0023)	Cinder	Two small fractured, sub-angular fragments of dark brown/black heat affected material; low density; non-magnetic. The fragmetns are porous and brittle in texture with frequent air bubble voids and appears glassy under magnification	2	N	0.13	10.5	6	4.5	charcoal	no	n/a	dimensions record largest fragment only

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
44006	44002	4-Post Structure (4D-0021)	Post-hole [4D-0005]	Cinder	Two small fractured, sub-angular fragments of dark brown/black heat affected material; low density; non-magnetic. The fragmetns are porous and brittle in texture with frequent air bubble voids and appears glassy under magnification	2	N	0.5	11	9	8.5	no	no	n/a	dimensions record largest fragment only
44014	44006	Hearth [4D-0013]	Building 1 (4D-0019)	Cinder	3 small amorphous fragments of dark-brown/black heat-affected material; porous and brittle in texture; non-magnetic	3	N	0.2	8	4.5	4	no	no	n/a	dimensions record largest fragment only

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
44029	44014	Ditch [4D-0011]	Building 1 (4D-0019)	Cinder	6 fragments of dark-brown/black heat-affected material; porous and brittle in texture with frequent air bubble voids; glassy in appearance under magnification.	6	N	1.3	16.5	12.5	9	no	no	n/a	dimensions record largest fragment only
44066	44041	Ring-ditch [4D-0240]	Building 4 (4D-0024)	Cinder	12 fragments of dark-brown/black heat affected material; porous and brittle in texture with frequent air bubble voids; glassy in appearance under magnification	12	N	1.8	21	14.5	9	no	no	n/a	dimensions record largest fragment only
44098	44040	n/a	Building 5 (4D-0025)	CInder	12 small angular fractured fragments of dark brown/black porous and brittle, heat-affected material. Low-density; non-magnetic.	12	N	13.8	38	38	19	no	no	n/a	dimensions record largest fragment only

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
44232	44113	Post-hole [4D-0190]	Building 5 (4D-0025)	Cinder	7 small angular fractured nodules of black/brown, porous, low-density cinder	7	N	0.2	11.5	8	6.5	no	no	n/a	dimensions record largest fragment only
44555	44261	Feature[4D-0554]	Building 6 (4D-0508)	Cinder	9 sub-rounded, amorphous, fragments of dark-brown/black heat-affected material; porous and brittle in texture; glassy in appearance under magnification; non-magnetic	9	n	2.6	16	15	10.5	no	no	n/a	dimensions record largest fragment only
236	90	Post-hole [4D-0235]	Building 5 (4D-0025)	Cinder	21 small, fractured and amorphous fragments of a dark brown/black porous and brittle heat affected material. Very similar in texture and morphology to cinder but with occasional vitrified areas.	21	N	2.57	13	12	8	no	no	n/a	dimensions record largest fragment only

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
4D-0016	40008	Hearth [4D-0013]	Building 1 (4D-0019)	Cinder	8 small, fractured and amorphous fragments of a dark brown/black porous and brittle heat affected material. Very similar in texture and morphology to cinder but with occasional vitrified areas.	8	N	1.8	18	13	17.5	no	no	n/a	dimensions record largest fragment only
4D-0085	40029	Post-hole [4D-0083]	Building 5 (4D-0025)	Cinder	16 fractured and friable amorphous fragments of a heat-affected but not vitrified material. In colour it is red-brown to dark brown, texture is granular and similar in appearance to cinder	16	N	11.8	22	17	14	no	n	n/a	dimensions record largest fragment only
44056	44021	n/a	Building 1 (4D-0019)	Cinder	A single, triangular fragment of dark grey, porous, brittle, heat-affected material; low-density.	1	N	12	13.5	8	5	no	no	n/a	

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
44361	44131	Pit [4D-0381]	Building 3 (4D-0023)	Cinder	Dark-brown/black heat affected material; porous and brittle in texture with frequent air bubble voids; glassy appearance under magnification.	1	N	0.6	20	12	10	no	no	n/a	

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
120	176	Ring-ditch [4D-0240]	Building 4 (4D-0024)	FAS/Low-density	36 amorphous, fractured, friable pieces of low-density, heat-affected material, vitrified only in patches. The pieces are red-brown/pale grey in colour, granular in texture with frequent small quartz inclusions with the appearance of burnt silty soil. Some have a curved concave/convex profile but others are amorphous. The vitrified areas are discrete and restricted but are porous, brittle and matt, ranging in colour from pale buff to a pale grey.	36	N	214.33	62	50	39.5	no	no	n/a	1 sample weighing 36.1g extracted and sent to D Dungworth for analysis. dimensions record largest fragment only

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
120	n/a	Ring-ditch [4D-0240]	Building 4 (4D-0024)	FAS/Low-density	5 angular and amorphous fragments of a friable, pale red-brown heat-affected material, vitrified only in patches. The vitrified inclusions have the appearance of cramp- light in colour and weight, porous but brittle, low-density and globular and molten looking in appearance. These globules are trapped in a matrix of burnt quartz-rich silty earth which has baked into a fused material with granular texture. Not magnetic.	5	N	278	91	72	40	no	no	n/a	dimensions record largest fragment only

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
120	115	Ring-ditch [4D-0240]	Building 4 (4D-0024)	FAS/Low-density	7 angular, fractured fragments of low-density, heat-affected material, granular in texture with the appearance of heat-affected silty soil and occasional vitrified and fused patches; pale red-brown to grey in colour; porous, brittle and friable. Not magnetic.	7	N	70.5	60	58	25.5	no	no	n/a	dimensions record largest fragment only

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions ?	Suggestive of metalworking ?	Stage	Notes
120	n/a	Ring-ditch [4D-0240]	Building 4 (4D-0024)	FAS/Low-density	Amorphous fragment of fuel ash slag, a heat-affected granular material with occasional quartz inclusions, vitrified on one surface only; ranges in colour from pale buff to grey to a red brown. Texture is granular where less heat affected; vitrified portions are molten-looking but porous and brittle.	1	N	23.1	51	39.5	31.5	no	no	n/a	

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
403	161	Ring-ditch segment [4D-0468]	Building 3 (4D-0023)	FAS/Low-density	9 fractured sub-angular fragments of low-density, heat-affected material, vitrified in patches with a general granular texture throughout; frequent small quartzite inclusions. The vitrified patches are porous and brittle in texture with frequent air bubble voids. Non Magnetic	9	N	1.8	15	12	9	no	no	n/a	dimensions record largest fragment only
4D-0015	40007	Hearth [4D-0013]	Building 1 (4D-0019)	FAS/Low-density	3 small amorphous fragments of low-density heat-affected/vitrified material. The pieces are porous and brittle in texture and range in colour from pale buff/red-brown/pale grey to black	3	N	2.2	18.5	15.5	11.5	no	no	n/a	dimensions record largest fragment only

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
4D-0026	40025	n/a	Building 5 (4D-0025)	FAS/Low-density	Two amorphous, sub-rounded fragments of low-density vitrified material; porous and brittle in texture and glassy in patches. Not magnetic.	2	N	6	25.5	19.5	19	no	n	n/a	dimensions record largest fragment only
4D-0098	40072	n/a	Building 5 (4D-0025)	FAS/Low-density	19 amorphous, sub-angular fractured fragments of heat-affected, low-density material with frequent patches of vitrification. The pieces are red-brown, dark brown and grey in colour with frequent flecks of quartzite with a porous and brittle texture very similar in patches to cinder. The vitrified patches have frequent air bubbles and are slightly glassy under magnification.	19	N	214.7	86.5	69	46.5	no	no	n/a	dimensions record largest fragment only

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
4D-0215	40083	n/a	Building 5 (4D-0025)	FAS/Low-density	54 small, sub-rounded, amorphous fragments of low-density vitrified material; pale grey-buff in colour through to dark red-brown/black; porous and brittle with a granular texture and frequent small quartzite inclusions. Vitrified patches are molten-looking with frequent air bubble voids.	54	N	31	29.5	21	10	no	no	n/a	dimensions record largest fragment only

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
40370	40150	Ring-ditch segments [4D-0433] [4D-0439] [4D-0444] [4D-0468]	Building 5 (4D-0025)	FAS/Low-density	18 small, fractured, angular and amorphous fragments of low-density vitrified material; pale brown-grey in colour; porous and brittle with a granular texture and frequent small quartzite inclusions. Vitrified patches are molten-looking with frequent air bubble voids.	18	N	3.9	14.5	13.5	9.5	no	no	n/a	dimensions record largest fragment only

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
44066	44041	Ring-ditch [4D-0240]	Building 4 (4D-0024)	FAS/Low-density	11 fractured sub-angular fragments of low-density, heat-affected material, vitrified in patches with a general granular texture throughout; frequent small quartzite inclusions. The vitrified patches are porous and brittle in texture with frequent air bubble voids. Non Magnetic	11	N	2	13	12	9	no	no	n/a	dimensions record largest fragment only
44120	44051	Ring-ditch [4D-0240]	Building 4 (4D-0024)	FAS/Low-density	13 fractured angular fragments of low-density, heat-affected material, vitrified in patches with a general granular texture throughout. The vitrified patches are porous and brittle in texture whilst the pieces as a whole are friable.	13	N	11.6	32.5	23	13	no	no	n/a	dimensions record largest fragment only

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
44186	44067	Ring-ditch [4D-0074]	Building 4 (4D-0024)	FAS/Low-density	7 sub-rounded fractured pieces of low-density, heat-affected granular material, vitrified in patches.	7	N	2.4	20	16	10	no	no	n/a	dimensions record largest fragment only
44248	44089	Post-hole [4D-0245]	Building 3 (4D-0023)	FAS/Low-density	7 small, fractured, angular and amorphous fragments of low-density vitrified material; pale brown-grey in colour; porous and brittle with a granular texture and frequent small quartzite inclusions. Vitrified patches are molten-looking with frequent air bubble voids.	7	N	3.1	21	17	13.5	no	no	n/a	dimensions record largest fragment only

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions ?	Suggestive of metalworking ?	Stage	Notes
44420	44154	Feature [4D-0444]	Building 3 (4D-0023)	FAS/Low-density	11 small, fractured, angular and amorphous fragments of low-density vitrified material; pale brown-grey in colour; porous and brittle with a granular texture and frequent small quartzite inclusions. Vitrified patches are molten-looking with frequent air bubble voids.	11	N	2.5	14	9.5	9	no	no	n/a	dimensions record largest fragment only
40398 / 40397	40141	Ring-ditch segment [4D-0386]	Building 3 (4D-0023)	FAS/Low-density	27 small fractured, sub-rounded fragments of low-density vitrified material; pale grey-buff in colour; porous, brittle and granular in texture with frequent small quartzite inclusions. Vitrified patches are molten looking with frequent air bubble voids.	27	N	15.4	23	18.5	17	no	no	n/a	dimensions record largest fragment only

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
44098	44040	n/a	Building 5 (4D-0025)	FAS/Low-density	Two small nodules of pale buff/grey fuel ash slag; low density; porous and brittle in texture with frequent air bubble voids.	2	N	0.3	9	9	7	no	no	n/a	dimensions record largest fragment only
112	173	Ring-ditch [4D-0240]	Building 4 (4D-0024)	Mag Res	Small flecks of magnetic residue; includes fragments of quartz, mica and schist. No hammerscale flakes or spheres noted	see mass	Y	0.6							
370	125	Ring-ditch segments [4D-0433] [4D-0439] [4D-0444] [4D-0468]	Building 5 (4D-0025)	Mag Res	Small flecks of magnetic residue; includes fragments of quartz, mica and schist. No hammerscale flakes or spheres noted	see mass	Y	0.02							
403	161	Ring-ditch segment [4D-0468]	Building 3 (4D-0023)	Mag Res	Small flecks of magnetic residue; includes fragments of quartz and schist. No hammerscale flakes or spheres noted	see mass	Y	0.8							

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions ?	Suggestive of metalworking ?	Stage	Notes
412	146	Ring-ditch segment [4D-0433]	Building 3 (4D-0023)	Mag Res	Small flecks of magnetic residue; includes fragments of quartz, mica and schist. No hammerscale flakes or spheres noted	see mass	Y	0.5							
514	251	Pit [4D-0512]	Building 6 (4D-0508)	Mag Res	Small flecks of magnetic residue; includes fragments of quartz, mica and schist. No hammerscale flakes or spheres noted	see mass	Y	0.3							
515	254	Post-hole [4D-0539]	Building 6 (4D-0508)	Mag Res	Small flecks of magnetic residue; includes fragments of quartz, schist, possible albertite. No hammerscale flakes or spheres noted.	see mass	Y	0.4							

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
521	255	Post-hole [4D-0523]	Building 6 (4D-0508)	Mag Res	Small flecks of magnetic residue; includes fragments of quartz, schist and haematite/pyrite (with cubiodal structure). No hammerscale flakes or spheres noted.	see mass	Y	0.2							
550	260	Ring-ditch segment [4D-0386]	Building 3 (4D-0023)	Mag Res	Small flecks of magnetic residue; includes fragments of quartz and schist. No hammerscale flakes or spheres noted	see mass	Y	0.1							
40538	40257	Post-hole [4D-0537]	Building 6 (4D-0508)	Mag Res	Small flecks of magnetic residue; includes fragments of quartz, mica and schist. No hammerscale flakes or spheres noted	see mass	Y	0.1							

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
44014	44006	Hearth [4D-0013]	Building 1 (4D-0019)	Mag Res	Small flecks of magnetic residue; includes fragments of quartz, mica and schist. No hammerscale flakes or spheres noted	see mass	Y	0.9							
44026	44025	n/a	Building 5 (4D-0025)	Mag Res	Small flecks of magnetic residue; includes fragments of quartz, mica and schist. No hammerscale flakes or spheres noted	see mass	Y	0.2							
44030	44009	Hearth [4D-0013]	Building 1 (4D-0019)	Mag Res	Small flecks of magnetic residue; includes fragments of quartz, mica and schist. No hammerscale flakes or spheres noted	see mass	Y	0.5							
44036	44020	Ditch [4D-0011]	Building 1 (4D-0019)	Mag Res	Small flecks of magnetic residue; includes fragments of quartz, mica and schist. No hammerscale flakes or spheres noted	see mass	Y	0.4							

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
44039	44026	Drainage ditch [4D-0017]	Building 5 (4D-0025)	Mag Res	Small flecks of magnetic residue; includes fragments of quartz, mica and schist. No hammerscale flakes or spheres noted	see mass	Y	0.4							
44140	44047	Post-hole [4D-0139]	Building 5 (4D-0025)	Mag Res	Small flecks of magnetic residue; includes fragments of quartz, mica and schist. No hammerscale flakes or spheres noted	see mass	Y	0.3							
44197	44070	Post-hole [4D-0196]	Building 5 (4D-0025)	Mag Res	Small flecks of magnetic residue; includes fragments of quartz, mica and schist. No hammerscale flakes or spheres noted	see mass	Y	0.03							
44198	44070	Post-hole [4D-0196]	Building 5 (4D-0025)	Mag Res	Small flecks of magnetic residue; includes fragments of mica and schist. No hammerscale flakes or spheres noted	see mass	Y	0.03							

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
44227	44085	Drainage ditch [4D-0151]	Building 4 (4D-0024)	Mag Res	Small flecks of magnetic residue; includes fragments of quartz, mica and schist. No hammerscale flakes or spheres noted	see mass	Y	0.2							
44232	44113	Post-hole [4D-0190]	Building 5 (4D-0025)	Mag Res	Small flecks of magnetic residue; includes fragments of quartz, mica and schist. No hammerscale flakes or spheres noted	see mass	Y	0.1							
44555	44261	Feature[4D-0554]	Building 6 (4D-0508)	Mag Res	Small flecks of magnetic residue; includes fragments of quartz and schist. No hammerscale flakes or spheres noted	see mass	Y	0.01							
340	116	Post-hole [4D-0338]	Building 5 (4D-0025)	MVR	Four small fragments of magnetic vitrified material; not diagnostic form.	4	Y	0.01				no	no	n/a	not measured

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
4D-0085	40029	Post-hole [4D-0083]	Building 5 (4D-0025)	MVR	Small flecks of magnetic residue; includes fragments of quartz, mica and schist. One tiny slag sphere noted	see mass	Y	0.1							
44144	44054	Post-hole [4D-0138]	Building 5 (4D-0025)	MVR	Single small fractured angular fragment of magentic vitrified residue; not diagnostic	see mass	Y	0.7							
44396	44140	Ring-ditch segment [4D-0386]	Building 3 (4D-0023)	MVR	Small flecks of magnetic residue; includes fragments of quartz, mica and schist. One tiny ?hammerscale flake noted	see mass	Y	0.1							
44420	44154	Feature [4D-0444]	Building 3 (4D-0023)	MVR	Small flecks of magnetic residue; includes fragments of quartz, mica and schist. One tiny slag sphere noted	see mass	Y	0.6							

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
unstrat			Building 6 (4D-0508)	PCSC fragment	Wedge-shaped fragment of a thin, sub-circular, plano-convex slag cake with rounded, uneven edges. Appears to represent less than 25% of a circular cake, edges broken. The upper surface is dished towards the now lost centre where it is fairly smooth from downwards blast of air flow from the bellows. The lower surface is convex and pitted with small angular charcoal impressions. The colour is red-brown and is slightly more grey in colour on the upper surface.	1	Y	108.4	83	68.5	23	charcoal fleck impressions on base	Y	probably smithing	

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
26		n/a	Building 5 (4D-0025)	RS	9 fractured, angular, amorphous fragments of dark grey, dense iron slag. Molten-looking in apperance and runned in places; frequent air bubble voids; one fragment slightly magnetic	9	y (1 piece only)	233.7	59	38	30	no	Y	not diagnostic to process; based on density alone, possibly smelting	dimensions record largest fragment only
44026	44025	n/a	Building 5 (4D-0025)	RS	7 fractured angular fragments of runned, molten-looking vitrified material; dense in texture; red-brown to grey in colour; occasional charcoal impressions	7	Y	67	43.5	43	25	charcoal impressions	Y	too small a fragment to confirm; probably smelting	dimensions record largest fragment only

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
unstrat	n/a	n/a	n/a	RS	Fractured fragment of runned slag; surfaces molten looking and flowed in appearance; dark red-grey/purple in colour; dense but with occasional air bubble voids in interior material (seen on break surface)	1	N	5.8	21.5	18.5	10.1	no	Y	too small a fragment to confirm; probably smelting	
unstrat			Building 5 (4D-0025)	RS	Sub-square angular fractured fragment of a piece of dense grey vitrified material; slag when molten has flowed around small charcoal fragments and impressions of the charcoal are present across the fractured surfaces. Slightly magnetic.	1	Y	30.9	42.5	35.5	23	Charcoal impressions throughout	Y	too small a fragment to confirm; probably smelting	

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
40396	40140	Ring-ditch segment [4D-0386]	Building 3 (4D-0023)	Stone	Flat angular fragment of albertite; dense black structure with natural lusture on surface. Natural	1	N	0.02	6.5	6.5	2	no	natural	n/a	natural
26		n/a	Building 5 (4D-0025)	Stone	stone: discarded	1	N	70				No	No	n/a	not measured
40390	40137	Pit [4D-0392]	Building 3 (4D-0023)	Stone	2 small soft stone fragments, pale green-grey in colour. Possibly a schist	2	N	0.2				no	no	n/a	not measured
164		Drainage ditch [4D-0151]	Building 4 (4D-0024)	UIS	Amorphous fragment of dense, red-brown, slightly magnetic unclassified iron slag; no signficant inclusions.	1	Y	35.4	50.5	41	21	rare charcoal impressions	Y	not diagnostic to process	
412	146	Ring-ditch segment [4D-0433]	Building 3 (4D-0023)	UIS	Small amorphous fragment of dense, dark grey, vitrified unclassified iron slag. Not magnetic	1	N	2.4	17	15	11		Y	too small a fragment to confirm; probably smelting	dimensions record largest fragment only

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions?	Suggestive of metalworking?	Stage	Notes
4D-0026	40025	n/a	Building 5 (4D-0025)	UIS	Nine fractured angular fragments of unclassified iron slag. The material is red-brown/grey in colour, dense in texture with occasional air bubble voids. No significant inclusions observed. Only two small fragments are magnetic.	9	y (2 pieces only)	15.2	26.5	29.5	25	no	Y	not diagnostic to process	dimensions record largest fragment only
44149	44055	Ditch [4D-0148]	Building 2 (4D-0022)	UIS	Small spall of molten-looking vitrified material; dark grey-purple in colour, molten-looking in apperance. No significant inclusions or impressions; not magnetic	1	N	0.4	11	11	2.5	no	Y but very small	not diagnostic	
236	90	Post-hole [4D-0235]	Building 5 (4D-0025)	Vit S	Small spall of mica-rich schist; magnetic.	1	Y	0.2				No	No	n/a	not measured

Context	Sample	Feature	Structure	Short ID	Description	Quantity	Magnetic	Mass (g)	L (mm)	W (mm)	T (mm)	Significant inclusions/impressions ?	Suggestive of metalworking ?	Stage	Notes
44081	44034	Post-hole [4D-0089]	Building 4 (4D-0024)	Vit S	Small, fractured, angular fragment of vitrified stone; under magnification the outer surfaces only are vitrified and heat-altered, the interior is solid with horizontal bedding.	1	Y (low)	1.6	16	15.5	1.5	no	no	n/a	fragment of ?fossilised rootlet also present

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Appendix-2.2.24 GOVAL
Client ID: ABSL13 NL006A
AOC project number 23242

Site summary

Excavation at Goval encompassed further settlement remains on the north-eastern bank of the River Don. The Iron Age settlement encompassed at least two post-built timber roundhouses, various pits and ditches and a feature identified in the field as a possible hearth [6A-0050], and two possible truncated basal pits of furnaces associated with metalworking waste {6A-0096] & [6A-0118]. C14 dates from the site are AD 70-126 and AD 31-121.

I've asked for further information about the possible hearth and furnace structures including photographs/plans or field sketches but I've not received anything to date. If more information that I've provided is required to conduct meaningful analysis of the samples sent, please let me know as I am repeatedly chasing our client for clarification.

Summary of vitrified debris

Approx 2.5 Kg of vitrified waste was recovered during excavation and includes waste suggestive of iron smelting only. No obvious waste from blacksmithing (such as small plano-convex hearth bottoms, collections of hammerscale flakes or spheres) is present. No large hearth bottom fragments were present. The slag assemblage consists principally of small quantities of fractured and fragmentary unclassified iron slags and runned slags as well as small quantities of magnetic vitrified residues which contain occasional atypical slag spheres.

The majority of the slags came from **Furnace [6A-0118**]. I have selected two fragments of runned slag from this feature (contexts 126 and 128); two pieces of unclassified iron slag (from contexts 126 and 145) and a small quantity of the magnetic vitrified residue (0.5g) from context 131 for analysis.

A much more restricted quantity of slags came from **Furnace [6A-0096]** but comprise small quantities of unclassified iron slag and magnetic vitrified residues with occasional flakes. The quantity of material is so small I have questioned the field interpretation as a furnace. I have extracted a small quantity of MVR and the only piece of UIS from this feature for analysis to compare to the composition of [6A-118].

Similarly, a very restricted quantity of iron slags came from **Hearth [6A-0050]** but includes unclassified iron slag and magnetic vitrified residues. I have extracted a single sample of Unclassified iron slag and a small quantity of magnetic vitrified residues for analysis to compare to the material from the two furnace features.

There is a fragment of what I think is roasted bog ore from a post-hole near to furnace 6A-0118 which I've also included for analysis to confirm the id as bog ore and to see if it is possible to detect whether ore of the same composition was that being smelted on site.

Scientific Examination of Ironworking Debris

David Dungworth

Introduction

The site of Goval, on the north-eastern bank of the River Don, is an Iron Age settlement with post-built roundhouses, two shallow pits interpreted in the field as possible basal pits for truncated ironworking furnaces (Furnace [6A-0118] and Furnace [6A-0096]), and a possible ironworking hearth (Furnace [6A-050]). The radiocarbon dates indicate activity in the first two centuries AD. The small assemblage of slag (approximately 2.5kg) was assessed by Dawn McLaren and includes small pieces of run slag and unclassified iron slag (two of these were obscured by iron concretions and during sampling it became apparent that these were further examples of run slag). There is no tap slag and are no furnace base fragments. There are no plano-convex hearth bases and no concentrations of hammerscale to indicate smithing.

Samples and Methodology

Ten samples of slag and magnetic residues (Table 1) were mounted in epoxy resin and ground to reveal a cross-section. This was then polished to a 1-micron finish using standard metallographic techniques. The polished samples were examined using a Scanning Electron Microscope (SEM) and the microstructure recorded using a back-scattered electron (BSE) detector (Figures 1–18). The chemical composition of discrete areas of the samples (Tables 2–10) was determined using an Energy dispersive X-ray spectrometer (EDS) attached to the SEM. For each sample a score of chemical homogeneity-heterogeneity (H) was calculated by summing (for each element present) the product of the mean times the standard deviation (divided by 100) (see Dungworth 2007, 3). Homogeneous samples (such as tap slags) tend to have low values for H (1.2±0.5) while heterogeneous samples have higher values: 2–4 for non-tapped smelting slags and even higher for some iron smithing slags.

Table 1. Goval samples

#	[ ]	< >	Feature Description	Slag Description
1	126	68	Furnace [6A-0118]	Run slag
2	128	72	Furnace [6A-0118]	Run slag
3	126	68	Furnace [6A-0118]	Run slag (partially obscured by iron concretion)
4	145	71	Furnace [6A-0118]	Run slag (partially obscured by iron concretion)
5	131	67	Furnace [6A-0118]	Magnetic residue
6	101	50	Furnace [6A-0096]	Unclassified
7	99	48	Furnace [6A-0096]	Magnetic residue
8	50	99	Furnace [6A-050]	Unclassified
9	50	99	Furnace [6A-050]	Magnetic residue
10	182		Post hole	Possible bog iron ore

Results

Sample 1

This sample has a typical iron slag microstructure (Figures 1 and 2): it is dominated by fayalite (Fe_2SiO_4) laths, and these contain some hercynite ($FeAl_2O_4$), along with dendritic wüstite (FeO), although this contains a small proportion of a second phase (slightly darker laths) which is possibly maghemite (Fe_2O_3). The regions between the fayalite laths are filled with a complex, microcrystalline matrix; the individual components of this matrix are too fine to allow discrete analysis of individual phases using SEM-EDS. The sample is quite homogeneous (H = 1.2) suggesting that it has been fully molten at some stage. The sample has a chemical composition typical of ironworking slags (Table 2), although the presence of barium and manganese suggest that this is a smelting slag rather than a smithing slag.

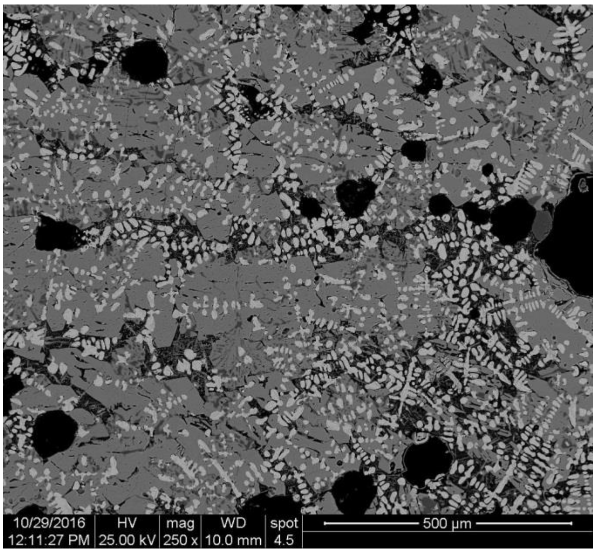

Figure 1. SEM (BSE) image of sample 1 showing porosity (black), fayalite (grey) and wüstite dendrites (white)

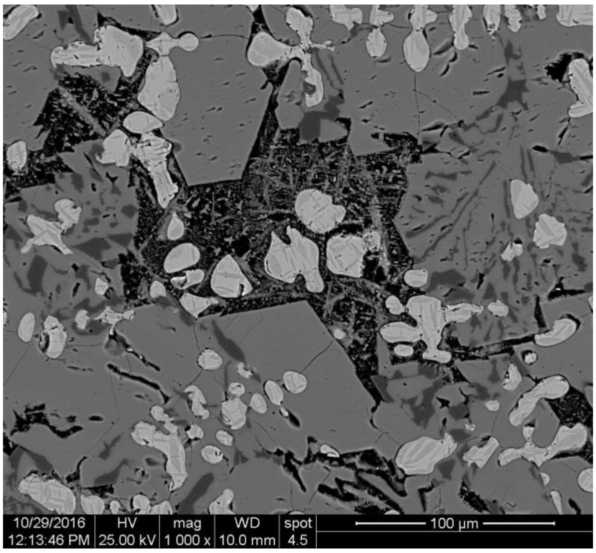

Figure 2. SEM (BSE) image of sample 1 showing micro-crystalline groundmass, surrounded by fayalite laths, which also contain dispersed eutectoid hercynite (dark grey), as well as wüstite droplets which contain some maghemite, mid-grey)

Table 2. Chemical composition of Sample 1 (6 separate areas) with the average and standard deviation (and H)

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	Cl	K_2O	CaO	TiO_2	V_2O_5	MnO	FeO	BaO	
Area 1	0.77	0.38	6.6	19.7	0.95	0.12	<0.1	0.65	0.88	0.25	<0.1	6.6	62.3	0.66	
Area 2	0.61	0.45	6.3	19.6	0.96	0.12	<0.1	0.59	0.80	0.25	<0.1	6.7	62.9	0.59	
Area 3	0.81	0.47	6.3	19.8	1.07	0.16	<0.1	0.81	0.96	0.24	<0.1	6.2	62.5	0.59	
Area 4	1.35	0.24	7.9	20.2	1.46	0.19	<0.1	1.32	1.63	0.43	<0.1	5.6	58.6	0.95	
Area 5	1.33	0.27	8.2	19.5	1.44	0.15	<0.1	1.13	1.49	0.30	<0.1	5.5	59.6	0.96	
Area 6	1.18	0.36	7.1	19.5	1.26	0.20	<0.1	0.94	1.26	0.31	<0.1	5.9	60.9	0.89	
Mean	**1.01**	**0.36**	**7.1**	**19.7**	**1.19**	**0.16**	**<0.1**	**0.91**	**1.17**	**0.30**	**<0.1**	**6.1**	**61.1**	**0.77**	
sd	0.32	0.09	0.8	0.3	0.23	0.04		0.28	0.34	0.07		0.5	1.7	0.18	
H	0.003	0.000	0.057	0.055	0.003	0.000	0.000	0.002	0.004	0.000	0.000	0.032	1.058	0.001	**1.2**

Sample 2

This sample has a slightly unusual although not unique microstructure for an ironworking slag (Figures 3 and 4). The sample contains a high proportion of an iron oxide (Figure 3) which is usually present as equiaxed grains (squares and triangles). Most ironworking slags contain the iron oxide wüstite; however, this usually forms as rounded dendrites (see samples 1, 3, 4, 6 and 8). The chemical analysis (SEM-EDS) of the iron oxide phase showed the presence of iron and oxygen (occasionally with small amounts of aluminium but never sufficient to classify this as hercynite). The SEM-EDS analysis indicated that the iron to oxygen ratio of this phase was greater than that typically seen in wüstite; on this basis, the iron oxide in this sample is tentatively identified as maghemite (Fe_2O_3). Maghemite has a spinel structure and so can form the equiaxed grains seen in this sample. Similar iron oxide microstructures are occasionally noted in contemporary iron slag assemblages from the region (*eg* Birnie).

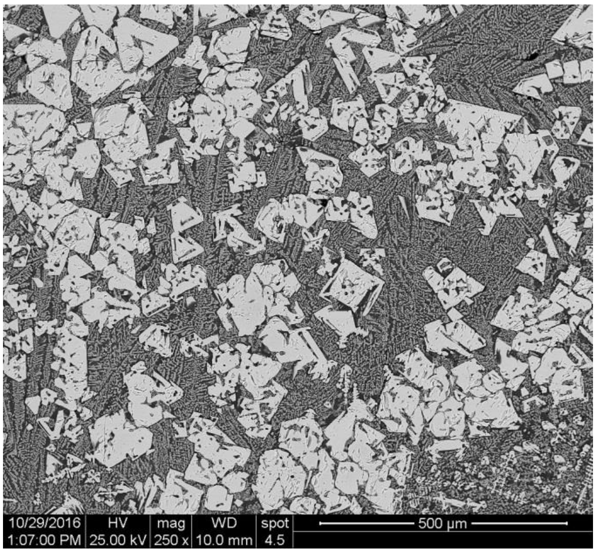

Figure 3. SEM (BSE) image of sample 2 showing white equiaxed spinel iron oxides (maghemite or magnetite), with fine fayalite laths (grey) in a darker, glassy matrix (cf leucite)

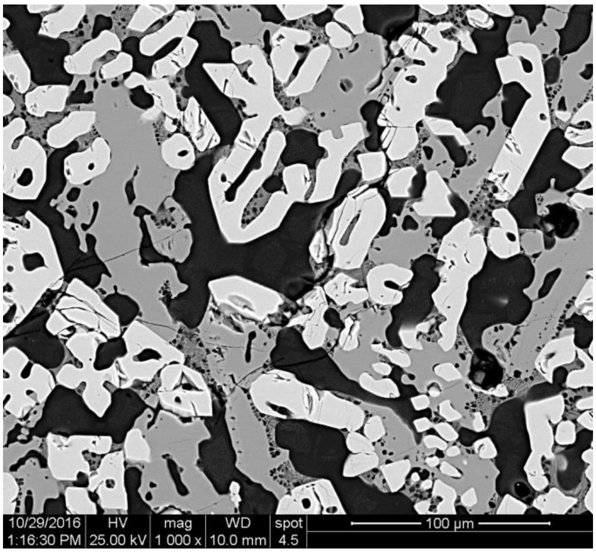

Figure 4. SEM (BSE) image of sample 2 showing dendritic white iron oxides (wüstite, maghemite or magnetite), with fine fayalite laths (grey) in a darker, glassy matrix (cf leucite)

Table 3. Chemical composition of Sample 2 (10 separate areas) with the average and standard deviation (and H)

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	Cl	K_2O	CaO	TiO_2	MnO	FeO	BaO	
Area 1	0.73	0.51	5.3	24.2	0.90	<0.1	<0.1	1.12	0.63	0.19	4.5	61.3	0.52	
Area 2	0.82	0.60	5.1	26.0	0.95	<0.1	<0.1	1.31	0.83	0.13	5.1	58.3	0.65	
Area 3	0.60	0.45	4.6	23.5	0.94	<0.1	<0.1	0.91	0.62	0.19	6.2	61.2	0.74	
Area 4	0.71	0.45	5.3	32.2	1.47	<0.1	<0.1	1.36	0.76	0.06	5.2	51.4	0.86	
Area 5	0.58	0.43	4.5	19.5	0.68	<0.1	<0.1	0.80	0.32	0.13	4.3	68.1	0.42	
Area 6	0.86	0.33	4.6	25.2	0.87	<0.1	<0.1	1.08	0.46	0.13	5.4	60.4	0.46	
Area 7	0.60	0.49	4.3	18.1	0.66	<0.1	<0.1	0.75	0.51	0.10	4.6	69.2	0.52	
Area 8	0.84	0.65	5.1	24.7	0.83	<0.1	<0.1	1.18	0.69	0.14	5.2	60.0	0.61	
Area 9	0.71	0.53	4.8	25.2	1.11	<0.1	<0.1	1.15	1.06	0.18	5.6	58.6	0.85	
Area 10	0.52	0.43	4.4	16.5	0.81	<0.1	<0.1	0.80	0.70	0.18	4.6	70.5	0.53	
Mean	**0.70**	**0.49**	**4.8**	**23.5**	**0.92**	**<0.1**	**<0.1**	**1.05**	**0.66**	**0.14**	**5.1**	**61.9**	**0.62**	
sd	0.12	0.09	0.38	4.5	0.23			0.22	0.21	0.04	0.6	5.8	0.15	
H	0.001	0.000	0.018	1.061	0.002	0.000	0.000	0.002	0.001	0.000	0.030	3.621	0.001	**4.7**

The sample also contains fayalite laths and a matrix which has a composition close to leucite ($KAlSi_2O_6$). The fact that the iron oxide is not wüstite (probably maghemite) suggests that the sample has an atypical thermal history. The apparent crystallinity of the matrix suggests that this sample has been held at a high temperature for a long period of time (sufficient for a normally glassy matrix to devitrify). Despite this the sample is relatively heterogeneous (H = 4.7) suggesting that it has never been fully molten. The sample has a chemical composition typical of ironworking slags (Table 3), although the presence of barium and manganese suggest that this is a smelting slag rather than a smithing slag.

Sample 3

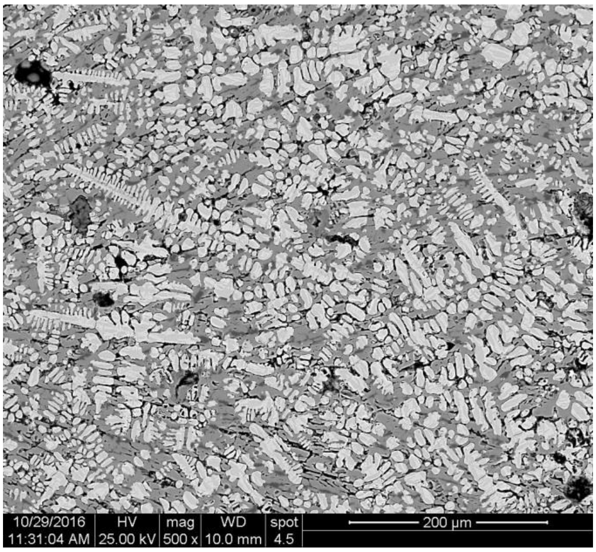

Figure 5. SEM (BSE) image of sample 3 showing wüstite dendrites (white) and fayalite laths (grey)

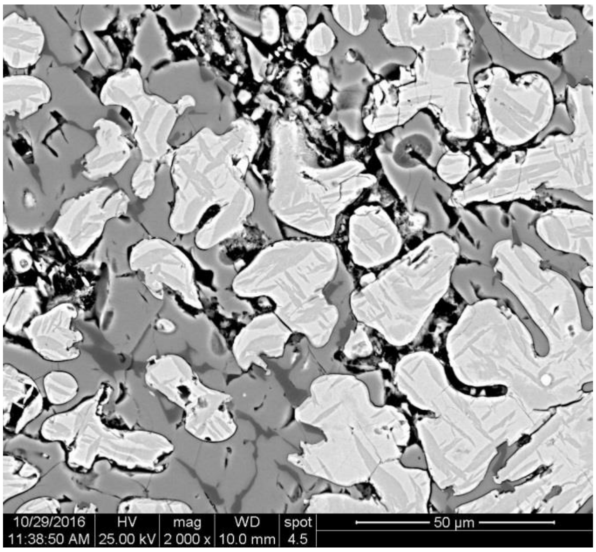

Figure 6. SEM (BSE) image of sample 3 showing wüstite droplets (white) which contain some maghemite(darker), superimposed on fayalite laths (grey), which also contain dispersed hercynite (dark grey)

Table 4. Chemical composition of Sample 3 (10 separate areas) with the average and standard deviation (and H)

	Na_2O	**MgO**	**Al_2O_3**	**SiO_2**	**P_2O_5**	**SO_3**	**K_2O**	**CaO**	**TiO_2**	**V_2O_5**	**MnO**	FeO	BaO	
Area 1	0.19	0.33	5.42	13.4	1.52	0.18	0.18	0.96	0.06	0.14	6.9	70.2	0.53	
Area 2	0.18	0.33	5.04	13.1	1.55	0.20	0.16	0.90	0.11	0.14	6.7	70.8	0.61	
Area 3	0.32	0.42	5.94	15.6	1.87	0.25	0.38	1.08	0.09	0.15	7.1	66.0	0.82	
Area 4	0.09	0.46	4.86	13.5	1.82	0.25	0.10	1.08	0.21	0.06	7.1	69.8	0.55	
Area 5	0.17	0.39	4.68	11.8	1.47	0.15	0.12	0.86	0.09	0.19	6.7	72.8	0.59	
Area 6	0.40	0.37	6.81	17.2	2.12	0.24	0.30	1.31	0.19	0.12	6.8	63.2	0.79	
Area 7	0.38	0.33	6.44	16.9	2.00	0.26	0.36	1.25	0.11	0.08	7.0	64.0	0.90	
Area 8	0.12	0.43	5.22	13.4	1.63	0.18	0.19	0.88	0.12	0.20	6.9	70.2	0.54	
Area 9	0.33	0.33	6.45	17.3	2.04	0.29	0.35	1.46	0.15	0.09	7.1	63.3	0.79	
Area 10	0.16	0.48	5.62	15.1	1.29	0.14	0.06	1.12	0.13	0.14	7.4	67.9	0.40	
Mean	**0.23**	**0.39**	**5.65**	**14.7**	**1.73**	**0.21**	**0.22**	**1.09**	**0.13**	**0.13**	**7.0**	**67.8**	**0.65**	
sd	0.11	0.06	0.74	1.96	0.28	0.05	0.12	0.20	0.05	0.05	0.2	3.47	0.16	
H	0.000	0.000	0.042	0.289	0.005	0.000	0.000	0.002	0.000	0.000	0.014	2.353	0.001	**2.7**

This sample has a typical iron slag microstructure (Figures 5 and 6): it is dominated by fayalite (Fe_2SiO_4) laths, and these contain some hercynite ($FeAl_2O_4$), along with dendritic wüstite (FeO), although this contains a small proportion of a second phase (slightly darker laths) which is possibly maghemite (Fe_2O_3). The regions between the fayalite laths are filled with a vitreous matrix. The sample is moderately homogeneous (H = 2.7) suggesting that it has been partially molten at some stage. The sample has a chemical composition typical of ironworking slags (Table 4), although the presence of barium and manganese suggest that this is a smelting slag rather than a smithing slag.

<u>Sample 4</u>

This sample has a typical microstructure for an ironworking slag (Figures 7 and 8). The sample contains a high proportion of an iron oxide which is present as rounded dendrites (typical of wüstite), although these also contain small laths of a darker iron oxide (interpreted as maghemite). The sample also contains fayalite laths (often with small areas of hercynite) and a complex, microcrystalline matrix. The sample is relatively homogeneous (H = 1.4) suggesting that it has been fully molten. The sample has a chemical composition typical of ironworking slags (Table 5), although the presence of barium and manganese suggest that this is a smelting slag rather than a smithing slag. The high proportion of wüstite visible in the section (Figure 7) is reflected in the relatively high iron oxide content (Table 5)

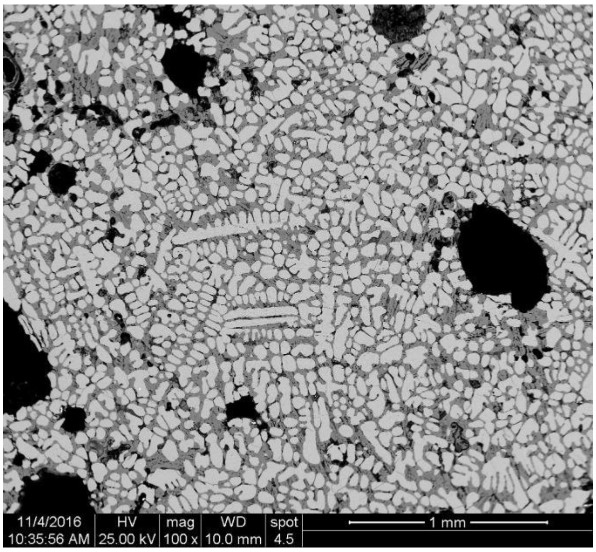

Figure 7. SEM (BSE) image of sample 4 showing wüstite dendrites (white) and fayalite laths (grey)

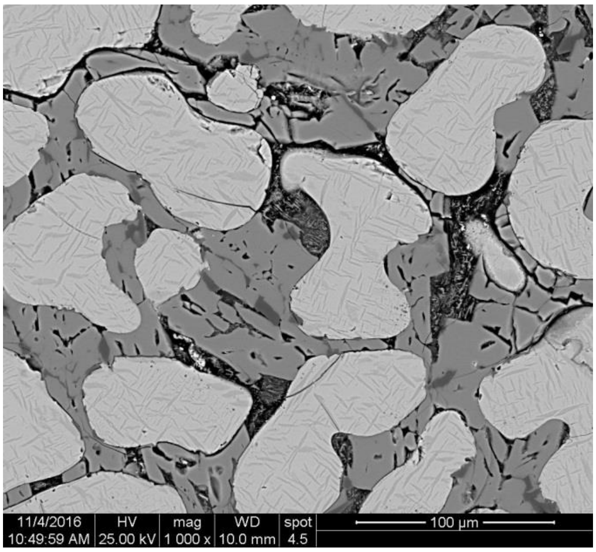

Figure 8. SEM (BSE) image of sample 4 showing wüstite droplets (white) which contain some maghemite(darker), superimposed on fayalite laths (grey), which also contain dispersed hercynite (dark grey), and a microcrystalline matrix

Table 5. Chemical composition of Sample 4 (5 separate areas) with the average and standard deviation (and H)

	Na_2O	**MgO**	**Al_2O_3**	**SiO_2**	**P_2O_5**	**SO_3**	**K_2O**	**CaO**	**TiO_2**	**V_2O_5**	**MnO**	FeO	BaO
Area 1	0.16	0.22	3.01	8.9	1.05	0.16	0.16	0.59	0.10	0.22	3.54	81.7	0.20
Area 2	<0.1	0.15	2.38	7.6	0.88	0.19	<0.1	0.49	0.13	0.20	3.17	84.6	0.10
Area 3	0.19	0.19	3.16	9.7	1.17	<0.1	0.19	0.59	0.13	0.13	3.39	80.8	0.19
Area 4	0.15	0.22	2.75	8.6	1.06	<0.1	<0.1	0.58	<0.1	0.13	3.32	82.7	0.15
Area 5	0.20	0.27	3.33	9.4	1.08	0.12	0.14	0.56	<0.1	0.15	3.29	81.0	0.29

Mean	**0.14**	**0.21**	**2.93**	**8.8**	**1.05**	**0.12**	**0.12**	**0.56**	**<0.1**	**0.17**	**3.34**	**82.2**	**0.19**	
sd	0.07	0.04	0.37	0.8	0.11	0.05	0.07	0.04		0.04	0.14	1.6	0.07	
H	0.000	0.000	0.011	0.073	0.001	0.000	0.000	0.000	0.000	0.000	0.005	1.282	0.000	**1.4**

Sample 5

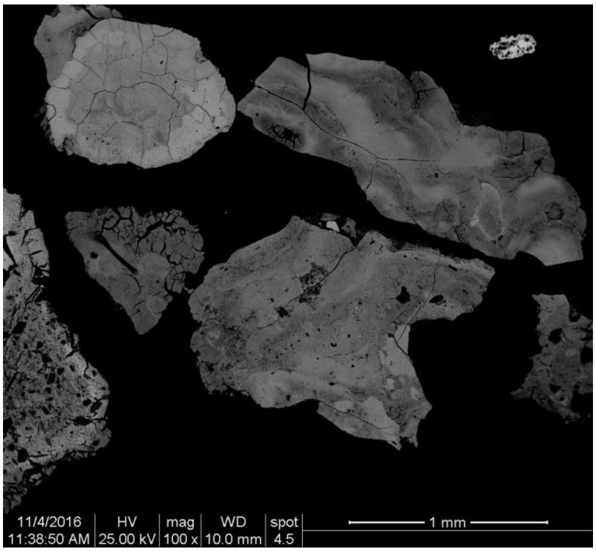

Figure 9. SEM (BSE) image of sample 5 showing fragments of iron-rich material (iron ore)

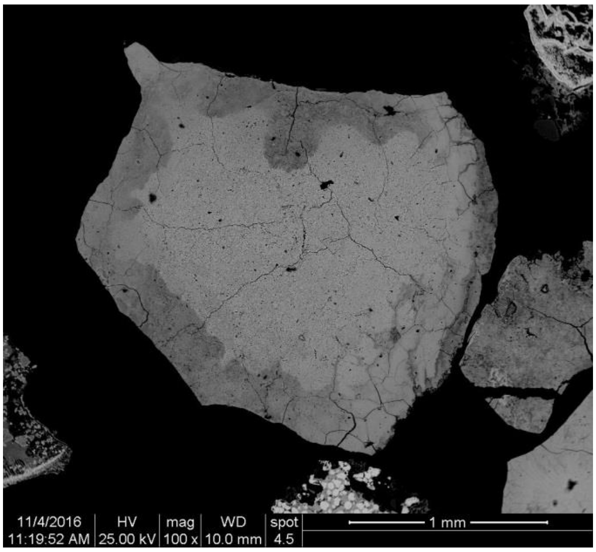

Figure 10. SEM (BSE) image of sample 5 showing a fragment of iron ore and cracking; probably produced by roasting

Sample 5 comprises small fragments of material (recovered from a soil sample) which responded to a magnet. These fragments were mounted together and the SEM images indicated that almost all were fragments of iron ore (cf samples 7, 9 and 10). Most of the fragments of iron ore display numerous cracks which could have formed when the ore was roasted. The roasting would also have converted some (or all) of the original mineral into magnetite (Fe_2O_4) or maghemite (Fe_2O_3), and so made it slightly magnetic. The fragments of iron ore are very iron rich (88wt% FeO) and would have made a very good bloomery smelting ore. The ore also contains other elements that are seen in the slags.

Table 6. Chemical composition of Sample 5 (10 separate fragments) with the average and standard deviation

	Na_2O	**MgO**	**Al_2O_3**	**SiO_2**	**P_2O_5**	**SO_3**	**Cl**	**K_2O**	**CaO**	**TiO_2**	**V_2O_5**	**MnO**	FeO	BaO	
Area 1	<0.1	<0.1	2.27	2.64	0.95	0.12	0.14	<0.1	0.20	<0.1	<0.1	3.03	90.5	<0.1	
Area 2	<0.1	<0.1	2.40	3.57	1.54	<0.1	0.21	<0.1	0.13	<0.1	0.25	0.41	91.3	<0.1	
Area 3	<0.1	<0.1	2.66	4.07	1.27	0.18	0.28	<0.1	0.23	<0.1	0.23	0.52	90.4	0.11	
Area 4	<0.1	<0.1	2.89	4.34	1.75	0.26	0.05	<0.1	0.20	<0.1	0.21	0.53	89.8	<0.1	
Area 5	0.28	0.44	4.64	9.06	0.94	0.35	0.28	0.43	0.41	<0.1	0.12	8.55	74.3	<0.1	
Area 6	<0.1	<0.1	3.87	3.92	0.72	0.18	0.12	<0.1	0.40	<0.1	<0.1	0.48	90.0	<0.1	
Area 7	0.10	<0.1	2.73	3.00	2.66	0.23	0.14	<0.1	0.23	<0.1	0.26	0.11	90.4	<0.1	
Area 8	0.29	0.21	4.08	8.89	1.28	0.23	0.28	0.20	0.36	<0.1	0.20	1.25	82.5	<0.1	
Area 9	<0.1	<0.1	2.19	3.69	0.88	0.14	0.19	<0.1	0.11	<0.1	<0.1	0.80	91.8	<0.1	
Area 10	<0.1	0.16	1.95	3.88	1.58	0.21	0.13	<0.1	0.28	<0.1	0.20	0.44	91.1	<0.1	
Mean	**<0.1**	**0.12**	**2.97**	**4.71**	**1.36**	**0.20**	**0.18**	**0.10**	**0.26**	**<0.1**	**0.17**	**1.61**	**88.2**	**<0.1**	
sd		0.13	0.91	2.31	0.57	0.07	0.08	0.12	0.11		0.08	2.57	5.5		
H	0.000	0.000	0.027	0.109	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.041	4.878	0.000	**5.1**

Sample 6

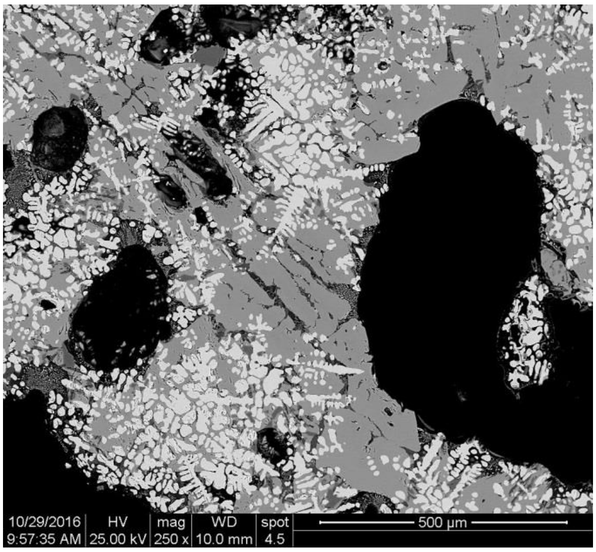

Figure 11. SEM (BSE) image of sample 6 showing large areas of porosity (black), wüstite (white) and fayalite laths (grey)

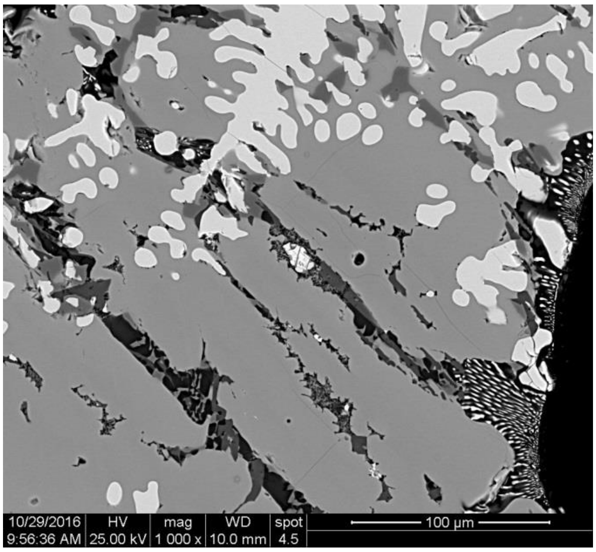

Figure 12. SEM (BSE) image of sample 6 showing wüstite dendrites (white) and fayalite laths (grey) with smaller amounts of hercynite (within the fayalite and slightly darker) and leucite (dark grey) as single phased particles and as a wüstite-leucite eutectic (right-hand side of the image)

This sample has a typical iron slag microstructure (Figures 11 and 12): it is dominated by fayalite (Fe_2SiO_4) laths, and these contain small amounts of hercynite ($FeAl_2O_4$), along with dendritic wüstite (FeO). The regions between the fayalite laths are filled with a partially devitrified matrix. The matrix contains some leucite but other phases are usually present as such small particles that they cannot be analysed using SEM-EDS. The sample is fairly heterogeneous (H = 4.7) suggesting that it has only ever been partially molten at most. The relatively high proportion of porosity (Figure 11) is consistent with a slag which has never been fully molten. The sample has a chemical composition typical of ironworking slags (Table 7), although the presence of barium and manganese suggest that this is a smelting slag rather than a smithing slag.

Table 7. Chemical composition of Sample 6 (10 separate areas) with the average and standard deviation (and H)

	Na_2O	**MgO**	**Al_2O_3**	**SiO_2**	**P_2O_5**	**SO_3**	**K_2O**	**CaO**	**TiO_2**	**V_2O_5**	**MnO**	FeO	BaO
Area 1	0.51	0.62	5.61	15.0	3.55	0.18	0.49	2.66	0.15	<0.1	2.80	68.1	0.16
Area 2	0.55	0.70	4.79	14.0	2.76	0.13	0.55	2.30	<0.1	0.12	2.65	71.0	0.26
Area 3	0.58	0.91	3.50	18.6	1.69	0.11	0.44	1.69	<0.1	0.11	3.21	68.8	0.23
Area 4	0.77	0.81	4.70	17.3	3.00	0.19	0.69	2.65	0.10	<0.1	2.88	66.5	0.33
Area 5	0.57	0.83	5.46	18.6	3.32	0.12	0.68	2.94	<0.1	<0.1	3.05	63.9	0.24
Area 6	0.20	0.70	2.98	11.7	1.82	0.10	0.09	1.51	0.10	0.10	2.64	77.8	0.10
Area 7	0.73	0.85	4.73	20.1	3.43	0.23	0.59	2.84	0.13	<0.1	3.26	62.6	0.34
Area 8	0.91	0.83	6.74	19.6	4.98	0.35	1.17	4.65	0.18	<0.1	3.55	56.4	0.50
Area 9	0.57	0.70	6.03	20.6	2.81	0.18	1.30	2.53	0.14	<0.1	2.95	61.8	0.30
Area 10	0.75	0.61	5.83	20.7	3.60	0.20	1.19	3.54	0.14	<0.1	3.10	59.8	0.37
Mean	**0.61**	**0.76**	**5.04**	**17.6**	**3.10**	**0.18**	**0.72**	**2.73**	**0.12**	**0.08**	**3.01**	**65.7**	**0.28**
sd	0.19	0.10	1.15	3.1	0.94	0.07	0.39	0.89	0.03	0.03	0.29	6.2	0.11

H	0.001	0.001	0.058	0.541	0.029	0.000	0.003	0.024	0.000	0.000	0.009	4.046	0.000	**4.7**

Sample 7

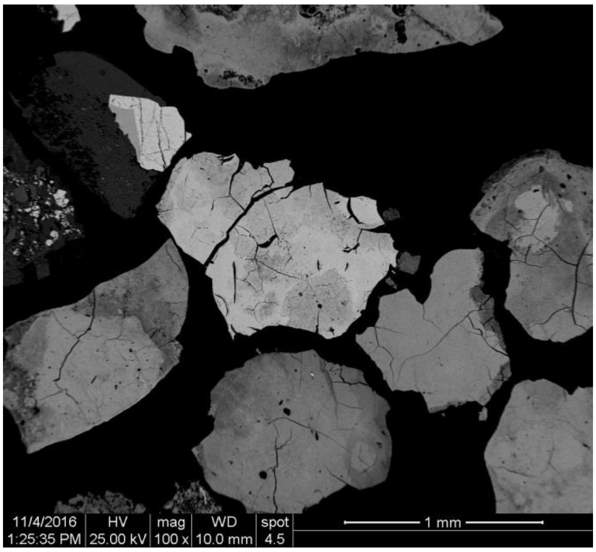

Figure 13. SEM (BSE) image of sample 7 showing fragments of iron-rich material (iron ore) and some siliceous rocks

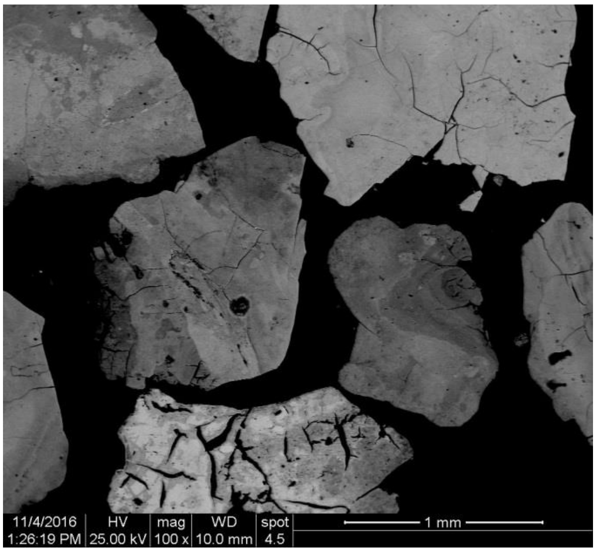

Figure 14. SEM (BSE) image of sample 7 showing fragments of iron ore and cracking; probably produced by roasting

Sample 7 comprises small fragments of material (recovered from a soil sample) which responded to a magnet. These fragments were mounted together and the SEM images indicated that almost all were fragments of iron ore (cf samples 5, 9 and 10). Most of the fragments of iron ore display numerous cracks which could have formed when the ore was roasted. The roasting would also have converted some (or all) of the original mineral (presumably goethite, FeOOH) into magnetite (Fe_2O_4) or maghemite (Fe_2O_3), and so made it slightly magnetic. The fragments of iron ore are very iron rich (91wt% FeO) and would have made a very good bloomery smelting ore (Table 8). The ore also contains other elements that are seen in the slags.

Table 8. Chemical composition of Sample 7 (7 separate fragments) with the average and standard deviation

	Na_2O	**MgO**	**Al_2O_3**	**SiO_2**	**P_2O_5**	**SO_3**	**Cl**	**K_2O**	**CaO**	**TiO_2**	**V_2O_5**	**MnO**	FeO	BaO	
Area 1	<0.1	<0.1	1.24	3.64	0.74	0.10	0.15	<0.1	<0.1	<0.1	0.10	0.41	93.5	<0.1	
Area 2	<0.1	<0.1	1.43	4.24	0.74	0.12	0.13	<0.1	<0.1	0.10	<0.1	0.48	92.6	<0.1	
Area 3	<0.1	<0.1	1.16	3.39	0.71	0.10	0.16	0.00	0.10	<0.1	<0.1	0.35	93.9	<0.1	
Area 4	0.96	0.10	3.49	8.44	1.12	0.13	0.25	0.15	0.19	<0.1	<0.1	0.85	84.0	0.15	
Area 5	0.10	<0.1	1.70	3.29	1.29	<0.1	0.24	<0.1	0.10	<0.1	<0.1	0.37	92.7	<0.1	
Area 6	0.29	<0.1	2.78	6.10	0.91	<0.1	<0.1	<0.1	0.11	<0.1	<0.1	0.49	89.0	<0.1	
Area 7	0.14	<0.1	1.80	2.92	1.66	0.10	0.25	<0.1	0.08	0.10	0.13	0.65	92.3	<0.1	
Mean	**0.22**	**<0.1**	**1.94**	**4.58**	**1.02**	**0.08**	**0.18**	**<0.1**	**0.10**	**<0.1**	**<0.1**	**0.52**	**91.2**	**<0.1**	
sd	0.34		0.87	2.00	0.36	0.06	0.07		0.05			0.18	3.5		
H	0.001	0.000	0.017	0.092	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.001	3.199	0.000	**3.3**

Sample 8

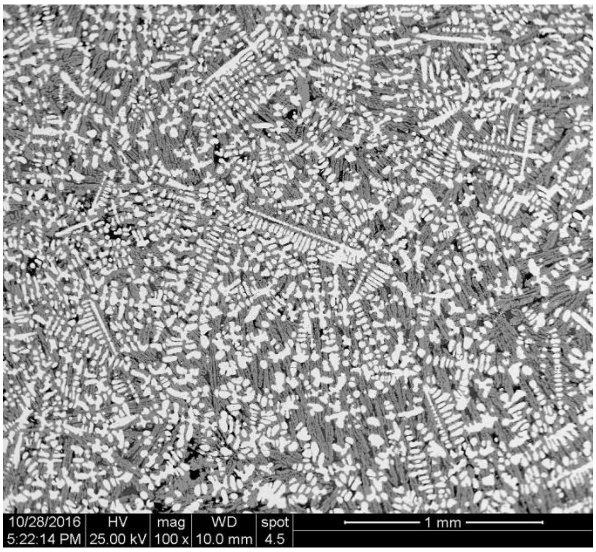

Figure 15. SEM (BSE) image of sample 8 showing well defined wüstite dendrites (white and fayalite laths (grey) and a matrix (dark grey)

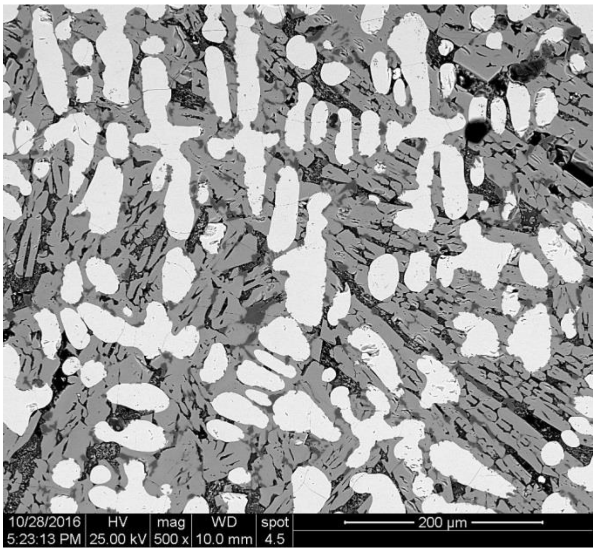

Figure 16. SEM (BSE) image of sample 8 showing wüstite and fayalite as well as a partially devitrified matrix which contains hercynite and leucite

Table 9. Chemical composition of Sample 8 (5 separate areas) with the average and standard deviation (and H)

	Na_2O	**MgO**	**Al_2O_3**	**SiO_2**	**P_2O_5**	**SO_3**	**Cl**	**K_2O**	**CaO**	**TiO_2**	**V_2O_5**	**MnO**	FeO	BaO	
Area 1	0.17	<0.1	1.76	3.1	0.93	<0.1	0.16	<0.1	0.18	<0.1	0.12	0.34	93.0	<0.1	
Area 2	0.63	0.14	4.70	11.0	1.66	<0.1	0.34	0.29	0.32	<0.1	<0.1	4.79	75.6	0.42	
Area 3	0.40	0.14	3.16	7.9	2.08	<0.1	0.19	<0.1	0.30	0.16	0.16	4.02	81.0	0.32	
Area 4	0.82	0.11	4.57	8.7	2.22	<0.1	0.34	0.21	0.37	<0.1	<0.1	7.77	74.3	0.60	
Area 5	0.34	<0.1	2.77	5.6	1.62	<0.1	0.28	0.13	0.28	<0.1	<0.1	4.28	84.3	0.33	
Mean	**0.47**	**0.11**	**3.39**	**7.2**	**1.70**	**<0.1**	**0.26**	**0.15**	**0.29**	**<0.1**	**<0.1**	**4.24**	**81.6**	**0.33**	
sd	0.25	0.03	1.25	3.0	0.5		0.08	0.1	0.07			2.64	7.6	0.22	
H	0.001	0.000	0.042	0.218	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.112	6.164	0.001	**6.5**

This sample has a typical iron slag microstructure (Figures 15 and 16): it is contains variable proportions of dendritic wüstite, occasionally up to 1mm long (but some areas were wüstite-free), and fayalite laths. The spaces between the fayalite laths are filled with a partially devitrified matrix which includes hercynite and leucite (other phases are present but are too small to allow SEM-EDS analysis). The sample appears to be quite heterogeneous (H = 6.5) but this is mainly due to the gross variation in the presence of wüstite. The large size of the wüstite dendrites and the fayalite laths, suggest that the sample had been sufficiently molten to allow the growth of large crystals during cooling. The sample has a chemical composition typical of ironworking slags (Table 9), although the presence of barium and manganese suggest that this is a smelting slag rather than a smithing slag.

Sample 9

Sample 9 comprises small fragments of material (recovered from a soil sample) which responded to a magnet. These fragments were mounted together and the SEM images (Figure 17) indicated that most were fragments of igneous rock (quartz, feldspars and other minerals), as well as a small proportion of iron ore (cf samples 5, 7 and 10). Most of the fragments of iron ore display numerous cracks which could have formed when the ore was roasted. The roasting would also have converted some (or all) of the original mineral (presumably goethite, FeOOH) into magnetite (Fe_2O_4) or maghemite (Fe_2O_3), and so made it slightly magnetic. The fragments of iron ore are very iron rich (90wt% FeO) and would have made a very good bloomery smelting ore (Table 10). The ore also contains other elements that are seen in the slags.

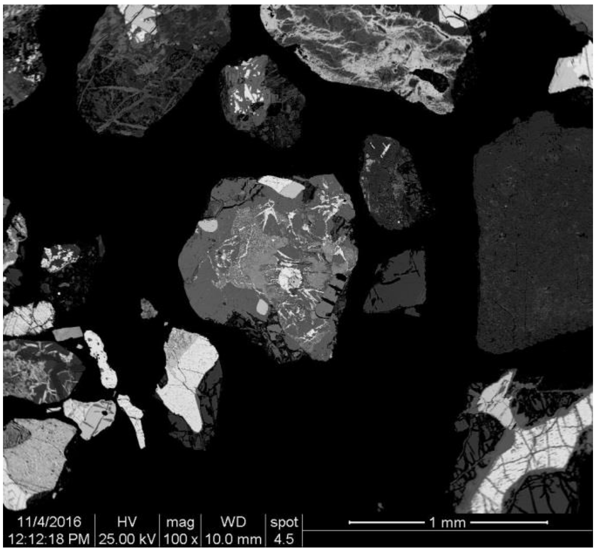

Figure 17. SEM (BSE) image of sample 9 showing the presence of numerous igneous rocks and minerals as well as a small proportion of iron-rich rocks (iron ore)

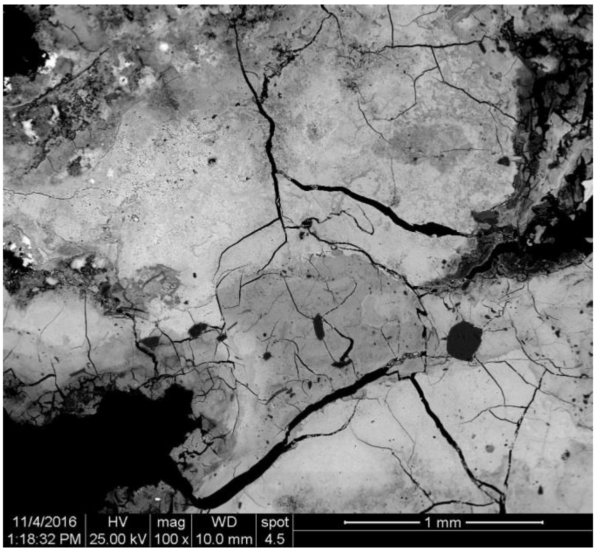

Figure 18. SEM (BSE) image of sample 10 showing iron-rich rock (bog iron ore) with numerous cracks

Table 10. Chemical composition of Sample 9 (5 separate fragments) with the average and standard deviation

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	Cl	K_2O	CaO	TiO_2	V_2O_5	MnO	FeO	BaO	
Area 1	<0.1	<0.1	1.70	3.21	1.71	<0.1	<0.1	<0.1	0.20	<0.1	<0.1	0.31	92.6	<0.1	
Area 2	0.48	0.37	6.17	13.36	1.85	0.10	0.27	0.74	0.25	0.13	0.17	0.76	75.2	0.10	
Area 3	<0.1	0.17	0.62	2.86	0.67	0.18	<0.1	<0.1	0.11	<0.1	<0.1	0.08	95.1	<0.1	
Area 4	<0.1	<0.1	1.03	3.23	1.32	<0.1	0.18	<0.1	<0.1	<0.1	<0.1	0.42	93.6	<0.1	
Area 5	<0.1	<0.1	1.28	4.15	0.86	0.10	0.25	<0.1	<0.1	<0.1	<0.1	0.43	92.6	<0.1	
Mean	**0.15**	**<0.1**	**2.16**	**5.36**	**1.28**	**<0.1**	**0.16**	**0.19**	**0.13**	**<0.1**	**<0.1**	**0.40**	**89.8**	**<0.1**	
sd	0.19		2.27	4.50	0.51		0.11	0.31	0.09			0.25	8.3		
H	0.000	0.000	0.052	0.203	0.003	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.681	0.000	**0.9**

Sample 10

Table 11. Chemical composition of Sample 10 (5 separate areas) with the average and standard deviation

	Na_2O	**MgO**	**Al_2O_3**	**SiO_2**	**P_2O_5**	**SO_3**	**Cl**	**K_2O**	**CaO**	**TiO_2**	**V_2O_5**	**MnO**	FeO	BaO	
Area 1	0.17	<0.1	1.76	3.1	0.93	<0.1	0.16	<0.1	0.18	<0.1	0.12	0.34	93.0	<0.1	
Area 2	0.63	0.14	4.70	11.0	1.66	<0.1	0.34	0.29	0.32	<0.1	<0.1	4.79	75.6	0.42	
Area 3	0.40	0.14	3.16	7.9	2.08	<0.1	0.19	<0.1	0.30	<0.1	0.16	4.02	81.0	0.32	
Area 4	0.82	0.11	4.57	8.7	2.22	<0.1	0.34	0.21	0.37	<0.1	<0.1	7.77	74.3	0.60	
Area 5	0.34	<0.1	2.77	5.6	1.62	<0.1	0.28	0.13	0.28	<0.1	<0.1	4.28	84.3	0.33	
Mean	**0.47**	**0.11**	**3.39**	**7.3**	**1.70**	**<0.1**	**0.26**	**0.15**	**0.29**	**<0.1**	**<0.1**	**4.24**	**81.6**	**0.33**	
sd	0.25	0.03	1.25	3.0	0.50		0.08	0.10	0.07			2.64	7.5	0.22	
H	0.001	0.000	0.042	0.218	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.112	6.164	0.001	6.5

Sample 10 comprises a single lump of iron-rich rock which responded to a magnet. This has a microstructure typical of bog iron ore (Figure 18, cf Samples 5, 7 and 9). The bog iron ore displays numerous cracks which could have formed when the ore was roasted (Figure 18). The roasting would also have converted some (or all) of the original mineral (presumably goethite, FeOOH) into magnetite (Fe_2O_4) or maghemite (Fe_2O_3), and so made it slightly magnetic. The fragment of bog iron ore is iron rich (82wt% FeO) and would have made a good bloomery smelting ore (Table 11). The ore also contains other elements that are seen in the slags.

Discussion

The iron slags examined (samples 1–4, 6 and 8) have broadly similar microstructures and chemical compositions; some variation is to be expected for a reaction where the iron was never molten and the slag would only need to be fluid enough to flow under its own weight (Table 12). All samples contain a high proportion of iron silicate (fayalite) and this has usually solidified as long thin plates or laths (the iron in fayalite is present as Fe^{2+} but has to varying degrees been replaced by Mn^{2+}). The outer fringes of the fayalite laths have often trapped hercynite crystals. Free iron oxide crystals are present and occasionally abundant. In most cases the free iron oxide is present as wüstite (iron present as Fe^{2+}) but more oxidised forms are apparent. Many of the wüstite grains contain small laths of what is probably maghemite (iron present as both Fe^{2+} and Fe^{3+}). The spaces between the fayalite laths contain small pockets of material of a varied nature. In some cases this is a glassy but in others distinct crystalline phases have formed, such as hercynite, leucite and fayalite. The finer crystalline phases were too small to allow individual analysis using SEM-EDS. Sample 2 is atypical as it appears that all of the wüstite has been converted to maghemite, while sample 4 contains a high proportion of wüstite and so has a high iron oxide content. All of the slags contain high levels of manganese (and to some extent barium) which are usually associated with smelting slags (as opposed to smithing slags).

Table 12. Average chemical composition of the slag samples

	Na_2O	**MgO**	**Al_2O_3**	**SiO_2**	**P_2O_5**	**SO_3**	**Cl**	**K_2O**	**CaO**	**TiO_2**	**MnO**	FeO	BaO
Slag 1	1.0	0.4	7.1	19.7	1.2	0.2	<0.1	0.9	1.2	0.3	6.1	61.1	0.8
Slag 2	0.7	0.5	4.8	23.5	0.9	<0.1	<0.1	1.0	0.7	0.1	5.1	61.9	0.6
Slag 3	0.2	0.4	5.7	14.7	1.7	0.2	<0.1	0.2	1.1	0.1	7.0	67.8	0.7
Slag 4	0.1	0.2	2.9	8.9	1.1	0.1	<0.1	0.1	0.6	<0.1	3.3	82.2	0.2
Slag 6	0.6	0.8	5.0	17.6	3.1	0.2	<0.1	0.7	2.7	0.1	3.0	65.7	0.3

Slag 8	0.9	0.9	7.5	18.9	2.0	0.3	<0.1	0.7	0.9	0.2	3.0	64.3	0.3

All three of the features identified as possible furnaces or hearths in the field contain small fragments of roasted iron ore (1–2mm). The similarity between these residues and the sample of bog iron ore suggests that bog iron was the ore source used. Such small fragments of ore would have tended to fall through a furnace in the gaps between the charcoal lumps before they could be converted into slag and bloom. The samples of bog iron ore display typical chemical compositions with high levels of iron and minor amounts of manganese and phosphorus (Table 13).

Table 13. Average chemical composition of the bog iron ore samples

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	Cl	K_2O	CaO	TiO_2	MnO	FeO	BaO
Ore 5	<0.1	0.1	3.0	4.7	1.4	0.2	0.2	0.1	0.3	<0.1	1.6	88.2	<0.1
Ore 7	0.2	<0.1	1.9	4.6	1.0	<0.1	0.2	<0.1	0.1	<0.1	0.5	91.2	<0.1
Ore 9	0.2	<0.1	2.2	5.4	1.3	<0.1	0.2	0.2	0.1	<0.1	0.4	89.8	<0.1
Ore 10	0.5	0.1	3.4	7.3	1.7	<0.1	0.3	0.2	0.3	<0.1	4.2	81.6	0.3

The chemical composition of a smelting slag is influenced by several factors: the most important is the ore itself, but the fuel used and the furnace can all make material contributions to the slag (Crew 2000; Dungworth 2011). If the analyses of the bog iron ore (Table 13) are used as a starting point it is possible to develop simple models which will predict the chemical composition of a smelting slag. The simplest approach is to assume that a proportion of the iron in the ore is reduced to metal (the bloom) while the remainder is converted into slag (this is modelled by lowering the iron content of the ore and then normalising to 100wt%). This simple model predicts a slag with a composition which is close to the actual slag (Figure 19; Table 14); however there are some small differences which suggest that the actual smelting was more complicated. The Al:Si ratio in the actual slag (0.3) is lower than the ore only model (0.5). This is probably because a proportion of the furnace lining melted to form the slag (furnace linings generally have quite low Al:Si values, 0.2). The actual slag also contains more magnesium and calcium than predicted by an ore only model which is probably due to the dissolution of some charcoal fuel ashes into the slag. The model also predicts higher levels of phosphorus than are seen in the actual slag. Some phosphorus might be volatilised (like the chlorine) and some may partition into the bloom rather than the slag. A more detailed mass balance model is not possible as data on the chemical composition of the fuel usually has to be inferred, and at Goval there were no samples of furnace lining recovered.

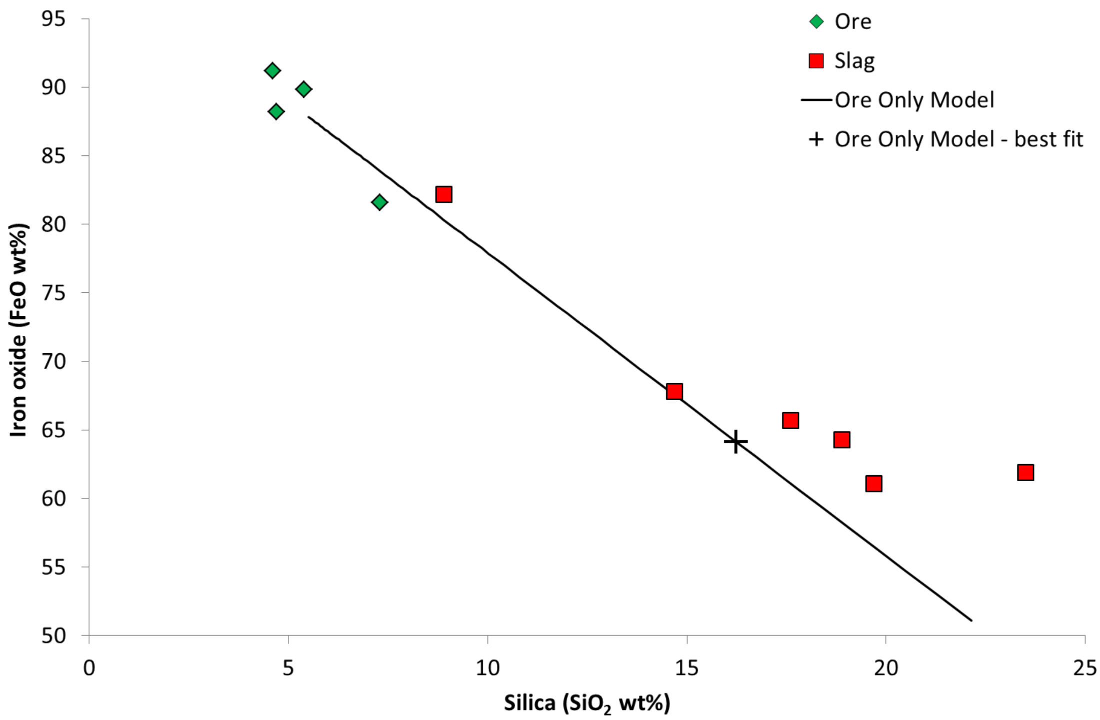

Figure 19. Average iron and silicon content of ore and slag from Goval with a model of slag composition based on just the ore

Table 14. Actual slag composition (average of all samples) and modelled slag composition based on the average composition of the ore (with some iron removed to form a bloom)

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	Cl	K_2O	CaO	TiO_2	MnO	FeO	BaO
Ore Only Model	0.6	0.1	7.1	14.9	3.7	0.1	0.7	0.3	0.5	<0. 1	4.6	67.0	0.2
Average Actual Slag	0.6	0.5	5.5	17.2	1.7	0.2	<0.1	0.6	1.2	0.1	4.6	67.2	0.5

Overall the Goval slag samples share similar chemical compositions with other early bloomery slags from Scotland (Table 15). The composition of these slags is also distinct from early bloomery slag from England (cf Paynter 2006). While the Scottish bloomery slags share the same high aluminium and manganese contents as early bloomery slags from the east Midlands and the Weald, the latter are distinguished by higher levels of titanium (the Wealden slags also contain more calcium). The differences between the different English iron smelting regions are likely to be a result of the use of different ores (although furnace technology may also play a role). The differences between the Scottish and the English slags suggest that the Scottish ore sources were distinct from English ones. The presence of bog iron ore at Goval confirms that this was an important (and possibly dominant) source of iron ore in the Iron Age. There are some minor differences in chemical composition between Goval and other early Scottish bloomery slags (*eg* the phosphorus is higher and the potassium and calcium are lower in the Goval slags); however, the significance of these differences is not clear at this stage.

Table 15. Average chemical composition of the Forres slags and some comparable Scottish bloomery slag (data for Argyll from Photos-Jones et al *1998; Atkinson and Photos-Jones 1999)*

	Na_2O	**MgO**	**Al_2O_3**	**SiO_2**	**P_2O_5**	**SO_3**	**Cl**	**K_2O**	**CaO**	**TiO_2**	**MnO**	**FeO**	**BaO**
Forres	0.9	0.2	11.5	21.6	0.3	0.2	<0.2	1.5	1.1	0.1	2.5	59.8	<0.2

	±0.4	±0.1	±9.6	±3.4	±0.2	±0.1		±0.3	±0.5	±0.1	±2.0	±8.1	
Birnie	0.7	0.3	6.4	24.4	0.7	<0.2	0.3	1.1	1.1	0.2	3.8	60.7	0.3
	±0.3	±0.1	±2.4	±6.9	±0.4		±0.3	±0.5	±0.9	±0.1	±5.4	±9.7	±0.7
Culduthel	0.9	0.5	7.2	24.0	0.6	0.2	nr	1.9	3.3	0.1	3.0	58.0	0.3
	±0.5	±0.2	±2.9	±7.4	±0.2	±0.1		±0.8	±1.6	±0.1	±3.1	±12.8	±0.4
Argyll	0.9	0.3	7.1	22.3	0.5	0.4	nr	1.3	1.2	0.3	8.5	56.7	0.4
	±0.7	±0.3	±1.6	±4.8	±0.2	±0.1		±0.6	±0.7	±0.3	±4.0	±10.7	±0.2

The examination of the ironworking residues from Goval provides confirmation that they are all associated with the manufacture of bloomery iron (or possibly steel) from bog iron ores.

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Goval, Aberdeenshire (ABSL13 NL006A)

Report on metalworking evidence & fired clay

AOC project no. 23242

14th December 2016

AOC Archaeology Group

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Goval, Aberdeenshire (ABSL13 NL006A)

Report on metalworking evidence & fired clay

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Date of Report:	**13th December 2016**

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Introduction

A total of 2370.6g of vitrified material, dominated by waste produced as the result of ferrous metalworking activities was recovered during excavation and from soil sample processing. Visual examination of the individual pieces complemented by chemical and microstructural analysis of selected samples indicates that the ferrous metalworking slags are fragments of waste from iron smelting. No debris indicative of bloom- or blacksmithing were recognised amongst the assemblage. Three potential truncated metalworking features were identified in the field. One, [6A-0118], which survived as a series of intercutting pits associated with evidence of *in situ* burning, produced over 1.2Kg of slag indicative of iron smelting and may represent the heavily disturbed and truncated basal features of a smelting furnace. The second, [6A-0096], is of a similar form to the feature just described but was associated with so little vitrified material (only 18g) that a direct association with metalworking is under question. A third feature, pit [6A-0050], also contained small quantities of vitrified material but may not have been directly related to metalworking activities.

Classification

Classification of the Goval material was based on two stages of examination. The first involved macroscopic visual examination of the slag, categorising the material based on density, colour, morphology, vesicularity and magnetic properties. This examination formed the basis for initial classification of the material and the construction of a detailed archive catalogue to record the assemblage in full is presented in the site archive and summarised below in Table 1. A representative sample of the assemblage was then selected for chemical analysis to allow the composition of the slags to be identified and compared to contemporary assemblages of ferrous metalworking waste from Scotland. The aim of this analysis was, in part, to test the accuracy of visual categorisation and also to determine whether differences in the composition of the slags could be identified across the site which could indicate the use of different ores, technologies, techniques and chronological change. Samples of runned slag, unclassified iron slag and magnetic vitrified residues were selected from three features identified in the field as possible metalworking features [6A-0096], [6A-0118] and [6A-0050]. In addition, a fragment of ore from [6A-0181] was selected for analysis to compare with the chemical signature of the possible ore source which influenced the formation of the iron working slags.

A detailed description of the sampling strategy, preparation and methods of examination and analysis, as well as a full list of results are included in the archive.

Table 1: Summary of the Goval vitrified material by type and mass

Type	Mass (g)
Runned slag (RS)	534.7
Unclassified iron slag/runned (UIS/RS)	679.9
Magnetic vitrified residue (MVR)	1030.5
Vitrified ceramic (VC)	56
Ore	28
Cinder	0.4
Fuel ash slag (FAS)	1.5
Other	39.6
Total	2370.6

Ferrous metalworking slags

A fairly limited range and quantity of metalworking slags (1.2Kg) are present amongst the assemblage in the form of small fractured fragments of runned molten-looking slags (RS) and more heterogeneous iron silicate slag (UIS). No fragments of tap slag and no furnace base fragments are present. There are no plano-convex hearth bases and no concentrations of hammerscale to indicate smithing.

Runned slags, of which 534g have been identified from Goval, are typically runs of non-magnetic dense grey slag which are liquid or flowed in appearance. Runned slag can be formed in the lower portion of the furnace where the heat is more intense, allowing the gangue to solidify and flow between and around the charcoal used as fuel. Such 'runned' slags, where found in quantity and comprising sizeable pieces, are typically seen as the debris from smelting from a non-tapped bloomery furnace.

Small fractured amorphous pieces of iron silicate slag (UIS) are a common component of slag assemblages and are typically interpreted as rake-out material from a smelting furnace or smithing hearth. Differentiating between the two processes (e.g. smelting and smithing) through visual examination of this material alone is difficult and for this reason such slags are often referred to as undiagnostic ironworking slags. At Goval, small quantities of unclassified iron slags (679.9g) were recovered in direct association with fractured pieces of runned slag suggestive of smelting waste, implying that this material was generated through the same process.

Two fragments of runned slag and two pieces of unclassified iron slag from feature [6A-0118] and fragments of unclassified slag from (6A-0101) [6A-0096] and (6A-0050) [6A-0050] were selected for chemical and microstructural analysis. Except for one sample of runned slag from [6A-0118] (sample #2; discussed below) they were all found to have typical chemical compositions and microstructures for Scottish Iron Age ironworking slags (Table 3). Two of the pieces identified macroscopically as unclassified iron slag fragments from [6A-0118] were found on analysis to be corroded pieces of 'runned slag'. These 'runned' slags (Figures 1 & 2) were found to be dominated by fayalite (Fe_2SiO_4) laths, with some hercynite ($FeAl_2O_4$), along with dendritic wüstite (FeO). A small proportion of a second phase (slightly darker laths) were also noted which may be maghemite (Fe_2O_3). The regions between the fayalite laths are typically filled with a complex, microcrystalline matrix; the individual components of this matrix are too fine to allow discrete analysis of individual phases using SEM-EDS. The samples displayed various levels of heterogeneity and homogeneity (from H= 1.2 to H= 2.7) demonstrating that some pieces achieved a fully molten state whilst others only became partially molten during the ironworking process.

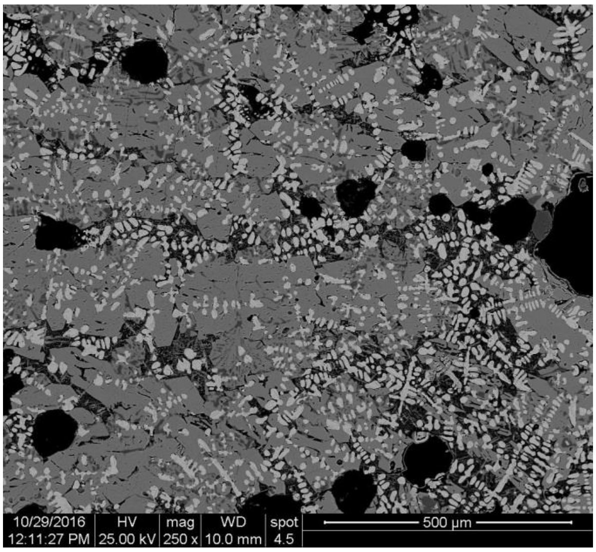

Figure 1. SEM (BSE) image of sample of runned slag from [6A-0118] (S#1) showing porosity (black), fayalite (grey) and wüstite dendrites (white)

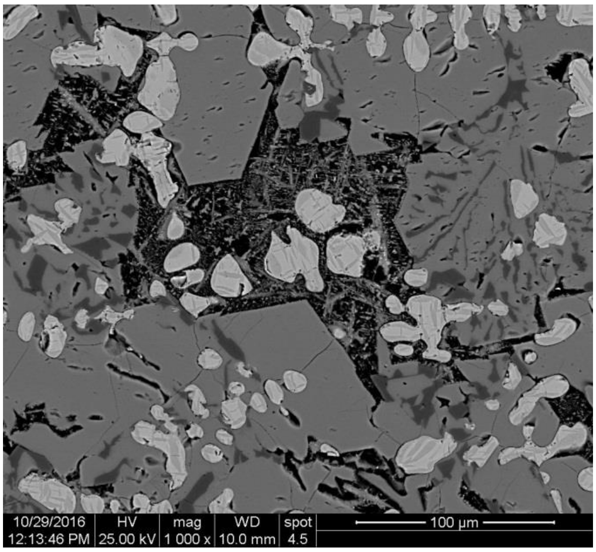

Figure 2. SEM (BSE) image of sample of runned slag from [6A-0118] (S#1) showing micro-crystalline groundmass, surrounded by fayalite laths, which also contain dispersed eutectoid hercynite (dark grey), as well as wüstite droplets which contain some maghemite, mid-grey)

One of the samples of 'runned' slag (sample #2) from [6A-0118] appeared visually consistent with the other samples selected but its chemical composition and microstructure was different to the others analysed (Table 3). This sample has a slightly unusual although not unique microstructure for an ironworking slag (Figures 3 and 4). The sample contains a high proportion of an iron oxide (Figure 3) which is usually present as equiaxed grains (squares and triangles). Most ironworking slags contain the iron oxide wüstite; however, this usually forms as rounded dendrites. The chemical analysis (SEM-EDS) of the iron oxide phase showed the presence of iron and oxygen (occasionally with small amounts of aluminium but never sufficient to classify this as hercynite). The SEM-EDS analysis indicated that the iron to oxygen ratio of this phase was greater than that typically seen in wüstite; on this basis, the iron oxide in this sample is tentatively identified as maghemite (Fe_2O_3). Maghemite has a spinel structure and so can form the equiaxed grains seen in this sample. Similar iron oxide microstructures are occasionally noted in contemporary iron slag assemblages from the region (*eg* Birnie, Moray; Cruickshanks & Dungworth forthcoming).

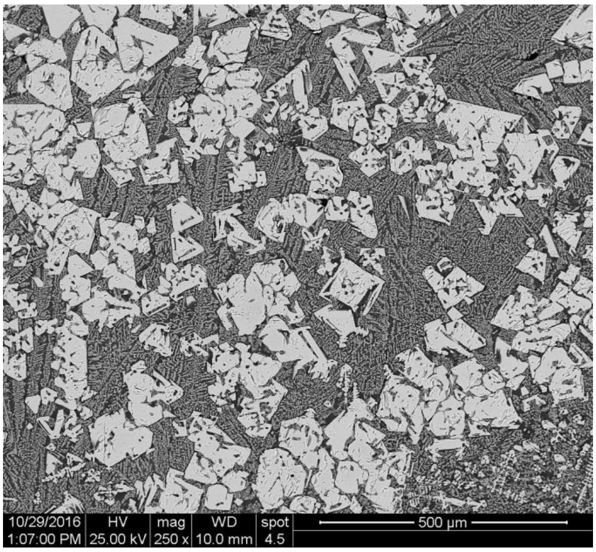

Figure 3. SEM (BSE) image of a sample of 'runned' slag from (6A-0128), S#2, showing white equiaxed spinel iron oxides (maghemite or magnetite), with fine fayalite laths (grey) in a darker, glassy matrix (cf leucite)

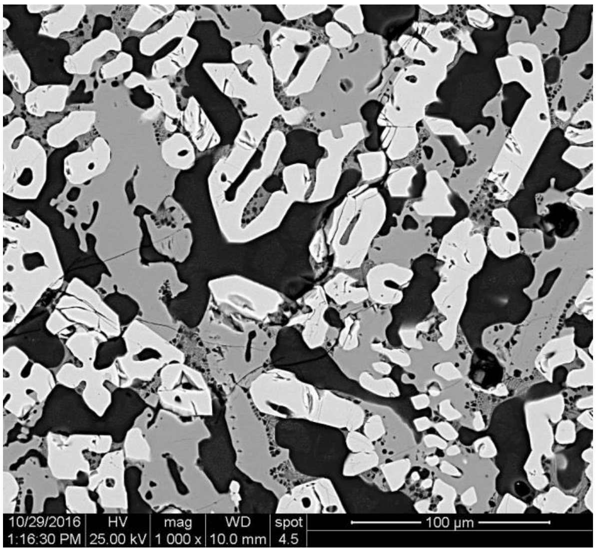

Figure 4. SEM (BSE) image of a sample of 'runned' slag from (6A-0128), S#2, showing dendritic white iron oxides (wüstite, maghemite or magnetite), with fine fayalite laths (grey) in a darker, glassy matrix (cf leucite)

The sample also contains fayalite laths and a matrix which has a composition close to leucite ($KAlSi_2O_6$). The fact that the iron oxide is not wüstite (probably maghemite) suggests that the sample has an atypical thermal history. The apparent crystallinity of the matrix suggests that this sample has been held at a high temperature for a long period of time (sufficient for a normally glassy matrix to devitrify). Despite this the sample is relatively heterogeneous (H = 4.7) suggesting that it has never been fully molten.

The unclassified iron slags that were analysed showed a similar chemical composition to the 'runned' slags from the site but with greater levels of heterogeneity indicating that they were never fully molten during the ironworking process.

The presence of barium and manganese in all the 'runned' and unclassified iron slags analysed suggests that these are smelting slags rather than smithing slags.

Magnetic vitrified residue

A significant quantity of magnetic vitrified residues (1030.5g) were recovered during soil sample processing from a scatter of negative features across the excavated area with a specific concentration deriving from feature [6A-0118]. Magnetic residues are typically not diagnostic of metalworking activities principally because they form a heterogenous type which differs significantly in composition and appearance from site to site and can often be dominated by heat-affected natural materials such as stones, conglomerates of soil and fuel ashes which have reacted under exposure to high temperatures. Those from Goval are dominated by small fractured granules (ave. c. 2mm diameter) of heat-affected material that is dark-brown in colour and homogeneous in texture.

Samples of this dark-brown magnetic granular material were selected for further analysis from features [6A-0118], [6A-0096] and [6A-0050] (Table 4). Those from [6A-0050] were found to be dominated by heat-affected igneous rocks but small quantities of roasted bog ore were also detected. The samples from [6A-0118] and [6A-0096] were almost all fragments of iron ore. Most of the fragments of iron ore display numerous cracks which could have formed when the ore was roasted (Figure 5). The roasting would also have converted some (or all) of the original mineral into magnetite (Fe_2O_4) or maghemite (Fe_2O_3), and so made it slightly magnetic. The fragments of iron ore are very iron rich (88wt% FeO to 91wt% FeO) and would have made a very good bloomery smelting ore. The ore also contains other elements that are seen in the slags.

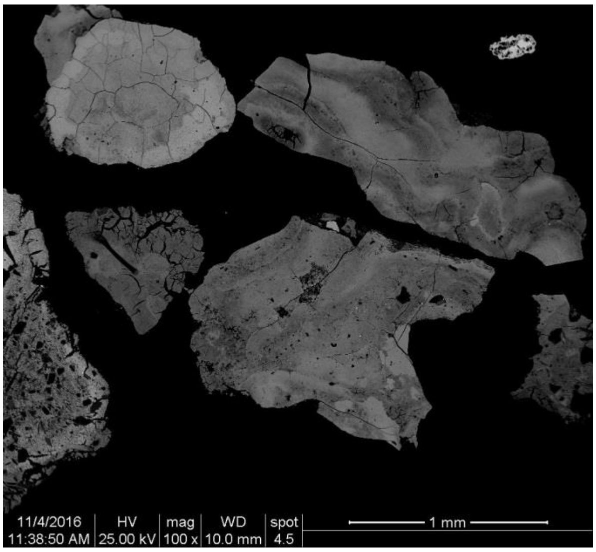

Figure 5. SEM (BSE) image of a sample of MVR from [6A-0118], S#5, showing fragments of iron-rich material (iron ore)

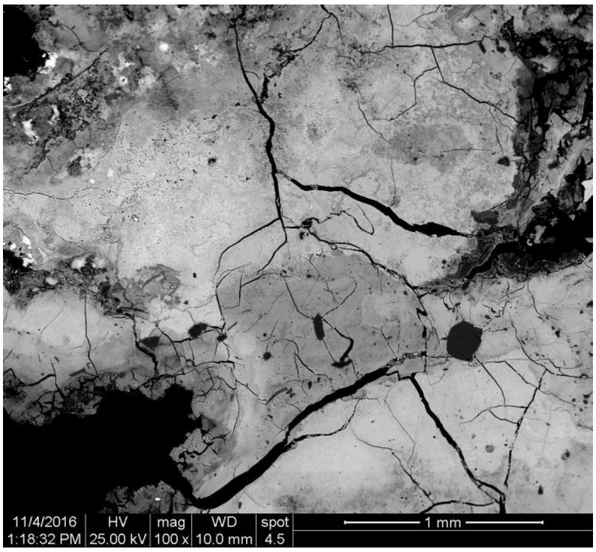

Figure 6. SEM (BSE) image of a sample of bog ore from [6A-0181], S#10, showing numerous cracks; probably produced by roasting

Undiagnostic vitrified and heat-affected materials

Vitrified ceramic

A total of 56g of vitrified ceramic was present from contexts (6A-0050), (6A-0118), (6A-0124), (6A-0151), (6A-0171). The largest quantity (36.4g) came from mixed contexts. Recovery of vitrified ceramic is not indicative of ironworking, but could have been produced within any clay-built high temperature hearth. Often the material shows a compositional gradient from unmodified fired clay on one surface to an irregular cindery material on the other (Starley 2000, 339) and where directly associated with ferrous metalworking structures, can be slag attacked on the internal surface.

Fuel ash slag

Fuel ash slags are formed when material such as sand, earth, clay, stones or ceramics are subjected to high temperatures, for example in a hearth. During heating these materials react, melt or fuse with alkali in ash, producing glassy (vitreous) and porous materials. These slags can be formed during any high temperature pyrotechnic process and are not necessarily indicative of deliberate industrial activity (McDonnell 1994, 230). Only 1.5g of this material was present amongst the assemblage.

Ore and other

Small quantities of cinder (0.4g), raw bog ore (28g) and a fragment of pyrite (36.9g) were also recognised.

The bog ore fragment came from the fill of post-hole [6A-0181]. Although unrelated to any possible metalworking features identified in the field a sample was analysed to determine whether a similar ore had been used during the ironworking process that produced the slags found on the site. The bog iron ore displays numerous cracks which could have formed when the ore was roasted (Figure 6). The roasting would also have converted some (or all) of the original mineral (presumably goethite, FeOOH) into magnetite

(Fe_2O_4) or maghemite (Fe_2O_3), and so made it slightly magnetic. The fragment of bog iron ore is iron rich (82wt% FeO) and would have made a good bloomery smelting ore (Table 4).

Contextual analysis

The largest concentration of ferrous metalworking slags from this site comes from the truncated feature [6A-0118] interpreted on site as the disturbed base of a metalworking structure, due to its surviving form, the quantities of slag recovered in association with it and because of the extensive evidence of burning of surrounding and underlying soils. A charcoal sample from one of the fills of this feature (6A-0124) returned a radiocarbon date of 1930±26 BP (AD31-121 cal BC at 2 sigma; SUERC-57930 (GU36356)). In total 1266g of vitrified material came from the various fills of this feature and comprise 115.5g of runned slag, 604.9g of a mixture of small fractured fragments of unclassified iron slag and small runned fragments, 542g of magnetic vitrified residues and 3.6g of vitrified ceramic. The slags are dominated by fragments of waste indicative of primary iron smelting including runned and amorphous rake-out material and small granular magnetic residues which chemical and microstructural analysis has confirmed are mostly pieces of roasted bog ore which must have fallen to the base of the smelting furnace whilst in operation.

Table 2: Summary of quantity and range of vitrified and heat affected materials by feature and context

Feature	Context	RS	UIS/RS	MVR	VC	FAS	Cinder	Ore	Other	Sub-total mass (g)
Structure 6A-0016	6A-0017						0.2			*0.2*
Post-hole 6A-0022	6A-0022			1.1						*1.1*
Post-hole 6A-0024	6A-0027			0.1						*0.1*
Pit 6A-0036	6A-0037						0.1			*0.1*
Post-hole 6A-0046	6A-0047								39.6	*39.6*
Pit 6A-0049	6A-0050		27.7	1.8	6.9		0.1			*36.5*
	6A-0099			13.4						*13.4*
	6A-0101		3.5	0.8						*4.3*
Feature 6A-0096	6A-0102			0.3						*0.3*
	6A-0118	115.5			1					*116.5*
	6A-0120			13.3						*13.3*
	6A-0121		26.2	52.4						*78.6*
	6A-0124		43.1	124.8	2.6					*170.5*
	6A-0126		293.6	170.8						*464.4*
	6A-0128		53.6	96.6						*150.2*
	6A-0130			22.6						*22.6*
	6A-0131		78.8	14.5						*93.3*
Metalworking feature 6A-0118	6A-0145		109.6	47						*156.6*
Linear feature 6A-0134	6A-0135			0.1						*0.1*
Linear feature 6A-0136	6A-0137			0.1						*0.1*
Deposit 6A-0151	6A-0151		19.8	108.2	3.4					*131.4*
Pit/post-hole 6A-0170	6A-0171			1	5.7					*6.7*
Post-hole 6A-0181	6A-0182							28		*28*
Mixed		414.9		361.6	36.4					*812.9*
Unstrat		4.3	24			1.5				*29.8*
Sub-total mass (g)		*534.7*	*679.9*	*1030.5*	*56*	*1.5*	*0.4*	*28*	*39.6*	**2370.6**

A second possible truncated metalworking feature was identified on site [6A-0096]. It was categorised as a possible metalworking furnace due to its similarity in form to [6A-0118] and because of the recovery of small fragments of slag from the interior fills. Yet, only 18g of vitrified material was present comprising small quantities of runned and unclassified iron slags and magnetic vitrified residues. Macroscopic analysis alongside detailed chemical and microstructural analysis of a sample of these residues confirm that they are likely to have been produced during iron smelting. However, the quantities of waste recovered from this feature are so small and restricted in range that identification of the associated feature as a possible furnace is questioned, as a much larger and more comprehensive assemblage of slags would be anticipated by reference to other *in situ* furnace structures elsewhere, such as those at Culduthel, Inverness (Murray 2007; Murray 2008; McLaren & Dungworth 2012), East Beechwood Farm, Inverness (McLaren & Engl forthcoming), Grantown Road, Moray (McLaren & Dungworth 2016) and Bellfield, North Kessock (Murray 2011; McLaren 2012). The small quantity of waste contrasts strongly with the comprehensive suite of debris recovered from [6A-0118] at the same site. It is likely, therefore, that the 18g of vitrified material recovered from this feature is residual waste deriving from smelting activities close-by which have become incorporated incidentally within the fills.

A third feature, pit [6A-0049], was initially thought to represent a potential metalworking related hearth but only a scatter of waste (36.5g) was recovered from the fills. An associated sample of charcoal from this feature was radiocarbon dated to 1908±29BP (AD70-126 cal BC at 2 sigma; SUERC-57928 (GU36354)).

The remaining 1030.1g of waste represents a residual scatter of material within negative features such as pits, postholes, linear features, and deposits across the excavated area. Vitrified and associated material came from four postholes, including 1.1g of magnetic vitrified residue from [6A-0022], 0.1g of magnetic vitrified residue from [6A-0024], a fragment of pyrite from [6A-0046], 28g of raw bog ore from [6A-0081] and 1g of magnetic vitrified residue and 5.7g of vitrified ceramic from pit/posthole [6A-0170]. One pit, [6A-0037], contained 0.1g of cinder. Linear features [6A-0134] and [6A-0136] both included 0.1g of magnetic vitrified residues within their fills and 0.2g of cinder came from structure [6A-0016]. More substantial quantities of metalwork residues (812.9g) including runned slags, magnetic vitrified residues and associated vitrified ceramics came from mixed contexts.

Chemical analysis

The iron slags examined have broadly similar microstructures and chemical compositions; some variation is to be expected for a process where the iron was never molten and the slag would only need to be fluid enough to flow under its own weight (Table 3). All samples contain a high proportion of iron silicate (fayalite) and this has usually solidified as long thin plates or laths (the iron in fayalite is present as Fe^{2+} but has to varying degrees been replaced by Mn^{2+}). The outer fringes of the fayalite laths have often trapped hercynite crystals. Free iron oxide crystals are present and occasionally abundant. In most cases the free iron oxide is present as wüstite (iron present as Fe^{2+}) but more oxidised forms are apparent. Many of the wüstite grains contain small laths of what is probably maghemite (iron present as both Fe^{2+} and Fe^{3+}). The spaces between the fayalite laths contain small pockets of material of a varied nature. In some cases this is a glassy material but in others distinct crystalline phases have formed, such as hercynite, leucite and fayalite. The finer crystalline phases were too small to allow individual analysis using SEM-EDS. Sample 2 is atypical as it appears that all of the wüstite has been converted to maghemite, while sample 4 contains a high proportion of wüstite and so has a high iron oxide content. All of the slags contain high levels of manganese (and to some extent barium) which are usually associated with smelting slags (as opposed to smithing slags).

Table 3. Average chemical composition of the slag samples

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	Cl	K_2O	CaO	TiO_2	MnO	FeO	BaO
RS [6A-0118]; sample #1	1	0.4	7.1	19.7	1.2	0.2	<0.1	0.9	1.2	0.3	6.1	61.1	0.8
RS [6A-0118]; sample #2	0.7	0.5	4.8	23.5	0.9	<0.1	<0.1	1	0.7	0.1	5.1	61.9	0.6
RS/UIS [6A-0118]; sample #3	0.2	0.4	5.7	14.7	1.7	0.2	<0.1	0.2	1.1	0.1	7	67.8	0.7
RS/UIS [6A-0118]; sample #4	0.1	0.2	2.9	8.9	1.1	0.1	<0.1	0.1	0.6	<0.1	3.3	82.2	0.2
UIS [6A-0096]; sample #6	0.6	0.8	5	17.6	3.1	0.2	<0.1	0.7	2.7	0.1	3	65.7	0.3
UIS [6A-0050]; sample #8	0.9	0.9	7.5	18.9	2	0.3	<0.1	0.7	0.9	0.2	3	64.3	0.3

The similarity between these residues and the sample of bog iron ore suggests that bog iron was the ore source used. Such small fragments of ore would have tended to fall through a furnace in the gaps between the charcoal lumps before they could be converted into slag and bloom. The samples of bog iron ore display typical chemical compositions with high levels of iron and minor amounts of manganese and phosphorus (Table 4).

Table 4. Average chemical composition of the bog iron ore samples

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	Cl	K_2O	CaO	TiO_2	MnO	FeO	BaO
MVR [6A-0118]; sample #5	<0.1	0.1	3	4.7	1.4	0.2	0.2	0.1	0.3	<0.1	1.6	88.2	<0.1
MVR [6A-0096]; sample #7	0.2	<0.1	1.9	4.6	1	<0.1	0.2	<0.1	0.1	<0.1	0.5	91.2	<0.1
MVR [6A-0050]; sample #9	0.2	<0.1	2.2	5.4	1.3	<0.1	0.2	0.2	0.1	<0.1	0.4	89.8	<0.1
Ore [6A-0181]; sample #10	0.5	0.1	3.4	7.3	1.7	<0.1	0.3	0.2	0.3	<0.1	4.2	81.6	0.3

The chemical composition of a smelting slag is influenced by several factors: the most important is the ore itself, but the fuel used and the furnace can all make material contributions to the slag (Crew 2000; Dungworth 2011). If the analyses of the bog iron ore (Table 4) are used as a starting point it is possible to develop simple models which will predict the chemical composition of a smelting slag. The simplest approach is to assume that a proportion of the iron in the ore is reduced to metal (the bloom) while the remainder is converted into slag (this is modelled by lowering the iron content of the ore and then normalising to 100wt%). This simple model predicts a slag with a composition which is close to the actual slag (Figure 7; Table 5); however there are some small differences which suggest that the actual smelting was more complicated. The Al:Si ratio in the actual slag (0.3) is lower than the ore only model (0.5). This is probably because a proportion of the furnace lining melted to form the slag (furnace linings generally have quite low Al:Si values, 0.2). The actual slag also contains more magnesium and calcium than predicted by an ore only model which is probably due to the dissolution of some charcoal fuel ashes into the slag. The model also predicts higher levels of phosphorus than are seen in the actual slag. Some phosphorus might be volatilised (like the chlorine) and some may partition into the bloom rather than the slag. A more detailed mass balance model is not possible as data on the chemical composition of the fuel usually has to be inferred, and at Goval there were no samples of furnace lining sampled.

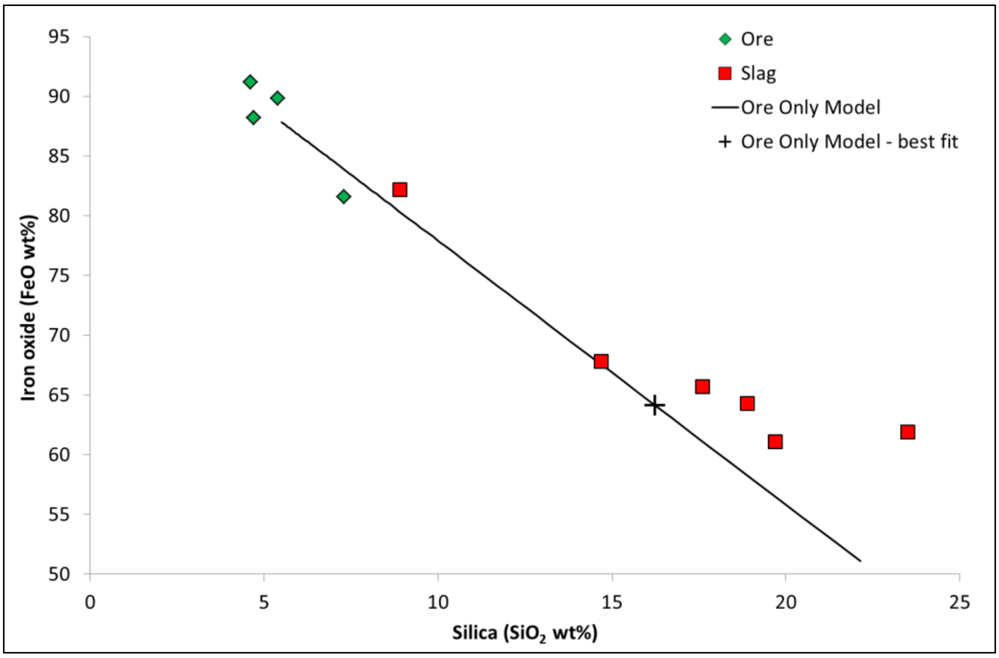

Figure 7. Average iron and silicon content of ore and slag from Goval with a model of slag composition based on just the ore

Table 5. Actual slag composition (average of all samples) and modelled slag composition based on the average composition of the ore (with some iron removed to form a bloom)

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	Cl	K_2O	CaO	TiO_2	MnO	FeO	BaO
Ore Only Model	0.6	0.1	7.1	14.9	3.7	0.1	0.7	0.3	0.5	<0. 1	4.6	67.0	0.2
Average Actual Slag	0.6	0.5	5.5	17.2	1.7	0.2	<0.1	0.6	1.2	0.1	4.6	67.2	0.5

Overall the Goval slag samples share similar chemical compositions with other early bloomery slags from Scotland (Table 6). The composition of these slags is also distinct from early bloomery slag from England (cf Paynter 2006). While the Scottish bloomery slags share the same high aluminium and manganese contents as early bloomery slags from the east Midlands and the Weald, the latter are distinguished by higher levels of titanium (the Wealden slags also contain more calcium). The differences between the different English iron smelting regions are likely to be a result of the use of different ores (although furnace technology may also play a role). The differences between the Scottish and the English slags suggests that the Scottish ore sources were distinct from the English ones. The presence of bog iron ore at Goval confirms that this was an important (and possibly dominant) source of iron ore in the Iron Age. There are some minor differences in chemical composition between Goval and other early Scottish bloomery slags (*eg* the phosphorus is higher and the potassium and calcium are lower in the Goval slags); however, the significance of these differences is not clear at this stage.

Table 6. Average chemical composition of comparable Scottish bloomery slag (data for Argyll from Photos-Jones et al 1998; Atkinson and Photos-Jones 1999)

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	Cl	K_2O	CaO	TiO_2	MnO	FeO	BaO
Grantown Road	0.9	0.2	11.5	21.6	0.3	0.2	<0.2	1.5	1.1	0.1	2.5	59.8	<0.2
	±0.4	±0.1	±9.6	±3.4	±0.2	±0.1		±0.3	±0.5	±0.1	±2.0	±8.1	
Birnie	0.7	0.3	6.4	24.4	0.7	<0.2	0.3	1.1	1.1	0.2	3.8	60.7	0.3
	±0.3	±0.1	±2.4	±6.9	±0.4		±0.3	±0.5	±0.9	±0.1	±5.4	±9.7	±0.7
Culduthel	0.9	0.5	7.2	24.0	0.6	0.2	nr	1.9	3.3	0.1	3.0	58.0	0.3
	±0.5	±0.2	±2.9	±7.4	±0.2	±0.1		±0.8	±1.6	±0.1	±3.1	±12.8	±0.4
Argyll	0.9	0.3	7.1	22.3	0.5	0.4	nr	1.3	1.2	0.3	8.5	56.7	0.4
	±0.7	±0.3	±1.6	±4.8	±0.2	±0.1		±0.6	±0.7	±0.3	±4.0	±10.7	±0.2

The examination of the ironworking residues from Goval provides confirmation that they are all associated with the manufacture of bloomery iron (or possibly steel) from bog iron ores.

Conclusion

The number of *in situ* metalworking features at Goval is small and the quantity of slags recovered is limited in quantity and range suggesting only small scale metalworking activities contemporary with the Iron Age occupation evidence. Macro and microscopic examination of the vitrified and heat affected material from the site demonstrates that the majority of waste derives from primary iron smelting. Several possible metalworking features were noted in the field but only one heavily truncated feature [6A-0118] can be confirmed as an iron smelting feature due to the presence of significant quantities of waste representing a suite of recognisable smelting slags. Intriguingly there is no evidence of blacksmithing to complement the evidence of iron smelting at the site but evidence of such an activity typically leaves more ephemeral traces than that surviving from iron smelting and could be easily destroyed through truncation of soils, as has been noted across the excavated area. Looking at the importance of the evidence of ferrous metalworking from the site more broadly, the metalworking waste and the processes this material represents provides a valuable addition to the growing corpus of Iron Age iron smelting sites in the north-east of Scotland.

The fired clay

Dawn McLaren

A total of 306.5g of heat-affected clay was recovered during soil sample processing from 15 contexts across the site and are summarised by weight and quantity by context in Table 1. The majority of the 158 individual pieces are small fractured fragments with no original surfaces surviving making it impossible to draw any useful conclusions about their original form or provenance. Sixty-six fragments (108.2g) were associated directly with an interconnected series of pits that may represent the truncated base of a ferrous metalworking feature [6A-0118] (contexts 6A-0118, -0121, -0124, -0126, -0128, -0130). These fragments are likely to represent degraded pieces of hearth or furnace lining. A further five fragments of fired clay (8.4g) were recovered from the various fills of truncated features [6A-0095] and [6A-0097] which also appear to be the focus of a high-temperature process.

Table 1: Summary of the fired clay by context

Context	Quantity	Mass (g)	Condition	Heat-affected	Shaped	Impressions
6A-0005	1	0.1	fractured	Y	N	N
6A-0035	1	0.1	abraded	Y	N	N
6A-0098	1	0.2	fractured	Y	N	N
6A-0099	4	8.1	abraded/ fractured	Y	N	N
6A-0102	1	0.1	abraded	Y	N	N
6A-0106	3	0.3	abraded	Y	N	N
6A-0118	6	6.6	fractured	Y	N	N
6A-0121	7	14.3	fractured	Y	N	Organics: grass/rush stems
6A-0124	30	46.2	Abraded /fractured	Y	N	Withy (21 mm Diam)
6A-0126	15	31.4	fractured	Y	N	Concave impression. Possible withy notch or junction between two moulded strips of clay
6A-0128	6	9.6	fractured	Y	N	N
6A-0130	1	0.1	fractured	Y	N	N
6A-0131	7	14.9	fractured	Y	N	N
6A-0145	13	9.8	abraded	Y	N	N
6A-0151	17	37.3	fractured	Y	N	N
Mixed	47	132.3	abraded/ fractured	Y	Y (x1)	N

Only three pieces amongst this small group of fired clay are worthy of further note. The first, from (6A-0124), relates to a possible truncated metalworking structure [6A-0118]. It preserves a thin elongated sub-circular notch on one fractured surface suggesting that the clay had been packed around an organic withy, perhaps part of a wattle and daub screen. The second, comprises a small fractured piece from (6A-0126), also associated with structure [6A-0118], which preserves a concave impression on one face. It is possible that this is an abraded surface of a withy impression, as already described, but the slightly uneven surface suggests that this may be a junction between two moulded strips of clay and could be a fragment of the hearth or furnace lining. A further fragment, which is very similar to that just described, retains distinct evidence of shaping but comes from mixed soils. It comprises two re-joining pieces of a curving sub-rectangular rod of clay, probably prepared as a coil for a thick, coil-constructed pottery vessel or structure of stacked clay construction such as the shaft superstructure of a furnace. The fragment is broken at both ends and all four faces are damaged. It survives to 66.5 mm in length, 27mm in width and 23 mm in thickness.

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Appendix-2.2.25 Report on use wear analysis on Aberdeenshire sites for Headland Archaeology - Karen Hardy

Introduction

Use wear analysis is a microscopic technique to determine whether an artefact has been used, the nature and extent of its use and in some cases the type of raw materials the artefacts have been used on. It has rarely been carried out on Scottish Mesolithic material. Exceptions to this include a study of use wear analysis on microliths from the island of Islay (Finlayson 1990; Finlayson & Mithen 1997, 2000) and a use wear analysis on a Mesolithic assemblage from the Isle of Skye site of Camas Daraich (Hardy, 2004). Stone tool manufacture had, on the whole, only one aim which was to produce usable items that could be used. This was achieved in very many ways over the three million years when stone was a primary raw material, but the Mesolithic is renowned for its microlithic technology. With this in mind, use wear analysis can provide a wealth of information that contributes greatly to the general interpretation of a site and the range of activities carried out. It can provide information on the aims of artefact modification and the knapping process. Based on ethnographic work (eg White 1968; White & Thomas 1972; Hayden 1979; Hardy & Sillitoe, 2005; Sillitoe & Hardy 2003; Van Gijn, 2014) and use wear analysis on archaeological specimens, it is clear that there is a wide range of usable artefacts, and in many cases, these do not correspond with the traditional typological identification of debitage and modified artefacts.

Use wear analysis uses a combination of macro and microscopic edge damage patterns together with polish, which is visible microscopically, to determine the extent and nature of use (Grace, 1989). This approach to lithics analysis differs from technological analyses in that the manufacture o
f the tool and its typological characteristics are not evaluated, rather the artefact edges are examined to determine how the piece was actually used. This includes investigation into whether the piece has been modified by having been used, and examination of all edges, both unretouched as well as retouched. The overall size and shape of the tool and other morphological features, such as the edge angles, can also be significant in determining the way a tool is used and these are also included in the analysis.

As an edge is used, it loses its sharpness and its shape can alter. The most immediately visible effect of this can be a straightening of an edge or a part of an edge. This is rapidly determined, by eye, by looking at a piece (Figure 1). Edge straightening is caused by the wearing down of the edge and is normally accompanied by micro-fractures.

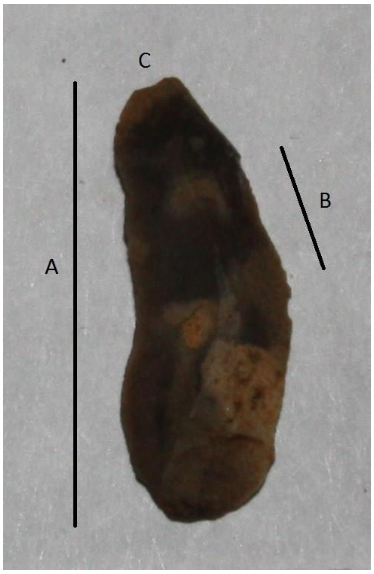


Figure 1 ABNL13/3B, 1011. Used edges A and B.

However, microscopic edge fractures are dependent on numerous factors other than use, including the nature of the raw material, the thinness of the edge and stress, which may range from being carried around in a pouch by the user, trampling, soil, or even post-excavation abrasion, for example bagging with other artefacts. If an artefact shows a concentration of fractures, often combined with unnatural straightening on one edge or part of an edge, then it is likely to be due to use. By contrast, if an artefact, particularly a thin one, has inconsistent or random fractures around all or most of its edges, then it is more likely to be related to something other than use.

There are three main types of micro-fractures, these are called flake, snap or step. Though their presence can be felt as a roughening of the edge, the types of fractures are only distinguishable using an enhancement, either a high magnification eye magnifier, or a microscope. A flake fracture is the removal, through use, of a small piece of the edge. The removal appears in form similar to a miniature retouching flake with the negative part of the fracture visible. Snap fractures occur when a part of the edge is removed. Step fractures are similar to flake fractures except that the end of the flake scar is abrupt and hinged. While flake and snap fractures can occur when a tool is used in a parallel motion (in a cutting motion for example), step fractures can be an indication of a percussive or perpendicular motion (Figure 2)

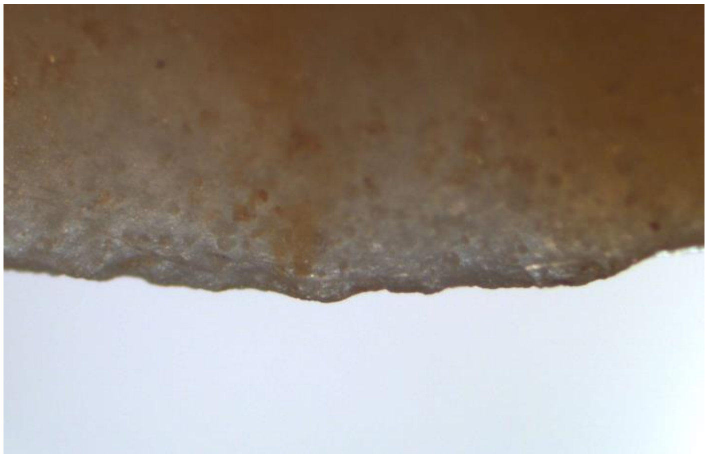


Figure 2. Example of microfractures. ABSL13/2D, number 2457.

Like edge fracturing, polish may be due to many different factors. Spots of polish, or polish that occurs at random across a surface, are unlikely to have been caused by use (Figure 3).

Figure 3. Polish spot. ABSL13/2D, number 7743.

When an edge is used repetitively, it can become smooth and rounded, and can have the appearance of being polished. Polish occurs as the lithic material is repeatedly rubbed against the material being worked, this smoothes and flattens the edge. The development of polish can provide an indication of the extent an edge has been used, for example very abrasive polish together with a rounded edge suggests a greater extent of use than an edge that may have fractures but is not deeply rounded, and which only has light polish. The depth the polish extends into the surface of the artefact can provide information on the pliability of the worked material. For example, hard materials such as bone and antler will be abrasive to an edge and cause extensive fracturing and straightening of an edge, but by the non-pliable nature of the material, the polish will be restricted to the edge only. Softer materials such as hide and plant materials which are pliable can result in a pattern of polish that extends well away from the edge and onto the surface of the stone tool. Striations are lines of polish that are visible on the tool surface. Where these are present, they can demonstrate the way the tool has been used (Figure 4). The combination between the straightening and rounding, the extent of polish and the type of micro-fractures, can together provide an indication of the way the artefact was used and the type of raw material that it was used to work on.

Figure 4a. ABSL13/2D, number 2232. Example of invasive polish. Figure 4b. ABSL13/2D, number 2258. Example of polish in parallel lines.

Determining the use of tools is difficult without experimental comparison. A particular problem in Scotland is that the wide range of different raw materials means that for a full and detailed use wear analysis to take place, a full experimental programme is required for each individual raw material, as each may respond differently to pressure and movement, something that is expensive and time consuming. Yet similar raw materials respond to stress in similar ways. For example, fine-grained, silicious materials such as chert, flint and bloodstone tend to produce comparable wear patterns. While determining specific use is not possible without detailed dedicated experimental replicative programmes, certain features can provide a good indication. For example, lines of polish all lying in one direction point to the dominant direction of use, for example if they all lie perpendicular to an edge they indicate use in an up/ down (scraping) motion. Polish that extends deep into an edge is likely to have been used on a pliable material, such as hide, and polish that is restricted to the limits of an edge is likely to have been used on a hard or brittle material, such as bone. Step fractures are more likely to be the result of a percussive or sharp motion while snap and flake fractures are more likely to result from cutting, whittling, or scraping (Hardy, 2004).

In this study this did not occur, however, an experimental assemblage on a different raw material was available from a previous study (Hardy and Shiel 2007). As both the raw materials are flint, the experimental tools were re-examined as part of this study and these have provided some general indicators on the way tools may have been used.

The aims of the use wear analysis were as follows:

1. To determine which artefacts have been used.
2. To obtain as much information as possible on the nature of the use including edges used, type of use, intensity and potential hardness of raw materials worked.
3. To provide information that can lead to a better understanding of the type activities carried out in it. Ultimately, determining the most probable function of artefacts in an assemblage contributes to the reconstruction of the nature of the context or site within which the pieces were found, and the types of activities carried out there.

Materials and methods

The studied assemblage is on flint which was very widely used in prehistory, it is relatively easy to knap, and it can produce a very sharp edge. It is a very fine-grained material that polishes easily when used, therefore the extent and nature of polish can be readily visible. An assemblage of 98 artefacts from two sites (ABSL13/2D and ABNL13/3B), comprising both retouched and unretouched artefacts as well as technological pieces were submitted for use wear analysis (Table 1). As these artefacts were selected for their potential use wear, they are not representative of the overall proportion of used artefacts across the whole assemblage. Of the materials from site ABSL13/2D, 17 were marked as Upper Palaeolithic. As these therefore represent what appears to be a different assemblage, these pieces have been separated out and are considered independently (Table 3).

Table 1. Artefacts examined.

Artefact type	ABNL13/3B	ABSL13/2D	ABSL13/2D/Upper Palaeolithic
Blades/backed blades	8	18	3
Crested blades		4	6
Cores	1		1
Edge retouched flakes		3	
End scrapers	3	5	1
Unretouched flakes	11	3	1
Microblades		2	
Microliths	7		

Truncations	2	2	2
Point/piercers		2	2
Polished edges		9	
Serrations		1	
Scrapers (side)			1
Total	32	49	17

The analysis was conducted at the University of Edinburgh, School of History, Classics and Archaeology first using a binocular microscope, to determine the used edge(s), this was followed by examination using a Leica DM 750P optical microscope, and x4 and x10 lenses. All imaging was conducted using an attached Leica camera and the imaging programme LAS core. Major morphological attributes were evaluated first. This comprised length, width, thickness and evaluation of artificial edge straightening. Next, a binocular microscopic analysis was conducted while the artefact was held, this enabled it to be moved around and examined from all angles, to determine the location and extent of used edges. A rough drawing was made at this point, all used edges were marked and the edge angles of the used edges were recorded.

Though the artefacts were washed prior to being submitted for this analysis, handling can interfere with use wear and in particular can mask polish, therefore each artefact was cleaned using cotton buds dipped in acetone to remove all finger marks, before and during examination, when considered necessary. The artefact was then wiped clean and placed ventral side up on a microscope slide and attached to the slide using Blutack. An initial scan around all edges confirmed which edges had been used, and the distribution and nature of the edge wear was recorded. This began with the nature and extent of micro-fracturing, and was followed by an examination of the presence and extent of polish. Where size permitted, artefacts were then turned over and the dorsal side of the edges was examined. In some cases artefacts were too big to examine on the dorsal side. This is because the edges need to be examined flat, which requires that artefacts to be slanted on the dorsal side – when an artefact is too large, there is not enough space to do this. Retouched edges were also not examined dorsally. Where an artefact was small enough, the edge rounding was examined on this microscope, where this was not possible rounding was evaluated in the binocular microscope.

Experimental assemblage.

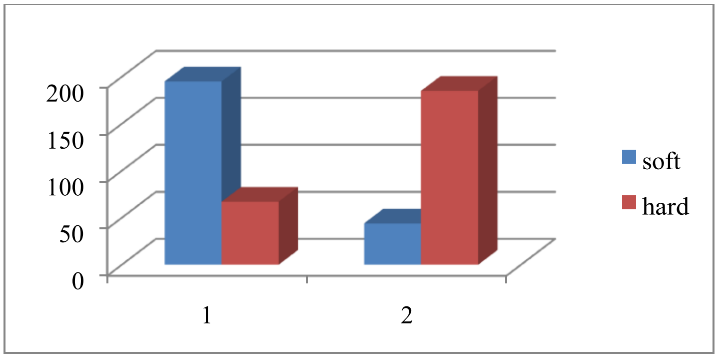
24 pieces from an experimental assemblage on a different type of flint were examined to detect patterns in the use wear that could be used to assist in the determination of the types of use wear and how these are linked to the type of actions that could have caused these. 12 pieces were used on soft materials, this includes skinning deer, piercing hide, scraping hide cutting grass, cutting seaweed and cutting nettles, scraping nettles, descaling fish. 11 artefacts were used on medium and hard materials. Activities include debarking wood, piercing wood, cutting a groove in horn, grooving antler, cutting a groove into a stone, cutting a groove into a shell (Table 2).

Table 2. Experimental tools

USE WEAR	Soft materials	Hard materials
Flake and snap fractures	90	27
Step fractures	10	45 (one snapped)
Edge rounding	16	70
Smoothed	15 (one piercer and one hide scraping tool)	
Continuous /invasive polish	80	40
Edge only polish	8	60
No polish	8 (plus one broken)	
Oblique/parallel polish lines	10	
Perpendicular polish lines	10 (one piece, scraping nettles)	10

An evaluation of the soft and hard features of use wear clearly demonstrates the distinction between these. ‘Soft’ features include flake and snap fractures, continuous/invasive polish, oblique/parallel polish lines, while ‘hard’ features comprise step fractures, heavy edge rounding, edge only polish and perpendicular polish lines (Figure 5).

Figure 5. Relative proportions of soft and hard features on experimental tools with known uses.



Results

Twelve pieces had no evidence of use and appear to be unused, six of these are from ABNL13/3B and six are from ABSL13/2D (Table 3). These comprise four blades/blade fragments, three flakes, one core, one end scraper, one piercer and two microliths. Six of these pieces are from site ABSL13/2D and include two Upper Palaeolithic artefacts. The unused retouched pieces are particularly interesting. They have been carefully made, and were clearly intended to be used, so the assumption is that they were accidentally lost. The unused artefacts were removed from the future analyses except for some morphological comparisons.

Table 3. Unused artefacts.

Artefact edges	Site ABNL13/3B	ABSL13/2D	ABSL13/2D/Upper Palaeolithic
Backed blades /blades	1	2	1
End scrapers			1
Cores	1		
Microliths	2		
Piercer		1	
Retouched/unretouched flake	2	1	
Total	6	4	2

One of the most important points to remember when evaluating or conducting a use wear analysis is that most used tools are unretouched flakes and blades, and that formal tool types represent a tiny proportion of the overall use of an assemblage. Most of the artefacts that were used had more than one used edge. These comprised most commonly, both lateral edges, though one or two lateral edges and a point or distal edge could also demonstrate evidence of being used. In some cases, only parts of an edge were used. Therefore, the number of used edges/points is 184 (Table 4).

Table 4. Used edges.

Artefact edges	ABNL13/3B	ABSL13/2D	ABSL13/2D/Upper Palaeolithic
Lateral edges	26	73	13
Distal ends	7	11	3
Points and pointed corners	13	25	2
Unused	6	4	1
Total	52	113	19

Cluster 1 Upper Palaeolithic pieces

As these artefacts are Upper Palaeolithic and therefore not linked to the majority of the site, these 17 artefacts are considered as a separate group. These pieces are generally large (mean length= 49mm, mean width= 21mm, mean thickness= 10mm) and have relatively wide edge angles, mean = 49^{o}.

All show evidence of use except two pieces (end scraper CAT10214 and a blade CAT6592), all have use wear on their lateral edges while two artefacts that could be examined also have use wear on their distal edge. All the used artefacts in this group show evidence of having been well used and have patterns of intense micro-fracturing along their used edges. Nine of the 15 used edges, representing 60% of used edges and 6 artefacts, had step fractures most likely indicating a hard material or intensive working. Two of the 3 crested blades are the most intensively used pieces in this group with two and in one case, three edges on each piece having evidence for intensive use. The use wear on these pieces suggest they were used in a perpendicular manner most likely for scraping. The closest parallel with the experimental pieces is debarking wood, and the size of the edge angles together with the use wear patterns and the varied extent of polish development which is non-invasive, suggest that wood working is a very likely possibility.

One piece was recorded as a point (CAT10456) and it does indeed have the morphological appearance of a point. However, examination of the use wear shows that the focus of use was the right lateral edge, and this continued up to the point. However, the point itself, as a separate entity was not used. This piece demonstrates the value of use wear analysis as it gives an insight into the mind of the manufacturer that is not always immediately visible. Another piece, also recorded as a point (10265) may well have been used as a point, as this has snapped off, most likely as a result of use. However, this piece also had evidence of intensive use along its right edge. These artefacts will be compared to similar artefacts in the clusters below.

Cluster 2 Polished edge pieces.

10 pieces from ABSL13/2D (CAT10639, CAT10645, CAT10657, CAT10659, CAT10605, CAT10660, CAT10729, CAT10734, CAT10737, CAT10754) were identified previously as pieces with polished edges. From the use wear perspective, they are also a group, and have most use features in common. All these artefacts are ‘blade-like flakes’ and are a similar size and shape (mean length 31cm, mean width 20cm, mean thickness 8.5), with wide rounded distal ends and relatively short, straight, lateral edges. They are all heavily rounded around these edges and have the same polish pattern. This extends along the edges and round into the dorsal. The polish pattern on the ventral side begins at the edge and does not extend into the ventral surface of the artefact. This suggests they were held with the ventral face upwards, and used in a pulling fashion, on soft material.

Their roundness was so pronounced that they must have been heavily used in this way. Though none of the experimental pieces has this type of extreme rounding, the nature of the polish distribution and the rounding, suggests they were used as a smoother of some sort on a soft material. For example, they could have been used on hide, to remove the fat or smooth and soften the material. In terms of size and shape, there appears to be little correlation with their use. Artefact lengths range from 31-48mm, shape (width/length) ranges from 0.3 (long and thin) to 0.87 (short and squat), however, edge angles are almost universally low (average 18.4^{o}).

Cluster 3 End scrapers

There are nine used end scrapers in the assemblage. Three of these are from ABNL13/3B, five from ABSL13/2D and one is Upper Palaeolithic though this was unused (Table 5). The most noticeable morphological features of the end scrapers are that they are wide relative to their length and, unsurprisingly, have thick edge angles. However, when looking at the different sites a difference in their sizes, the Upper Palaeolithic artefact is much larger, though thinner, than all the other artefacts, yet has a much steeper edge angle. As this was not used, we cannot examine any different use wear traces, and the morphological difference may well be cultural.

Table 5. End scraper edge angle measurements.

Averages	ABNL13/3B	ABSL13/2D	ABSL13/2D/Upper Palaeolithic
Length	31	24	45 (one piece, unused)
Edge angle	71	71	85
Shape	0.84	0.95	0.65

Overall, possibly the most unexpected result in relation to the end scrapers, is the fact that most display very little evidence of use. In every case, the edges are sharp, and the polish is either on the tips of the retouching flakes or only on the extreme edges, though two pieces (CAT10223, CAT10227) also have horizontal polish lines suggesting a horizontal scraping motion rather than a perpendicular motion. One piece (CAT2461) also has evidence of being used along its lower left lateral (unretouched) edge. This short edge has intensive fracturing, but the polish development is only on the tips of the fracture ends, suggesting again, a relatively light use. Why these pieces have been so little used is unclear, but the small amount of evidence that is present, largely the restricted polish distribution, suggests they were used though very lightly, on relatively hard materials, most probably wood.

In addition to the end scrapers, seven artefacts have use wear evidence indicating their distal ends were used. This does not include the distal corners that have been classified in the Points, tips and corners cluster, above. Two of these, the Upper Palaeolithic crested blades have already been discussed. There are no specific noticeable features of these artefacts, except in one case, a crested blade with a steep edge angle and intensive use wear (CAT10099) which suggests suggesting very heavy use. These artefacts will be included in the lateral edges evaluations as it is most likely they were perceived as useful unretouched edges, rather than distal edges, by the users.

Cluster 4 Points, tips and corners

32 pieces had tips on their distal end and seven more pieces had distal corners that had been used as tips making a total of 39 pieces. 14 were from ABNL13/3B and 25 from ABSL13/2D. Of these, 23 were snapped off at the tip, three had tips that were unbroken but rounded, 4 had signs of use but were unbroken and the remaining nine were unbroken and appeared not to have been used. Adjacent to all of the used tips were micro fractures, in most cases these were intensive and most of the pieces had evidence of rounding on the remaining tip suggesting a rotational movement. Four pieces had additional polish striations that provide a closer indication of the type of movement, of these, three were transversal demonstrating a rotational movement, while one piece had parallel polish striations suggesting a direct punching-type movement. Twenty-two of the tips were on blades or crested blades, five were on flakes, one possible Havelete point, five microliths, three blades with oblique truncations and one piece (CAT10276) described as a piercer. One of the unused pieces was a carefully made piercer, as mentioned above.

Corners are particularly interesting as they are unlikely to be identified in a standard technological analysis as of independent significance. In fact, as is the case here and elsewhere (Hardy 2004), corners are often deliberately used. Corners, by their morphology can be stronger than points and this is reflected in their use.

Cluster 5 Microliths and microblades

Seven microliths, two very small backed blades and two microblades were examined. They range in length between 10-27mm. Two microliths and one backed blade showed no evidence of use. The remaining artefacts all show evidence of heavy flake and snap fractures and one backed blade (ABNL13/3B) has parallel polish lines. Together this suggests transversal motions, probably cutting. The polish is interesting as it is largely edge only, suggesting a harder material. Three of these pieces have possible evidence for hafting (see below) which is interesting as microliths are considered to be hafted for use, largely due to their very small size.

Clusters 6 and 7 Unretouched edges.

There is a total of 70 pieces, both unretouched blades and flakes and retouched artefacts, that have evidence for use. This totals 106 edges altogether with use wear, not counting the polished edges pieces which are considered separately above. These artefacts are predominantly blades, crested blades, and flakes (Table 6).

Table 6. Unretouched used edges.

	ABNL13/3B	ABSL13/2D	ABSL13/2D/UP
Blades	9	29	
Crested blade		11	6
Microlith	5		
flake	14	5	1
truncations	2	6	2
Backed blade			2
Microblade		5	
Core			1
Serration		2	
Edge retouch		3	
Point			2
Bladescraper			1
Total	30	61	15

Retouched artefacts were evaluated separately to determine if these had been used in a different way.

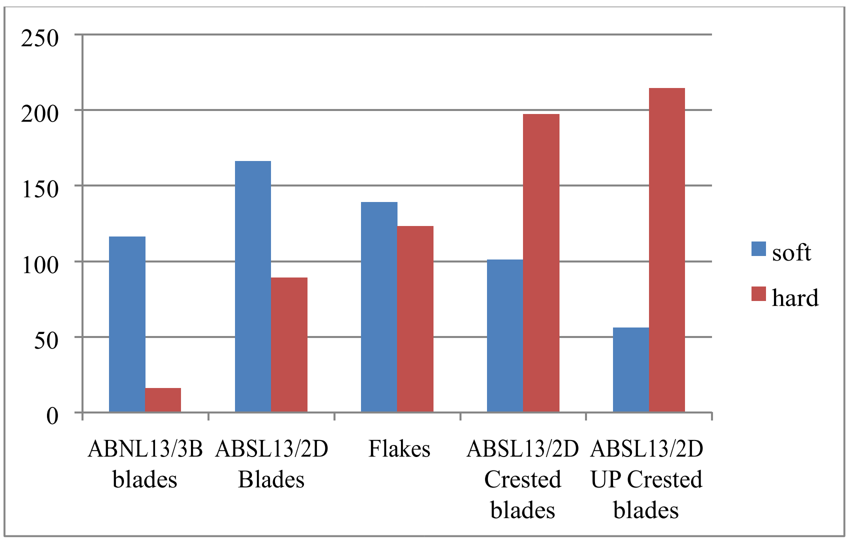
Table 7. Use wear features, unretouched artefacts

USE WEAR	ABNL13/3B (%)blades	ABSL13/2D Blades (%)	ABSL13/2D Flakes	ABSL13/2D Crested blades (%)	ABSL13/2D UP Crested blades (%)
Flake and snap fractures	100	72	68	46	14
Step fractures	0	24	31	54	86
Edge rounding	16	53	52	94	71
Continuous /invasive polish	16	69	60	54	28
Edge only polish		9	40	45	57

No polish		22		1	14
Oblique/parallel		3	11	1	
polish lines					
Perpendicular polish lines		3		4	

The use wear features were divided into 'soft' and 'hard'. While the exact use cannot be determined, these largely represent heavy use, such as scraping or a medium-hard material, and 'soft' use, such as cutting or a soft material. The result can be seen in Table 7. An examination into the different types of use wear has clearly demonstrated two categories of artefacts correlated with different uses.

Figure 6 Difference between soft and hard use wear features, unretouched artefacts



The sum of the percentages for the use wear features two groups (soft and hard) was added together to determine whether a pattern of use existed that was different for each artefact group. Figure 6 demonstrates that indeed there is a clear distinction with two major groups emerging. The artefacts that are 'softest' are the blades. B blades (ABNL13/3B) are shown to have the most abundant 'soft' features and least 'hard' features. These are followed by the blades from ABSL13/2D which are also predominantly 'soft' though with a slightly higher number of hard features. Flakes fall exactly in the middle with almost 50% on soft and hard. Crested blades have strong 'hard' features and fewer 'soft' features while Upper Palaeolithic blades are almost entirely 'hard'. A closer look at the flake assemblage which attempted correlations using a range of morphological features such has overall size, length and edge angle did not produce any correlations. Therefore it must be assumed that flakes were most likely to be used in a range of different ways.

Examination of the size and shape of the different groups of unretouched artefacts and their use wear shows that overall length and edge angle correlate well with use wear. The length and edge angles of blades from both ABNL13/3B and ABSL13/2D are significantly smaller than the crested blades. Shape, which is the width divided by the length has no correlation with use wear. Flakes do not correlate with either group.

Table 8. Morphological features of unretouched artefacts

Average	B. BLADES	D BLADES	Flakes	CR B	UP CR B
Length	36	38	36	47	65
Edge angle	34	39	42	50	44
shape	0.42	0.35	0.67	0.37	0.42

The retouched artefacts were considered separately, to determine whether there are any use wear features that suggest these might have been used differently to the unretouched artefacts.

Table 9. Use wear on retouched artefacts.

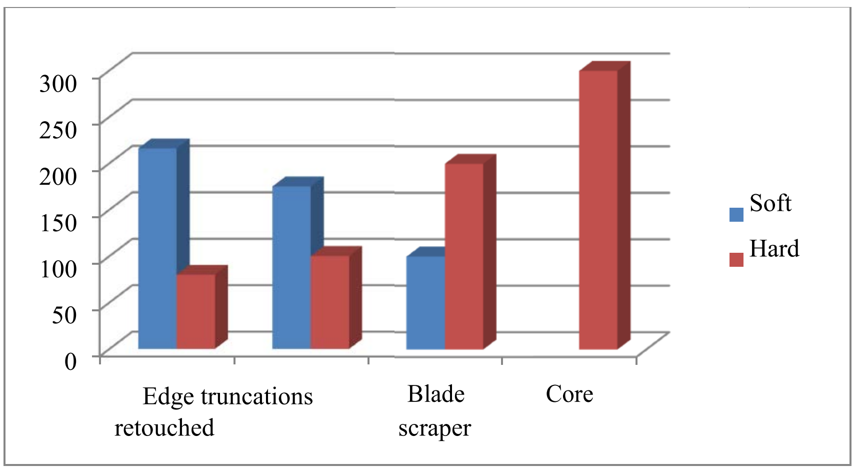
USE WEAR	Edge retouched	truncations	Blade scraper (1 artefact)	Cores (1 artefact)
Flake and snap fractures	100	75		
Step fractures	0	25	100	100
Edge rounding	80	50	100	100
Continuous /invasive polish	66	75	100	28
Edge only polish		25		100
No polish				
Oblique/parallel polish lines	50	25		
Perpendicular polish lines				
Length	43	23	69	73
Shape	0.45	0.5	0.47	30

Edge angle	52	37	52	66

There is once again, a clear separation between the groups Edge retouched pieces and truncated pieces have a greater proportion of ‘soft’ use wear traces, while the blade scraper and the core fall into the ‘hard’ category. Size and edge angle once again correlate well this these groupings while once again, shape does not. It should be remembered that these artefact groups are very small and, in the case of the core and the blade scraper, represent only one artefact each.

Taking all the features together, for both the unretouched and retouched artefacts, two clear clusters emerge though flakes fall almost directly in the middle and may be in either group.

Figure 7 Difference between soft and hard use wear features, retouched artefacts



Cluster 6 comprises blades, edge retouched pieces, serrations and truncated pieces. These all have a predominance of ‘soft’ features, are all relatively small artefacts with relatively small edge angles. This group represents pieces that were most likely used for cutting materials that will have been soft, such as plant materials, and activities such as skinning animals.

Cluster 7 comprises crested blades and large retouched pieces with wide edge angles. These pieces have edge wear correlated with heavy use or use on hard materials. They were more likely to have been used in a scraping motion or in cutting of hard materials such as wood or bone.

Hafting

Four pieces have possible evidence for hafting. These are all small pieces, 2 microliths, a microblade and a piercer. These pieces all had extended polish across parts of their surface.

In one case the retouched edge of a microlith was rounded which may be the result of having been placed in a haft which would have them rubbed while it was being used.

Discussion.

Most usable edges are used. There is no formality in use of the artefacts and these appear to be used in the best way possible according to their size and shape. This means that small artefacts with lower edge angles were used largely on lighter materials and for cutting rather than scraping. Flint takes a very sharp edge and there is little doubt that the artefacts would have been highly efficient for activities such as skinning animals or removing the outer parts of edible plants or possibly even descaling fish.

Artefacts that are formal types are not necessarily used in the expected way or only on the prepared edge. One example is an end scraper that was used, not on its scraping end, but on a small piece of unretouched edge separate from the retouched edge.

There is a clear distinction in use wear between the Mesolithic and the Upper Palaeolithic assemblages. This may though be due at least in part to the different types of artefacts. However, a comparison between the Mesolithic and Upper Palaeolithic crested blades, suggests that the Upper Palaeolithic ones were more heavily used.

Possibly the most surprising feature of this assemblage is that there are very few artefacts with evidence for extensive use. The exception to this is the polished-edge pieces of cluster 2. These pieces were so well used that their edges are completely rounded and smoothed. Other than this, there is very little well-developed polish on other artefacts. It is particularly surprising that tools such as the end scrapers have so little evidence for being used. This suggests that there was ready access to abundant raw materials and that manufacturing was swift and easy. The exception to this is the microliths. Retouching flakes on microliths are sometimes so small they can only be clearly see using a magnifier. In many cases their use wear is relatively intensive, and they are likely to have been used of a relatively hard material. To gain the traction required for them to be used in this way suggests that they must have been hafted. Interestingly, the pieces with possible evidence for hafting are all very small (see below).

While today we may find knapping challenging, it is important to remember that the Mesolithic people are at the tail-end of a stone using heritage that extends for over 3 million years. Flaking stone is likely to have been embedded from a very early age and is something that people are likely to have done habitually throughout their lives.

When examining an assemblage from the perspective of use it becomes apparent that there is a great deal of flexibility in the use of tools. Artefacts such as crested blades, in particular, which are generally considered to be technological pieces, have been repeatedly shown to be very useful, and well used artefacts. In a context such as thew Mesolithic, where artefacts are made and mended, there is a huge range of potential activities that could be included. Not only food, but also all material culture items had to be made, and it is interesting to note that in ethnographic contexts where this has been studied, many more artefacts are used in manufacturing material culture items, made from plant materials and wood, as well as bone and antler that

A comparison with the use wear analysis results at other northern Mesolithic sites (Hardy 2004, 2007) reveal some clear similarities. The use of corners at the Isle of Skye site, Camas Daraich, is also very evident and suggests both cutting or grooving actions, as well as a rotational or stabbing action. This pattern is similar to the current assemblage. The use of points for cutting gives some indication of the way in which many unretouched flakes may have been held and used and compares with the way some knives are used today.

A second similarity with Camas Daraich, and with Howick (Hardy 2007) is in the pattern of use of unretouched blades. At these sites also, very few blades showed evidence of heavy use, though they had similar evidence of longitudinal cutting type motion as the current assemblage.

At Camas Daraich the only pieces with possible evidence for hafting are two microliths (both backed bladelets). This corresponds to the current assemblage in which four pieces, also microlithic or very small, are the only artefacts with evidence for hafting.

Examination of microliths from other Scottish Mesolithic and Northumbrian sites (Finlayson 1990; Finlayson & Mithen 2000; Mithen & Finlayson 2000; Hardy 2004, 2007), confirm that their use may be as cutting implements and that they have rarely been found to have use wear traces that link them to projectile use.

Though the use wear analysis cannot suggest precise tasks or worked materials, it is important to note that many studies, both of use wear on archaeological assemblages and of ethnographic material, have emphasized the role of lithic artefacts in the manufacture and maintenance of other tools (Hayden 1987; Hardy & Sillitoe 2003). It is generally accepted that the importance of stone tools is exaggerated because of their survival. The central role of plants in the pre-agrarian world is highlighted by Adovasio et al. (2007) who point out that in archaeological contexts with exceptional survival of plant materials, fibre artefacts outnumber stone tools by a factor of 20 to 1, while in anaerobic conditions 95% of all artefacts are either made of wood or fibre. Any prehistoric tool kit will no doubt have incorporated artefacts of many different materials of which stone was but a part.

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