Plant Macrofossils

Elizabeth Huckerby

General Environmental Introduction: eighteen environmental bulk (of at least 30 litres) and four monolith samples were taken during the excavation of the Drigg burnt mound in 1999 and 2000 for the assessment and analysis of environmental remains including pollen, invertebrate remains, charcoal and charred and waterlogged plant remains . Of the eighteen bulk samples 10 were from Trench A, from Layers ***13*** (1), ***14*** (3), ***15*** (2) and ***16*** (4) and 8 from B, Layers ***13*** (1), ***14*** (3) and ***17*** (4). Four 0.50m monoliths of the peat (organic layer) were taken immediately adjacent to the southern edge of the burnt layer. The following table summarises the numbers and types of samples:

Sample type	**Number**
Bulk + wood	18
monoliths	4 (2 x 1999, 2 x 2000)
Arthropod	6 (included in bulk)
Radiocarbon	20
Groundwater	2

A two phased environmental assessment was undertaken in 2000 and 2010 and recommendations were made for further pollen and charcoal analysis and for the inclusion of the plant and insect remains assessment data in the publication (OA North, 2009, 2011).

Plant Macrofossils Methodology: the plant remains in nine bulk samples taken from Element 1 and all adjacent peat deposits, as well as from a layer of humified material within the band of intercalated layers of sand and humified material were assessed. The samples were from above the 'hearth', the burnt layer itself, and the peat layer beneath, and also from above and below the worked wood in Trench B. Contiguous samples were taken from one of the four monoliths, which were taken through the peat (organic layer) immediately adjacent to the southern edge of the burnt layer. The processing and assessment methodology is described in OA North (2009, 2011). The data from the bulk and monolith samples are summarised below and those from monolith are shown as histograms of their relative abundance in Figure x.

Bulk Samples and Monoliths: plant macrofossils from nine bulk samples were identified and recorded with the aim of defining the possible use of Element 1. All samples contained wood fragments, amorphous organic material, charcoal, sand, and modern roots from marram grass (*Ammophila arenaria*). The abundance of each component varied in the individual samples. Charcoal was very abundant in burnt layer [15] and least so after the abandonment of the burnt mound/hearth (layers [14] - [12]). Conversely, amorphous plant material dominated the assemblage above layer [15]. In samples from deposits earlier than the burnt layer, wood was more abundant. Bark, probably from birch, was recorded in layers [15] and [16] but less was seen at

other levels. No artefacts and hammerscale were identified in the samples examined. No remains of animal bones were identified in any samples during the evaluation.
The assemblage of identifiable plant macrofossils from burnt mound/hearth [15] and the layer immediately below it, [16], appreciably differed from the layer [14] above.

A sample from below the worked wood in layer [17] contained hazel nuts (identified in the field but not in the laboratory) and occasional seeds including hemp-agrimony (*Eupatorium cannabinium*) and marsh pennywort (*Hydrocotyle vulgaris*), but fewer than those in layers [15] and [16]. Hemp-agrimony is found growing today in damp places and beside water in either light or shade and marsh pennywort in bogs, fens, marshes and at the side of lakes (Stace 2010).
Within layers [15] and [16], blackberry (*Rubus subsection* Glandulosus) seeds were frequent-abundant, as were those of rushes (*Juncus*), together with some records of sedges (*Carex* and *Eleocharis*) and knotweed (*Polygonum*). Knotweed is a weed type that is found growing either as ruderals, amongst arable crops, and on fallow ground (Behre 1981). The assemblage from layers [15] and [16] suggests that the plant community was fairly open. Most British rush species, except *Juncus effusus*, grow in damp open conditions, whilst blackberries grow and fruit best in sunny or partially shaded places in a variety of habitat conditions. The few other seed types recorded also support the possibility of open conditions. Above the burnt layer, the samples from [14] contained abundant fungal sclerotia and fewer identifiable plant remains; this was related to a high degree of humification of the deposit.

Plant Macrofossils from the Monolith Sample: it was hoped to be able to reconstruct the local vegetation of the area around the burnt mound/ hearth during the period of its use, prior to it, and after its abandonment by recording the plant macrofossils from the monolith samples. The result are shown in Figure 11 and provide corroborative evidence to that from the bulk samples, except for the large numbers of undifferentiated grass seeds (J Huntley pers comm), which were not recorded in the bulk samples. It is of interest to note that these were more abundant whilst the burnt mound/hearth material was accumulating, and thus supports the possibility that the vegetation in the area was more open at that time than subsequently.

Discussion: It is assumed that the unworked wood in the organic deposits is *in situ*, but the absence of seeds from any woody taxa except blackberry and hazel nuts (the latter identified in the field) is unexpected. Birch bark was recorded and although birch produces prolific and very distinctive seeds, which are generally well preserved in waterlogged conditions, none were identified in the small samples assessed. This absence may indicate one of several circumstances: that the trees were already dead when the peat developed; that the current sample size is too small and further analysis might add to the data; or that the wood was in fact brought to the site by an outside agency. At this stage further speculation is not valid.
Both the plant remains and the pollen between 0.15m and 0.20m (burnt layer *15*) is of interest. A peak in birch pollen and bark, probably from birch immediately underlying the stones and the large numbers of grass seeds, sedge pollen and fern spores in Layer *15* and immediately afterwards suggesting that that vegetation became more open character. It is, however, of note that, as at other burnt mound sites in the north of England (in Cumbria (Heawood and Huckerby, 2002) and Northumberland (Topping 1998)), the range and quantity of charred plant remains at Drigg are disappointing.

The plant macrofossils from the burnt layer and peat (organic material) suggests that there are real differences in the vegetation of the area, which are shown in assemblages accrued before, during, and after the monument was in use. The presence of blackberries, grasses and rushes indicate the possibility of a local clearance when the worked wood and burnt mound/hearth were being used. The only firm evidence of food sources are wild ones, namely hazel nuts, found in layer [17] above the clay deposits, and the blackberries from layers [16] and [15] although some possible cereal-type pollen was recorded.

An important note that needs to be included: the fact that there was a two phased approach to the environmental programme has allowed the authors to make a few, important observations about the preservation of unprocessed environmental remains in samples, from this site, that have been stored for more than ten years and where the major form of preservation was by water-logging. Pollen preservation had remained excellent both in the previously unprocessed material and in the original pollen preparations. However the preservation of the plant remains in the unprocessed material, which had been stored in sealed plastic tubs, seems to have been adversely affected during storage with a high level of degradation of the wood. The waterlogged seeds may have been more stable. In contrast the original flots, which had been stored dried, appeared to have remained stable. No comparisons of the affects of long term storage on invertebrate remains could be made as these were only examined in 2010 after lengthy storage. Although David Smith did observe that preservation was poor (OANorth, 2011), however the authors suggest that because the peat originally was quite humified their state of preservation may have remained stable.

Topping, P, 1998 The excavation of burnt mounds at Titlington Mount, north Northumberland,1992-3, *Northern Archaeol*, **15/16**, 3-25

Drigg Burnt Mound – radiocarbon analysis

P D Marshall, E Huckerby, and G Cook

Introduction

Eleven archaeological and two ground water samples have been radiocarbon dated from the vicinity of the burnt mound at Drigg. Two charcoal samples were dated by Queen's University Belfast in the late 1970s (Pearson 1979) and 11 samples (ground water, charcoal, waterlogged wood, and peat) were submitted for radiocarbon analysis to the Scottish Universities Reactor Research Centre (SURRC) in 2002.

Objectives

The principal objectives of the dating program were:

5 to ascertain whether the Drigg nuclear fuel storage dump, *c* 0.5km to the east of the site, could affect the radiocarbon analysis of archaeological material;

6 to establish a chronology for the site, and;

7 to date the use of the burnt mound.

Sampling - I

Given the potential technical problems arising from the proximity of the site to the Drigg nuclear fuel storage dump, a modern water sample was taken from a surface pond a few metres inland from the excavation. If water percolating through the site had enhanced levels of radioactivity that could cause anomalous measurements on the archaeological material, then the dating of the site could have been jeopardised.

Results - Ground Water samples

The two groundwater measurements (AA-43497 and AA-43498; Table RC1) from dissolved inorganic carbon (114.2 ±0.6 pMC) and dissolved organic content (119.6 ±0.5 pMC) both showed evidence of ^{14}C enrichment, probably due to atmospheric nuclear weapons testing. The current ambient measurement is about 110 pMC, although in AD 1963 it was about 200 pMC! As their is no evidence of enrichment due to leakage from the nearby nuclear fuel storage dump it was felt we could have confidence in radiocarbon measurements made on archaeological material submitted from excavation of the burnt mound.

Sampling II – Burnt Mound

The first stage in sample selection for the material submitted in 2002 was to identify short-lived material which was demonstrably not residual in the context from which it was recovered. The taphonomic relationship between a sample and its context is the most hazardous link in this process, since the mechanisms by which a sample came to be in its context is a matter of interpretative decision rather than certain knowledge. Material was selected only where there was evidence that a sample had been put fresh into its context. The main category of material which met these taphonomic criteria were:

5 charcoal from the burnt mound itself - it was assumed that this represented the remains of fuel related to the use of the feature;

5 waterlogged wood from the structure (?trough or platform) under the mound;

6 waterlogged wood from the simple walkway.

In addition a series of 'bulk' peat samples (>200g) from above and below the burnt mound were taken to help refine its dating and provide chronological markers for palaeoenvironmental work. Humin and humic acid fraction measurements were made on all these samples to test the homogenity of the peat (Shore *et al* 1995; Howard *et al* 2009).

Once a group of potentially suitable samples had been identified, a number of models were built simulating the results of the dating programme. Radiocarbon results were simulated using the R_Simulate function in OxCal, with error terms estimated on the basis of the material available and the type of measurement to be commissioned (in this case all radiometric dates).

Radiocarbon Analysis and Quality Assurance

The samples processed by SURRC in 2002 were prepared using the methods outlined in Stenhouse and Baxter (1983) and measured using liquid scintillation spectrometry (Noakes *et al* 1965). The ground water samples were prepared in East Kilbride as described by Stenhouse and Baxter (1983) and converted to graphite (Slota *et al* 1987). They were measured by the University of Arizona AMS facility following Donahue *et al* (1997)

Both laboratories maintain continual programmes of quality assurance procedures, in addition to participation in international comparisons (Rozanski *et al* 1992; Scott *et al* 1988). These tests indicate no significant offsets and demonstrate the validity of the precision quoted.

The charcoal samples dated at Queen's University Belfast were pretreated following the method outlined in Smith *et al* (1971) and dated by liquid scintillation counting (Smith *et al* 1970). The first formal approaches to quality assurance were being adopted in the late 1970's, including laboratory inter-comparison exercises with published results (Otlet *et al* 1980). Queen's University Belfast were one of the laboratories taking part in this exercise and these tests indicate no significant offsets.

Results

The results, given in Table RC1, conventional radiocarbon ages and percent modern (Stuiver and Polach 1977) are quoted in accordance with the international standard known as the Trondheim convention (Stuiver and Kra 1986).

Calibration

The calibrations of the results, relating the radiocarbon measurements directly to calendar dates, are given in Table RC1 and in outline in Figure RC1. All have been calculated using the calibration curves of Reimer *et al* (2009) and Keuppers *et al* 2004 with the computer program OxCal (v4.1) (Bronk Ramsey 1995; 1998; 2001; 2009). The calibrated date ranges cited in the text are those for 95% confidence. They are quoted in the form recommended by Mook (1986), with the end points rounded outwards to 10 years. The ranges quoted in italics are *posterior density estimates* derived from mathematical modelling of archaeological problems (see below). The ranges in plain type in Table RC1 have been calculated according to the maximum intercept method (Stuiver and Reimer 1986). All other ranges are derived from the probability method (Stuiver and Reimer 1993).

Analysis and Interpretation
A Bayesian approach has been adopted for the interpretation of the chronology from this site (Buck *et al* 1996; Bayliss *et al* 2007). Although the simple calibrated dates are accurate estimates of the dates of the samples, this is usually not what archaeologists really wish to know. It is the dates of the archaeological events, which are represented by those samples, which are of interest. In the case of Drigg, it is the chronology of the burnt mound activity that is under consideration, not the dates of individual samples. The dates of this activity can be estimated not only using the scientific dating information from the radiocarbon measurements, but also by using the stratigraphic relationships between samples.

Fortunately, methodology is now available which allows the combination of these different types of information explicitly, to produce realistic estimates of the dates of 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 v4.1 (http://c14.arch.ox.ac.uk/). Details of the algorithms employed by this program are available from the on-line manual or in Bronk Ramsey (1995; 1998; 2001; 2009). The algorithm used in the model described below can be derived from the structure shown in Figure RC1.

Sequence and samples
The following section concentrates on describing the archaeological evidence which has been incorporated into the chronological model, explaining the reasoning behind the interpretative choices made in producing the model presented. These archaeological decisions fundamentally underpin the choice of statistical model.

The basal sample from the sequence was a 10-20mm thick slice of wood peat containing some small birch twigs from context 17. The measurements on the humic acid and humin fragments from the peat (GU-5888; 3980±50 BP and GU-5889; 4980±50 BP) are not statistically consistent (T'=5.8; ν=1; T'(5%)=3.8; Ward and Wilson 1978). Given we can assume a fairly acidic environment for the peat, thus discounting the possibility of a downwards migration of humic acids, as is often the case in alkaline conditions (Dresser, 1970), the difference in the measurements is perplexing. It is also worth noting that no systematic difference between the fractions is apparent in the other two pairs of results on peat samples from the site. The comparability of 'humic acid' and 'humin' fractions has been observed by Shore *et al* (1995), and so the difference may be an example of the one in twenty cases where the measurement error on the sample does not include its true date.

Directly above the peat [17-1016], but below the burnt stones of the mound, was a concentration of unworked wood [16-1024]. The wood lay on top of a worked timber [16-1023] and is thought to represent some sort of simple structure, perhaps the remnants of a trough or platform. Two samples [16-1024A and 1024B] both identified as *Quercus* sp. and comprising the outer ?10+ rings of pieces of roundwood were dated. The two measurements (GU-5892 and GU-5893) are statistically consistent (T'=0.0; ν=1; T'(5%)=3.8; Ward and Wilson 1978) and both pieces of wood could be of the same actual age.

The next sample in the sequence was a 10mm thick slice of woody peat [16-1011] from directly below the burnt stone layer. The measurements on the humic acid and humin fractions from this sample are statistically consistent (T'=1.6; ν=1; T'(5%)=3.8; Ward and Wilson 1978) and allow a weighted mean of 3899±38 BP to be calculated. Two charcoal samples from context 15 (containing the burnt stones) were dated; [15-1010] contained *Alnus* sp., *Betula* sp., and *Corylus* sp. and [15-1008] contained *Alnus* sp., *Betula* sp. and Pomoideae. Although single entity dating of charcoal samples is usually recommended (Ashmore 1999) it was felt justifiable in this case to "bulk" together the charcoal because it had a direct functional relationship to its context, ie we assumed that it represents fuel from the use of the burnt mound (Crowson and Bayliss, 1999). The two measurements (GU-5884 and GU-5885) are statistically consistent (T'=0.7; ν=1; T'(5%)=3.8; Ward and Wilson 1978) and could therefore be of the same actually age.

The two samples dated at Queen's University Belfast (UB-905 and UB-906) comprised bulk unidentified charcoal from the hearth (equivalent to context 15). Given that the charcoal samples assessed in 2002 contained a significant proportion of oak heartwood (Gale pers comm.) these samples could have a considerable age-at-death offset (Bowman 1990). For this reason the two results provide *termini post quos* for the use of the hearth. The two results (GU UB-905 and UB-906) are not statistically consistent (T'=20.8; ν=1; T'(5%)=3.8; Ward and Wilson 1978) and therefore contain material of different ages.

Two pieces of wood from context 19 were submitted; (1022A) the outer 10 rings of a piece of *Quercus* sp. roundwood, and (1022B) a piece of compressed *Betula* sp. roundwood with bark *in situ*. The two measurements (GU-5894 and GU-5895) are statistically consistent (T'=0.2; ν=1; T'(5%)=3.8; Ward and Wilson 1978) and therefore both samples could be of the same actual age. These samples were initially thought to come from context 16, ie below the burnt stone layer (15), however, following interrogation of the site archive it became apparent that they actually came from context 19, and their relationship to the burnt mound was thus less secure than at first thought. The two samples were, however, recovered in association with a massive plank of wood [19/10202], and appeared to have been placed deliberately, perhaps as a simple walkway across boggy ground. The plank itself was too large to be removed during the excavation, although subsequent erosion of the cliff face at Drigg has resulted in its removal and dendrochronological analysis (Groves, pers comm). The sample did not match any reference chronologies and therefore cannot be dated.

The humic acid and humin fractions (GU-5886 and GU-5887) from a 10mm slice of dark firm browny-black clayey peat directly overlying the burnt mound [14-1007] are statistically consistent (T'=0.7; ν=1; T'(5%)=3.8; Ward and Wilson 1978) and provide a weighted mean of 3770±35 BP. The last sample from the sequence, a piece of Salicaceae wood, also came from context 14 but was stratigraphically above the peat sample. It came from one of several concentrations of unmodified wood in the context, none of which was conclusively identified as being anthropogenic in origin, thus it is possible that the wood is redeposited.

The Model

In the model shown in Fig RC1 we have chosen to use the measurement made on the humic fraction of peat sample 17 (1016). This is because the humin fraction (GU-5889) would seem to represent reworked material inwashed when the basal peat formed, and thus the humic fraction (GU-5888) is more likely to represent the date when the peat first formed. The model shows good agreement between the stratigraphy and radiocarbon dates (Amodel=90%) and provides an estimate for the start of peat initiation on the site of *4315-3655 cal BC (95% probability, Boundary_start;* Fig RC1*).* The best estimate for the use of the burnt mound is *2430-2210 cal BC* (*95% probability*; *Last burnt mound*; Fig. RC2) and probably *2380-2290 cal BC* (*68% probability*). The activity associated with the burnt mound is constrained by the peat layers [16] and (14) below and above it and must therefore have lasted for a maximum of *90-325 years* (*95% probability*) or *155-280 years* (*68% probability*).

The 'structure' from context 16 dates to the later part of the fourth/beginning of the third millennium cal BC and is clearly much older than the burnt mound activity, although the wooden walkway (context 19) probably just pre-dates this activity.

Conclusions

The dating programme has been successful in meeting all of the objectives outlined above, and in particular providing a precise estimate for the date of the burnt mound - *2380-2290 cal BC* (*68% probability*). The relatively short lived nature of the activity associated with the burnt mound is consistent with other recently dated examples, eg Burlescombe, Devon (Best and Gent 2008); Northwold, Norfolk (Crowson and Bayliss 1999); and Willington, Derbyshire (Beamish 2009). The results also highlight the general Bronze Age currency of burnt mounds in mainland Britain (Bradley 2007).

References

Ashmore, P, 1999 Radiocarbon dating: avoiding errors by avoiding mixed samples, *Antiquity*, **73**, 124–30

Bayliss, A, Bronk Ramsey, C, van der Plicht, J, and Whittle, A, 2007 Bradshaw and Bayes: towards a timetable for the Neolithic, *Cambridge Journal of Archaeology* **17.1**, supplement, 1–28

Beamish, M G, 2009 Island visits: Neolithic and Bronze Age activity on the Trent Valley Floor, Excavations at Egginton and Willington, Derbyshire, 1998-1999, *Derbyshire Archaeological Journal*, **129**, 17–172

Best, J, and Gent, T, 2008 Bronze Age burnt mounds and early medieval timber structures at Town Farm Quarry, Burlescombe, Devon, *The Archaeological Journal*, **164**, 1–79

Bowman, S, 1990 *Radiocarbon Dating*, British Museum Press, London

Bradley, R, 2007 *The Prehistory of Britain and Ireland*, Cambridge University Press

Bronk Ramsey, C, 1995 Radiocarbon calibration and analysis of stratigraphy, *Radiocarbon*, **36**, 425–30

Bronk Ramsey, C, 1998 Probability and dating, *Radiocarbon*, **40**, 461–74

Bronk Ramsey, C, 2001 Development of the radiocarbon calibration program OxCal, *Radiocarbon*, **43**, 355–63

Bronk Ramsey, C, 2009 Bayesian analysis of radiocarbon dates, *Radiocarbon*, **51,** 337–360

Buck, C E, Cavanagh, W G, and Litton, C D, 1996 *Bayesian Approach to Interpreting Archaeological Data*, Chichester

Crowson, A, and Bayliss, A, 1999 Dating a burnt mound and its beakers at Northwold, Norfolk, in *Actes du 3eme congres international <<Archaeologie et 14C>>* Lyon, 6-10 Avril 1998 (eds J Evin, C Oberlin, J P Daugas, and J F Salles), Revue d'Archeometrie Suppl 1999 et Soc Prehist Fr Memoire, **26**, 243–8

Donahue, D J, Beck, J W, Biddulph, D, Burr, G S, Courtney, C, Damon, P E, Hatherway, A L, Hewitt, L, Jull, A J, Lange, T, Lifton, N, Maddock, R, McHargue, L R, O'Malley, J M, and Toolin, L J, 1977 Status of the NSF-Arizona AMS Laboratory, *Nuclear Instruments and Methods in Physics B*, **123**, 51–6

Dresser, Q, 1970, *A study of sampling and pretreatment of materials for radiocarbon dating*, unpubl PhD thesis, Queens Univ Belfast

Howard, A J, Gearey, B R, Fletcher, W, Hill, T, and Marshall, P, 2009 Radiocarbon dating, alluvial chronologies and the reconstruction of palaeoenvironmental events:

the validity of single date correlations, *Journal of Archaeological Science* **36**, 2680–2688

Kueppers, L M, Southon, J, Baer, P, and Harte, J, 2004 Dead wood biomass and turnover time, measured by radiocarbon, along a subalpine elevation gradient. *Oecologia*, **141**, 641–651.

Mook, W G, 1986 Business meeting: Recommendations/Resolutions adopted by the Twelfth International Radiocarbon Conference, *Radiocarbon*, **28**, 799

Noakes, J E, Kim, S M, and Stipp, J J, 1965 Chemical and counting advances in Liquid Scintillation Age dating, in *Proceedings of the Sixth International Conference on Radiocarbon and Tritium Dating* (eds E A Olsson and R M Chatters), 68–92, Washington D C

Otlet, R L, Walker, A J, Hewson, A D, and Burleigh, R, 1980 14C interlaboratory comparison in the UK: experiment design, preparation, and preliminary results, *Radiocarbon*, **22**, 936–46

Pearson, GW, 1979 Belfast radiocarbon dates IX, *Radiocarbon*, **21**, 274–90

Reimer, P J, Baillie, M G L, Bard, E, Bayliss, A, Beck, J W, Blackwell, P G, Bronk Ramsey, C, Buck, C E, Burr, G, Edwards, R L, Friedrich, M, Grootes, P M, Guilderson, T P, Hajdas, I, Heaton, T J, Hogg, A G, Hughen, K A, Kaiser, K F, Kromer, B, McCormac, F G, Manning, S W, Reimer, R W, Richards, D A, Southon, J R, Talamo, S, Turney, C S M, van der Plicht, J, and Weyhenmeyer, C E, 2009 IntCal09 and Marine09 radiocarbon age calibration curves, 0–50,000 years cal BP *Radiocarbon*, **51**, 1111–1150

Rozanski, K, Stichler, W, Gonfiantini, R, Scott, E M, Beukens, R P, Kromer, B, and van der Plicht, J, 1992 The IAEA ^{14}C intercomparison exercise 1990, *Radiocarbon*, **34**, 506–19

Scott, E M, Harkness, D D and Cook, G T, 1998 Inter-laboratory comparisons: lessons learned, *Radiocarbon*, **40**, 331–40

Shore, J S, Bartley, D D, Harkness, D D, 1995 Problems encountered with the ^{14}C dating of peat, *Quaternary Science Reviews*, **14**, 373–383

Slota, P J Jnr, Jull, A T J, Linick, T W, and Toolin, L J, 1987 Preparation of small samples for ^{14}C accelrator targets by catalytic reduction of CO_2 *Radiocarbon*, **29**, 303–6

Smith, A G, Pearson, G W, and Pilcher, J R, 1970 Belfast radiocarbon dates I, *Radiocarbon*, **13**, 285–290

Smith, A G, Pearson, G W, and Pilcher, J R, 1971 Belfast radiocarbon dates III, *Radiocarbon*, **12**, 103–125

Stenhouse, M J, and Baxter, M S, 1983 ^{14}C dating reproducibility: evidence from routine dating of archaeological samples, *PACT*, **8**, 147–61

Stuiver, M, and Kra, R S, 1986 Editorial comment, *Radiocarbon*, **28(2B)**, ii

Stuiver, M, and Polach, H A, 1977 Reporting of ^{14}C data, *Radiocarbon*, **19**, 355–63

Stuiver, M, and Reimer, P J, 1986 A computer program for radiocarbon age calculation, *Radiocarbon*, **28**, 1022–30

Stuiver, M, and Reimer, P J, 1993 Extended ^{14}C data base and revised CALIB 3.0 ^{14}C age calibration program, *Radiocarbon*, **35**, 215–30

Ward, G K, and Wilson, S R, 1978 Procedures for comparing and combining radiocarbon age determinations: a critique, *Archaeometry*, **20**, 19–31

Table RC1: Radiocarbon results

Lab No	**Sample Ref**	**Material**	**% modern**	**Radiocarbon Age (BP)**	**δ^{13}C (‰)**	**Weighted Mean**	**Calibrated date range (95 confidence)**	***Posterior density estimate (at 95% probability)***
AA-43497		Groundwater DIC	114.2±0.6		-23.1		cal AD 1989-1995	-
AA-43498		Groundwater DOC	119.6±0.5		-30.3		cal AD 1984-1991	-
GU-5884	[15] (1008)	Charcoal: *Alnus* sp. (8g), *Betula* sp. (4g) and Pomoideae (3g) (R Gale)		3900±50	-26.2		2570-2200 cal BC	*2460-2225 cal BC*
GU-5885	15 (1010)	Charcoal: *Alnus* sp. *(8g)* *Betula* sp. (6g) and *Corylus* sp. (1g) (R Gale)		3960±50	-26.9		2580-2290 cal BC	*2470-2285 cal BC*
GU-5886	14 (1007)	Peat: humic acid		3800±50	-29.0	3770±35 BP (T'=0.7; ν=1; T'(5%)=3.8)	2300-2040 cal BC	*2295-2135 cal BC*
GU-5887	14 (1007)	Peat: humin		3740±50	-29.8			
GU-5888	17 (1016)	Peat: humic acid		4980±50	-28.7		3950-3650 cal BC	*3930-3870 (6%) or 3820-3645 (89%) cal BC*
GU-5889	17 (1016)	Peat: humin		5150±50	-28.8		4050-3800 cal BC	*4050-3795 cal BC*

GU-5890	16 (1011)	Peat: humic acid		3940±50	-28.9	3899±38 BP (T'=1.6; ν =1; T'(5%)=3.8;)	2480-2210 cal BC	*2490-2345 cal BC*
GU-5891	16 (1011)	Peat: humin		3840±60	-29.3			
GU-5892	16 (1024A)	Wood: *Quercus* sp. roundwood		4410±50	-25.9		3340-2900 cal BC	*3330-3215 (19%) or 3185-3155 (3%) or 3130-2905 (73%) cal BC*
GU-5893	16 (1024B)	Wood: *Quercus* sp. roundwood, outer ?10 rings (R Gale)		4420±60	-26.0		3350-2900 cal BC	*3340-3210 (25%) or 3195-2910 (70%) cal BC*
GU-5894	19 (1022A)	Wood: *Betula* sp. narrow roundwood (diameter 25mm), *c* 5 growth rings (R Gale)		3990±70	-28.0		2840-2290 cal BC	*2855-2810 (4%) or 2750-2725 (1) or 2700-2290 (90%) cal BC*
GU-5895	19 (1022B)	Wood: *Betula* sp. compressed roundwood (70 x 30mm), bark *in situ* (R Gale)		4030±60	-28.1		2860-2450 cal BC	*2865-2805 (8%) or 2760-2450 (85%) or 2420-2405 (1%) or 2380-2350 (1%) cal BC*
GU-	14 (1021)	Wood:		3790±50	-		2460-2030 cal	*2275-2115 (81%)*

5896		Salicaceae (R Gale)			28.0		BC	*or 2200-2040 (14%) cal BC*
UB-905	Drigg heath A	Charcoal, unidentified		3780±55	- 24.9		2460-2030 cal BC	*2460-2170 cal BC*
UB-906	Drigg heath A	Charcoal, unidentified		4135±55	- 24.9		2890-2490 cal BC	*2885-2570 cal BC*

Figure RC1 Probability distributions of dates from Drigg burnt mound. Each distribution represents the relative probability that an event occurred at a particular time. For each of the radiocarbon dates 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 used. The large square brackets down the left hand side along with the OxCal keywords define the overall model exactly.

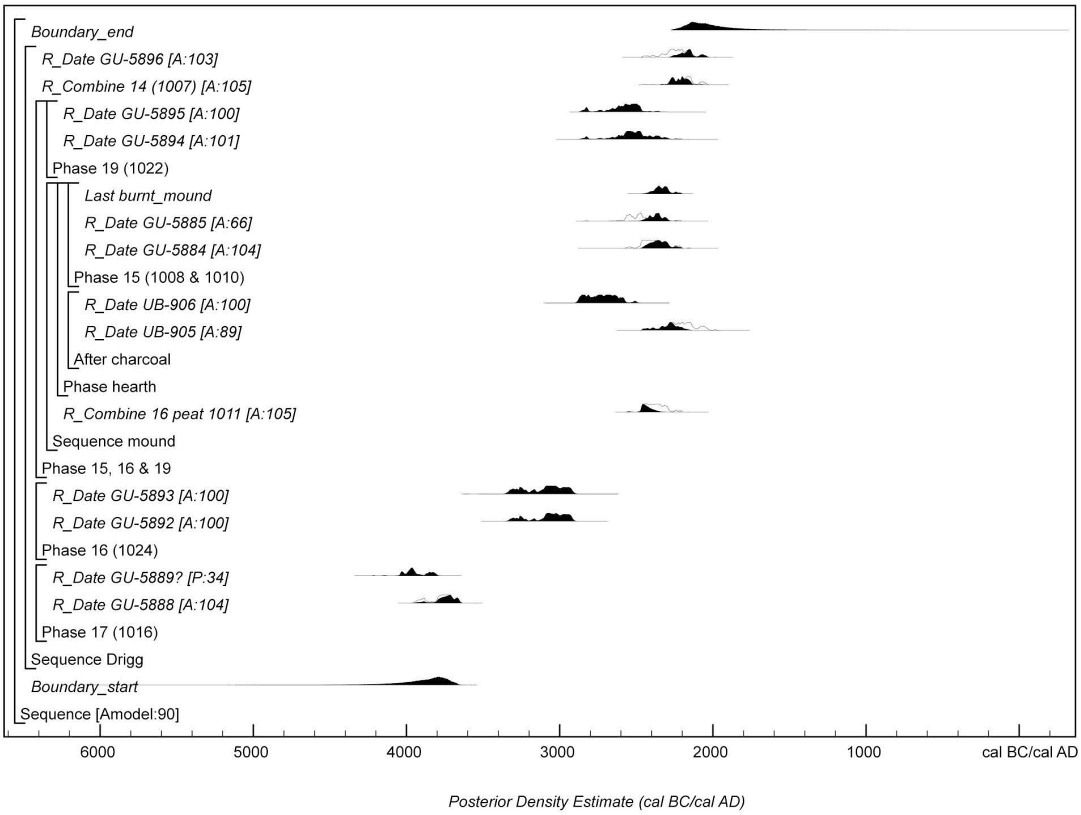

Figure RC2: Probability distributions of selected dates from Drigg burnt mound. Each distribution represents the relative probability that an event occurred at a particular time. For each of the radiocarbon dates two distributions have been plotted, one in outline, which is the result of simple radiocarbon calibration, and a solid one, which is based on the chronological model used. The large square brackets down the left hand side along with the OxCal keywords define the overall model exactly. The extract is taken from the model shown in Figure RC1