CHAPTER 7

THE POTENTIAL OF THE SECONDARY CONTEXT ARCHAEOLOGICAL RESOURCE

1. INTRODUCTION

The previous chapters assessed the temporal (Chapters 2, 3 & 6) and spatial (Chapters 4, 5 & 6) structure of the secondary context archaeological resource recovered from fluvial sedimentary sequences. These assessments correlated extant research (Chapters 2, 5 & 6) and reported new case study investigations (Chapters 3, 4 & 5). These assessments provide the platform from which the fundamental theme of this research project can be explored: what is the potential of the secondary context archaeological resource for the reconstruction of human/hominid behaviour during the early prehistoric periods (primarily the Lower, Middle and Upper Palaeolithic)?

Sections 2 and 3 address the spatial and temporal structures of the secondary context archaeological resource, with particular reference to the formation of artefact assemblages and their spatial and geochronological resolution. Building upon these models, Section 4 establishes analytical frameworks applicable to the secondary context archaeological resource and identifies the different spatio-temporal analytical scales that can be explored through these data. Section 5 maps these frameworks and analytical scales against extant archaeological research questions, and where relevant, tests whether these questions can be re-examined from alternative spatio-temporal perspectives. Finally, the potential and value of the secondary context archaeological resource is proposed (Section 6).

Specifically, the chapter explores four themes:

- The geo-chronological resolution of the archaeological resource and the relative importance of sedimentary, artefactual and palaeoenvironmental data.
- The spatial resolution of the archaeological resource, the relative importance of sedimentary and artefactual data, and the role of experimental archaeology and modern analogues.
- The analytical frameworks associated with the secondary context archaeological research, and their applicability to extant research questions and the varying spatio-temporal scales of hominid behaviour.
- The value of the secondary context archaeological resource, with specific reference to the range of available data and their spatio-temporal scales, their relevance to current research themes, and the current state of geoarchaeological methodologies.

2. PALIMPSESTS IN TIME

The geochronological resolution of the secondary context archaeological resource is concerned both with the fluvial activity that deposited a specific sedimentary unit (e.g. gravel or sand unit), and with the chronological catchment of the archaeological material. In other words, for how long were the recovered artefacts accumulating in the landscape prior to their incorporation with the fluvial sediments? This is clearly a multi-faceted problem, and the approach proposed here for its resolution incorporates geomorphological models, sedimentary data, artefactual material and palaeoenvironmental fossil evidence.

2.1 Fluvial activity across the glacial/interglacial cycle

The initial review of extant geomorphological models (Chapter 1) highlighted four issues of critical relevance to an assessment of the secondary context archaeological resource:

- A significant proportion of the fluvial activity that occurred during the Middle and Late Pleistocene is not preserved within the sedimentary record, due to subsequent, high energy erosional processes (e.g. Gibbard & Lewin 2002). This is especially applicable to the fine-grained sediments deposited under interglacial climatic regimes, but is also relevant with respect to the small-scale sedimentary features (both fine- and coarse-grained) that were formed in response to the high frequency, low magnitude climatic oscillations occurring within individual MI stages (see below).
- The majority of preserved fluvial activity occurs in association with the major glacial/interglacial climatic transitions of the Middle and Late Pleistocene). This reflects both the climatic instability of these phases (e.g. Bridgland 2000; Maddy *et al.* 2001; Vandenberghe 1995), and the high magnitude of these climatic oscillations, which results in the critical response thresholds of the majority of fluvial systems being exceeded and the formation of large-scale sedimentary features.
- River system response to the lower magnitude climatic oscillations (e.g. associated with stadial and interstadial events occurring *within* glacial phases) are variable, depending upon the specific threshold conditions of individual systems (Vandenberghe 2002). Moreover, the sedimentary units and erosional structures resulting from these episodes are typically vulnerable to subsequent erosion during the major transitional climatic phases (see above).
- River system responses to specific climatic change vary markedly between different rivers and between different zones (e.g. upland, lowland) of the same system (Howard & Macklin 1999).

Despite the availability of high resolution ice-core records of climate change (e.g. Anklin *et al.* 1993; Petit *et al.* 1999), it is clear that it is not possible to map the fluvial sedimentary archive against these climatic records, due to the discontinuous nature of the sedimentary record. Moreover, it is clear from optically stimulated luminescence dating of fluvial sediments (e.g. Chapter 3; Rhodes 2003), that it is not currently possible to develop high resolution sub-marine isotope stage (MIS) geochronologies for individual sedimentary episodes from the Middle Pleistocene.

Establishment of the geochronological resolution for archaeological secondary context sediments was therefore dependent upon Lateglacial and Lateglacial/Holocene transition models of fluvial systems, where high resolution radiocarbon chronologies could be established. Evidence from a wide range of studies suggested that the maximum time-spans associated with fluvial sedimentation activity (the deposition of individual units), incision and erosion were of a magnitude of 10^2 or 10^3 years (i.e. a few hundred or at most a few thousand years). It is also stressed that these estimates do not assume continuous activity, but rather represent the current limitations of geochronological dating techniques and the problems of correlating climatic and fluvial evolution. For example, Rose *et al.* (1980: Table 12.1) estimated that the erosion of discontinuous gully channels on the River Gipping at Sproughton, Suffolk occurred between 11,300 and 11,000 years BP, while braided and meandering river sedimentation of sands and gravels occurred between 11,000 and 9,500 years BP (based on radiocarbon dates and ages inferred from a coleopteran assemblage). The key point is that these erosion and sedimentation events cannot be demonstrated to have occurred continuously. Indeed it is highly probable that incision and sedimentation only occurred episodically in response to high-energy discharge events (e.g. annual, nival-floods). However, current geochronological tools cannot provide finer-resolution dating, so the 300 and 1,500 year time-spans represent the highest achievable geochronological resolution with respect to the incision and aggradation events. In effect, these time intervals represent periods during which incision (11,300–11,000 years BP) and sedimentation (11,000–9,500 years BP) were the dominant fluvial processes.

In the case of Middle Pleistocene sequences, high resolution geochronological dating is currently unattainable, but the chronologies from Lateglacial/Holocene sequences suggest minimum chronological units (MCU's) of 10^2 and 10^3 years in magnitude, with respect to fluvial incision and sedimentation events. It is stressed that these MCU's relate to the preserved fragment of the fluvial sedimentary record, which is proposed here to *probably* date to the major glacial/interglacial transitions of the Middle and Late Pleistocene. Palaeoenvironmental and biological data can also play a role in the establishment of Middle Pleistocene geochronological frameworks, although the value of these data tends to be inversely proportional to the species' palaeoclimatic and palaeoenvironmental sensitivity, and proportional to their preservation potential. For example, while non-marine molluscan (e.g. Preece 2001; Keen 2001) and coleopteran (e.g. Coope 2001) assemblages tend to be indicative of highly specific environmental conditions and probably document very short time-spans (e.g. 10^1, 10^2 years), they are typically primarily associated with organic, fine-grained deposits. Such deposits have low preservation potential (they are commonly eroded and replaced with coarse-grained sediments). Moreover, estimating time-spans on the basis of vertical changes in species composition (taken as an indicator of changing environmental conditions) is extremely difficult. Prior to the Holocene for example, the pollen zones of the Quaternary interglacials still do not boast an absolute chronology. Finally, even where biological data encases sedimentary terrace unit(s) (e.g. pollen-bearing clay deposits at the top and bottom of a sand/gravel sequence), the presence of erosive contacts within the sequence would add the considerable problem of undated depositional hiatuses to any proposed chronology.

By contrast, large mammal faunas occur within coarse-grained deposits (e.g. gravels and sands, although they are commonly derived and reworked (see below)), and while these species are not sensitive indicators of specific environmental conditions, variations in species' associations have been demonstrated to equate with interglacial sub-stage climatic variability (Schreve 2001a). Unfortunately, such variations have yet to be demonstrated for glacial sub-stages, but this application of biological data is currently the most important with respect to geochronological frameworks.

Overall therefore, the geochronological resolution of the fluvial sedimentary sequences (containing the secondary context archaeology) is modelled on the basis of:

1. Models of terrace formation and fluvial activity, which suggest that the majority of the fluvial activity preserved within the sedimentary record occurred during major glacial/interglacial transitions.
2. Analogies with radiocarbon dated Lateglacial sequences, which suggest minimum chronological units of 10^2 and 10^3 years in magnitude.
3. A semi-floating geochronological framework: individual fluvial events are not absolutely dated, but sedimentary sequences can be dated at a marine isotope stage level of resolution through relevant dating techniques (optically stimulated luminescence and amino-acid ratio) and Bridgland's (2001) cyclical model of terrace formation.

However, it has long been recognised that artefacts occurring within fluvial secondary contexts may be considerably older than their encasing deposits (e.g. Wymer 1968, 1999). This research has sought to highlight the considerable potential variation in the magnitude of the chronological catchment associated with derived artefact assemblages. These variations reflect a combination of factors including:

- The river zone, reflecting the differential geomorphological behaviour and preservation potential of fluvial systems in their upland and lowland stretches (e.g. Howard & Macklin 1999).
- Regional and local geomorphological factors (e.g. bedrock type, valley form) which can impact upon the degree of sediment re-working.
- Local depositional factors (e.g. the depositional location of the artefact assemblage) which can impact upon the tendency of the material to undergo subsequent re-working.
- The chronological location of the sediment within the glacial/interglacial cycle, which can impact upon the vulnerability of the deposit to subsequent reworking.

All of these themes are considered further below, with particular focus upon the development of a provisional model for the incorporation of archaeological material within fluvial deposits over geological time.

2.2 The river zone

It is clear that river systems will behave differently in their various zones or stretches (Chapter 2), and that generic models of temporal fluvial activity (e.g. across an interglacial/glacial cycle) greatly oversimplify this complexity (see Howard & Macklin 1999 for further discussion of this issue). Although some research specifically identifies the fluvial systems that are being modelled (e.g. Gibbard & Lewin (2002) highlight interglacial fluvial sedimentation in the lowland Britain zone; while Bridgland (2000) is concerned with temperate latitude valley systems beyond the reach of the Pleistocene ice sheets), in many cases the focus of the models is not specifically stated. However, since the model of fluvial activity proposed here (Chapter 2) is grounded in the extant research of Vandenberghe (1993, 1995, 2002, 2003), Bridgland (1994, 1995, 1996, 1998, 2000, 2001), Maddy *et al.* (2001) and Gibbard & Lewin (2002), the river system zones investigated by those authors are identified as base-line types against which to examine variability in river behaviour (e.g. between the upland and lowland zones). As noted above, Gibbard & Lewin's (2002) model of interglacial fluvial sedimentation was developed by lowland British rivers, while Maddy *et al.* (2001) and Bridgland's (2000) models of terrace development were based primarily on the Thames Valley, also a lowland British river. The source data of the Vandenberghe (1993, 1995, 2002, 2003) models is less clear, but his inclusion of case studies from the Dinkel and Reusel valleys in the Netherlands (Vandenberghe 1993, 1995), and the Maas, Belgium/the Netherlands (Vandenberghe 1995, 2002); the Somme, France; the Scheldt, Belgium, and the Thames, England (Vandenberghe 2002) suggests that his models are again primarily based upon lowland river system data.

Following the terminology and classifications of Howard & Macklin (1999), this would suggest that our model of fluvial activity (Chapter 2 & Sections 2.5, this chapter) is primarily relevant to lowland and perimarine river systems. Howard & Macklin (1999) therefore highlight five factors of relevance to the magnitude of the chronological catchment and the potential re-working of archaeological material within different zones of a river system, during the Pleistocene:

- Within the upland systems, long-term terrace preservation can be prohibited, especially in narrow valleys.
- Within the upland systems, high magnitude flooding is capable of flushing the sedimentary fills from the valleys.
- Within the upland and piedmont systems, incision will result in the re-working of archaeological materials.
- Within the piedmont systems, wider valley floors can allow for the long-term preservation of terrace units.
- Within the lowland and perimarine zones, the river system stability and dominance of vertical accretion can result in the burial and preservation of archaeological materials.

It is of course difficult, if not impossible, to accurately quantify the impacts of these factors upon the chronological catchments of derived archaeological materials. However, on a qualitative scale it is apparent that the degree of re-working and the magnitude of the chronological catchment are likely to increase from the perimarine/lowland zones to the upland zone. This increase can be characterised both in terms of the proportion of archaeological materials that are re-worked, and in the duration of the chronological catchment. In the former case for example, if *n* artefacts are incorporated into narrow valley, upland river systems, then the majority of those artefacts are likely to be subject to intensive reworking through channel incision and the erosion of floodplain and low level terrace sediments (Figure 230). By contrast, if *n* artefacts are incorporated into a wide valley, lowland river systems, then there is a much greater probability for the majority of those artefacts to avoid re-working and be retained within the floodplain sediments which subsequently evolve into middle and high level terrace sediments (this is also dependent on their position across the floodplain — Section 2.4 below). In terms of the chronological catchment duration, the frequent absence of long-term terrace sequences in the upland zone increases the potential for chronological catchments dating over 100,000's of years, as artefacts are repeatedly vertically re-worked from one unpreserved floodplain to the next through incision and flooding. By contrast, where long-term terrace sequences are able to develop (e.g. as in the lowland Thames valley), the potential for repeated vertical re-working and chronological catchments spanning 100,000's years is greatly reduced (Figure 230). Moreover, the extensive vertical accretion in the lowland and perimarine zones (as a result of fine-grained flooding events, especially during the interglacial phases) increases the potential for the burial and long-term preservation of locally derived material upon the floodplain. These interpretations can, and should, be tested against field and artefact data, specifically the evidence for the presence/absence of preserved terrace landforms and sediments in different river zones, and the physical condition of the recovered artefacts which offer a relative indicator of the degree of re-working to which they have been subjected.

Finally, it is stressed that the considerable sea-level fluctuations of the Pleistocene and the impacts of glaciation will have potentially influenced the geographical distribution of the different river zones at different time periods during the Quaternary. This change is more difficult to document for the upland and piedmont zones, since the impacts of glacial erosion and glacio-isostasy upon physiography and basin relief, and the extensive erosion of upland sediments, severely complicate the identification of channel gradients and valley slope morphologies (Howard & Macklin 1999). In the lowland zones, river status would vary between lowland and perimarine types in response to sea-level rise and fall. The preservation of fine-grained perimarine (e.g. estuarine) sediments would clearly vary between the modern on-shore and off-shore zones. In the off-shore zones for example, sediments deposited during low-sea level stands would be extremely vulnerable to both fluvial erosion (e.g. during the next low-stand event) and to the fluctuating marine transgressions and regressions of the Pleistocene. In the on-shore zones, the sediments would be especially vulnerable to fluvial erosion, although isostatic uplift should reduce the potential threat from subsequent marine transgressions and regressions. In general however, since the major contrast in fluvial behaviour is between the upland/piedmont and lowland/perimarine zones, the impacts of sea-level change and glacial activity are not as dramatic as they could, although these processes should still be born in mind, especially when dealing with river systems in the north of England.

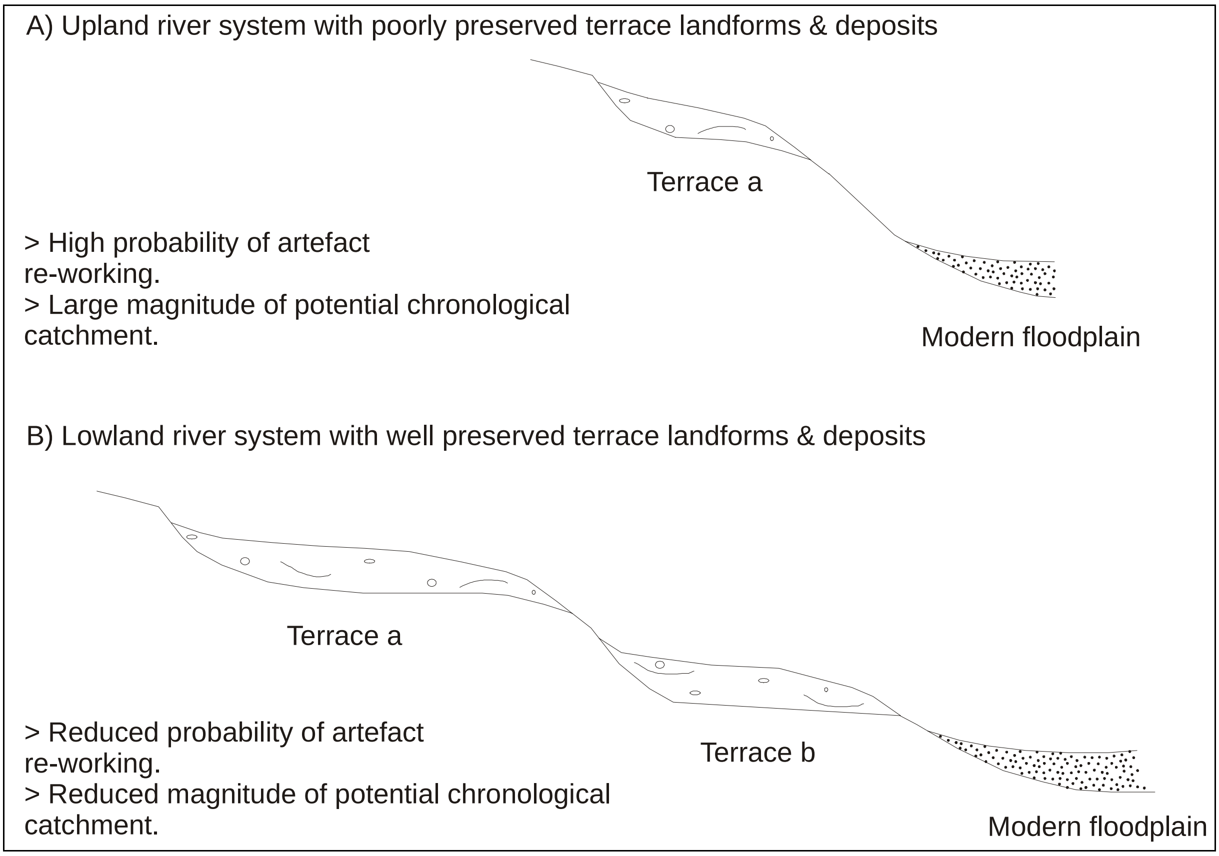

Figure 230: reworking models for upland and lowland zone rivers

2.3 Regional/local geomorphological factors

In many respects this theme explores similar issues to those outlined above. Of principle concern is the impact of regional and local geology upon fluvial behaviour. This was highlighted by Bridgland (1985) with respect to the terrace preservation associated with the rivers of the London Basin, and by Allen & Gibbard (1993) with respect to the rivers of the Solent Basin. Bridgland (1985: 31) observed that different patterns of terrace preservation could be related to the bedrock type, with major staircase sequences of terrace aggradations confined to areas of clayey bedrock. By contrast, sandy bedrock tended to be associated with the sporadic, but equal preservation of terraces on both sides of the valley, while terraces were largely absent in areas of chalk bedrock. In the Solent River basin, Allen & Gibbard (1993: 520–521) noted that the major staircase sequences of the Solent River (although only preserved on the northern valley side) were associated with Tertiary sands and clays, while the chalk bedrock on the fringes of the basin was associated with limited terrace preservation and narrow, steep valleys.

These patterns have highlighted the importance of bedrock type in influencing the pattern of terrace preservation. Bridgland has suggested that this reflects both the relative resistance to erosion of the bedrock type (this appears to be particularly important in the case of chalk) and the permeability of the bedrock:

- Relative resistance: rivers flowing over clay bedrock appear to move off their most recently deposited sands and gravels, and erode into the bedrock on the opposite valley side during downcutting phases. This process effects lateral migration of the river. By contrast, rivers flowing on chalk appear to remain entrenched in one position. When downcutting occurs these rivers cut into their own valley floor deposits rather than the bedrock. Lateral migration does not therefore occur.
- Permeability: Bridgland (1985: 29–30) also noted contrasting patterns of terrace preservation between areas of Tertiary clay (terrace staircases on one side of the valley) and unconsolidated sands (sporadic terraces on both sides of the valley). It has been argued that highly permeable sedimentary rocks (e.g. unconsolidated sands and gravels) can be surprisingly resistant to erosion because their permeability inhibits surface run-off. After initial unidirectional migration (e.g. to the south), clay-bedrock rivers are largely prevented from re-migrating north by the presence and resistance of permeable terrace sands and gravels, overlying the softer clays on that side of the valley. (It should also be noted that even when incision takes the channel below the level of the terrace deposits, the clay bedrock 'bluff' at the terrace edge is likely to be rapidly covered by slumped and soliflucted sands and gravels, which will continued to impede erosion of the northern valley side.) The river therefore tends to always migrate in same direction (e.g. southwards in this example), producing extensive terrace staircases on one side of the valley. In the case of sandy-bedrock rivers, there is little difference between the bedrock and the aggraded materials, so fluvial migration is bi-directional and terrace preservation occurs on both sides of the valley (Figure 231).

Overall, these patterns indicate that even within a particular river zone (e.g. the lowland zone of the Thames Basin), terrace preservation can vary markedly, ranging from terrace staircases to terrace-free gorges. It is also clear that the potential for re-working of archaeological materials will increase and decrease in response to these variations in terrace preservation. In other words, material recovered from low-level terraces within chalk-bedrock areas has the potential to have been heavily re-worked over multiple terrace-forming (and eroding) episodes, while materials recovered from low-level terraces at the base of long sequences are less likely to have been re-worked from top to bottom. However, the impact of this re-working upon the chronological catchments of the artefacts will also be partially influenced by the homogeneity or heterogeneity of the regional bedrock. For example, if a zone of chalk bedrock is relatively restricted (as are those underlying the Darent and Medway valleys in north Kent), then derived artefacts may be reworked downstream (due to floodplain sediment erosion and lack of terrace preservation) through the chalk bedrock gorge and re-deposited within the floodplain (preserved terrace sediments to be) over a relatively short time period. Under such circumstances, the chronological catchment would not necessarily be of a particularly large magnitude. By contrast, if the zone of chalk bedrock was relatively widespread (as is that underlying the upper part of the Test valley in north Hampshire), then derived artefacts might only be re-worked downstream (into sand/clay bedrock terrace sequences) over much longer time-spans. In these conditions, the chronological catchment might be of a considerably longer duration. Clearly these factors are important for the interpretation of derived artefact assemblages, and the concepts highlighted here should always be tested where possible against field and artefact data.

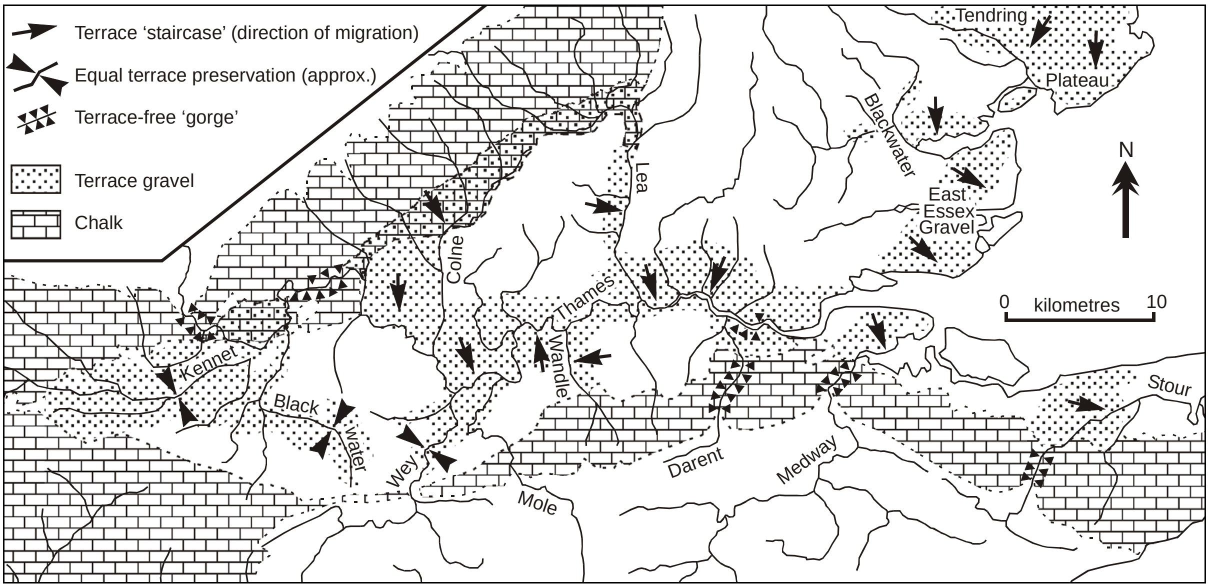

Figure 231: variable Pleistocene terrace preservation in southern English river systems (Bridgland 1985: Figure 1)

2.4 Local depositional factors

It is also stressed that the two-dimensional position of re-worked artefacts within a terrace unit can be significant with respect to the degree of potential re-working and the chronological catchment. For example, artefacts recovered from the margins of a former floodplain may be less likely to have been extensively re-worked than materials located nearer the middle of the former floodplain. This could reflect the courses adopted by the floodplain channel(s) or might also be a consequence of burial of the archaeology by slumping or the solifluction of slope deposits. However, it is currently difficult to assess this issue since it requires identification of the floodplain's extents and the contemporary valley slopes, the location of palaeochannels, and detailed information regarding the provenance of the artefacts (such information is often missing for older collections). Moreover, in many cases, the relevant sedimentary information is also unavailable due to limited preservation or, in the case of extant assemblages, quarrying away of the relevant sediments. Finally, it is noted that Gibbard & Lewin (2002) have suggested that floodplain re-working occurs rapidly under cold-climate regimes, suggesting that this factor may have been less significant over the long time-scales of the Pleistocene. Overall therefore, the issue of local variations in depositional environments (e.g. floodplain margins compared to channel margins) is acknowledged, and should be considered in those situations where the ancient floodplain environment can be adequately reconstructed.

2.5 Glacial/interglacial cycle

Of particular importance is the progression of fluvial behaviour over a glacial/interglacial cycle, following the model proposed here (Chapter 2) and Bridgland (1994, 1995, 1996, 1998, 2000, 2001), Maddy *et al.* (2001), Gibbard & Lewin (2002), and Vandenberghe (1993, 1995, 2002, 2003). It is proposed that the potential chronological catchment of a derived artefact assemblage will vary in magnitude, depending upon its chronological position within the interglacial cycle. For example, artefacts and sediments deposited immediately after the incision and cutting of a new floodplain are more likely to have been derived from the floodplain sediments of the higher terrace level, through which the river has recently incised. By contrast, artefacts and sediments deposited during the latest aggradation phases of a glacial/interglacial transition are more likely to have been reworked from the contemporary floodplain. The time-depths of these different chronological catchment can currently only be broadly estimated and differentiated in terms of temporal magnitudes (e.g. 10^2 compared to 10^5 years), reflecting the present lack of geochronological precision and the nature of the available data. Finally, it is emphasised that this classification deals in probabilities rather than absolutes, and is primarily intended as a heuristic device, and one that should ideally be further tested through field evidence and sediment modelling:

2.5.1 Phase 1A: the early glacial/interglacial transition (Figure 232A)

The river has recently incised a new floodplain surface, involving the reworking of considerable quantities of sediment from the older, higher floodplain (whose remaining sediments are now terrace deposits). Initial coarse-grained (gravel and sand) sedimentation across the braidplain during the aggradation phase is therefore likely to consist of materials (sediments and potentially archaeology) re-worked and sub-aerially eroded from the recently abandoned terrace level. Artefacts from the basal levels of the sediments, near the floodplain surface, are assumed to date to the earliest, initial phases of aggradation on stratigraphic grounds. They are therefore assigned a chronological catchment of 10^4 (10,000) and 10^5 (100,000) years, since they potentially date to a wide timespan covering the previous glacial/interglacial cycle. This chronological catchment should also be tested (where possible) against assessments of the physical condition of the artefacts (see Chapter 4–5 with respect to the physical transformation of lithic artefacts during fluvial transportation episodes). It is recognised that the stratigraphic interpretation described above should be confirmed where possible by field observations. For example, traces of subsequent erosive cut and fill activity removing earlier sediments would restrict the applicability of the stratigraphic model presented above.

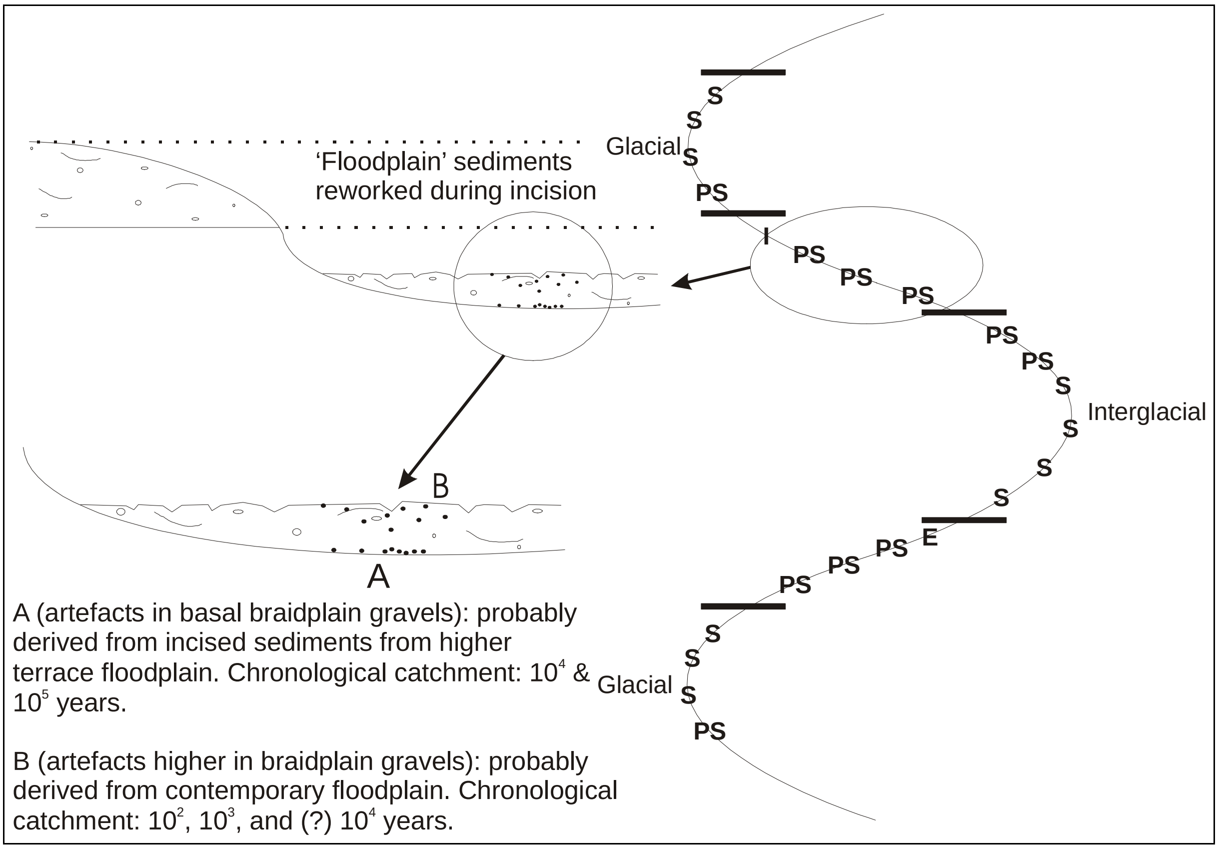

Figure 232: model of artefact reworking during the glacial/interglacial transition phase

2.5.2 Phase 1B: the later glacial/interglacial transition (Figure 232B)

The river system is undergoing a major phase of aggradation across the floodplain, involving the reworking of sediments supplied from both the floodplain surface and the marginal floodplain slopes. The continuing coarse-grained (sand and gravel) sedimentation across the braidplain is therefore likely to consist of sediments (and potentially archaeological materials) derived from the contemporary floodplain and adjacent landscape surfaces. Lithic and faunal artefacts from the upper levels of these sediments are considered to date to this later, continued phase of aggradation on the basis of stratigraphic principles. They are therefore assigned a chronological catchment of 10^2 (100), 10^3 (1,000), and possibly 10^4 (10,000) years, since they are primarily associated with the later aggradation phase of the glacial/interglacial transition. As previously, the model should be tested against the physical condition of the artefacts, whilst field evidence for depositional breaks (erosive contacts) in the sedimentary sequence would also support the model's emphasis on the later sedimentary events within the transitional climatic phase.

2.5.3 Phase 2: the early interglacial (Figure 233)

The river regime is stabilising the channel system inherited from the glacial/interglacial transition phase, combined with the vertical accretion of fine-grained sediments within abandoned channels and ex-braidplain depressions. The sediments are primarily supplied from the contemporary floodplain, while the relatively low energy nature of the fluvial system suggests that any archaeological materials have also been locally derived from the floodplain and channel complexes. Derived lithic and faunal materials from these sediments are therefore argued to date to this early interglacial phase, given the reduced ability of the river system to rework material from buried, coarse-grained sediments (see phases 1A and 1B above). The archaeology is therefore assigned a chronological catchment of 10^2 (100), 10^3 (1,000) years, and possibly 10^4 (10,000) years. The physical condition of the artefacts is particularly important in this case, since Chambers (pers. comm.) predicts differences between the *état physique* of artefacts subjected to coarse-grained and fine-grained sediment transport regimes.

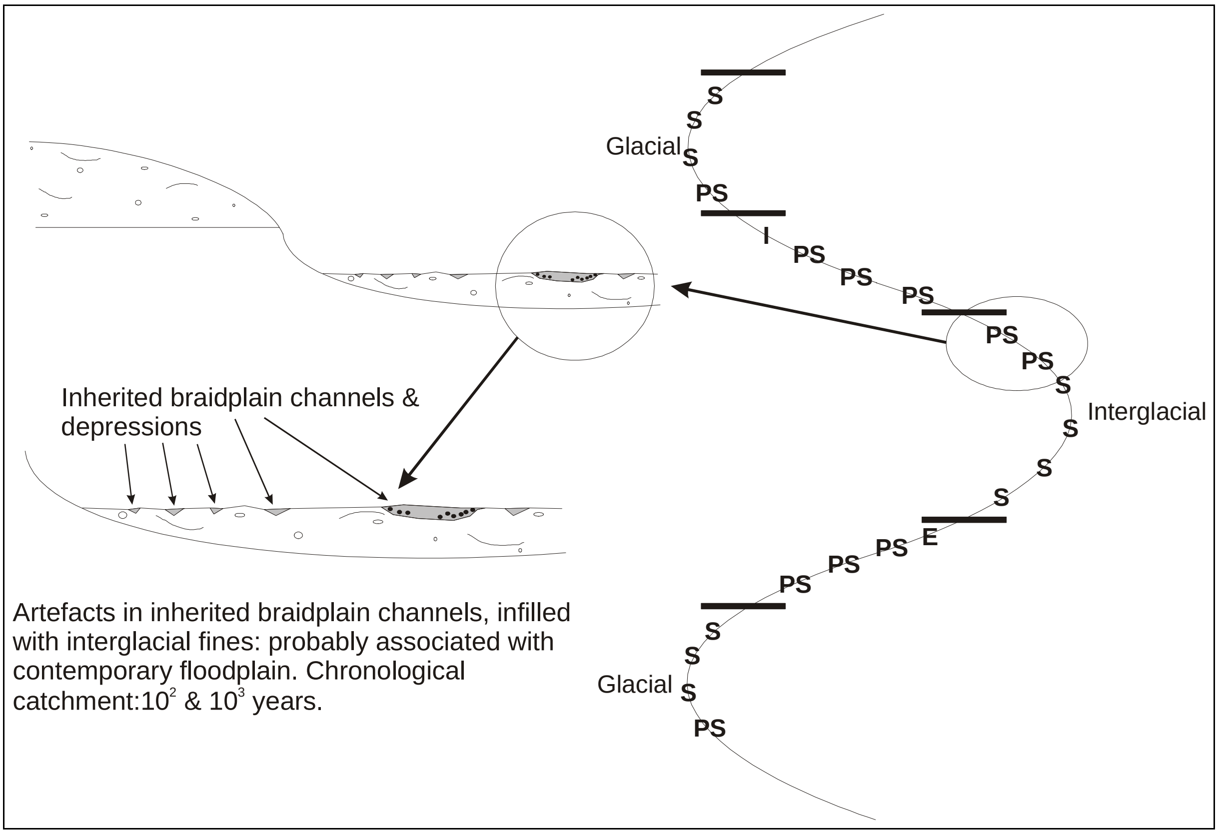

Figure 233: model of artefact re-working during the early interglacial phase

2.5.4 Phase 3A: the early interglacial/glacial transition (Figure 234A)

During the early phases of the interglacial/glacial transition, the high-energy river erodes extensively into the interglacial floodplain surface. This erosive activity reworks considerable quantities of fine-grained interglacial sediments and, potentially, older coarse-grained sediments from the previous glacial/interglacial transition. The succeeding aggradation phase of coarse-grained (gravel and sand) sedimentation across the braidplain is therefore likely to initially consist of older materials (sediments and potentially archaeology), re-worked from the contemporary floodplain. Artefacts (lithics and fauna) from the basal levels of the new sedimentary architecture, near the eroded floodplain surface, are assumed to date to the earliest, initial phases of this aggradation on stratigraphic grounds (as in phase 1A). They are therefore assigned a chronological catchment of 10^4 (10,000) and 10^5 (100,000) years, since they potentially date to a wide timespan covering the previous interglacial and glacial/interglacial transition. As emphasised above, the chronological catchment should be tested against the physical conditions of the artefacts (see Modules 4–5), while the stratigraphic interpretation should be confirmed where possible by field observations.

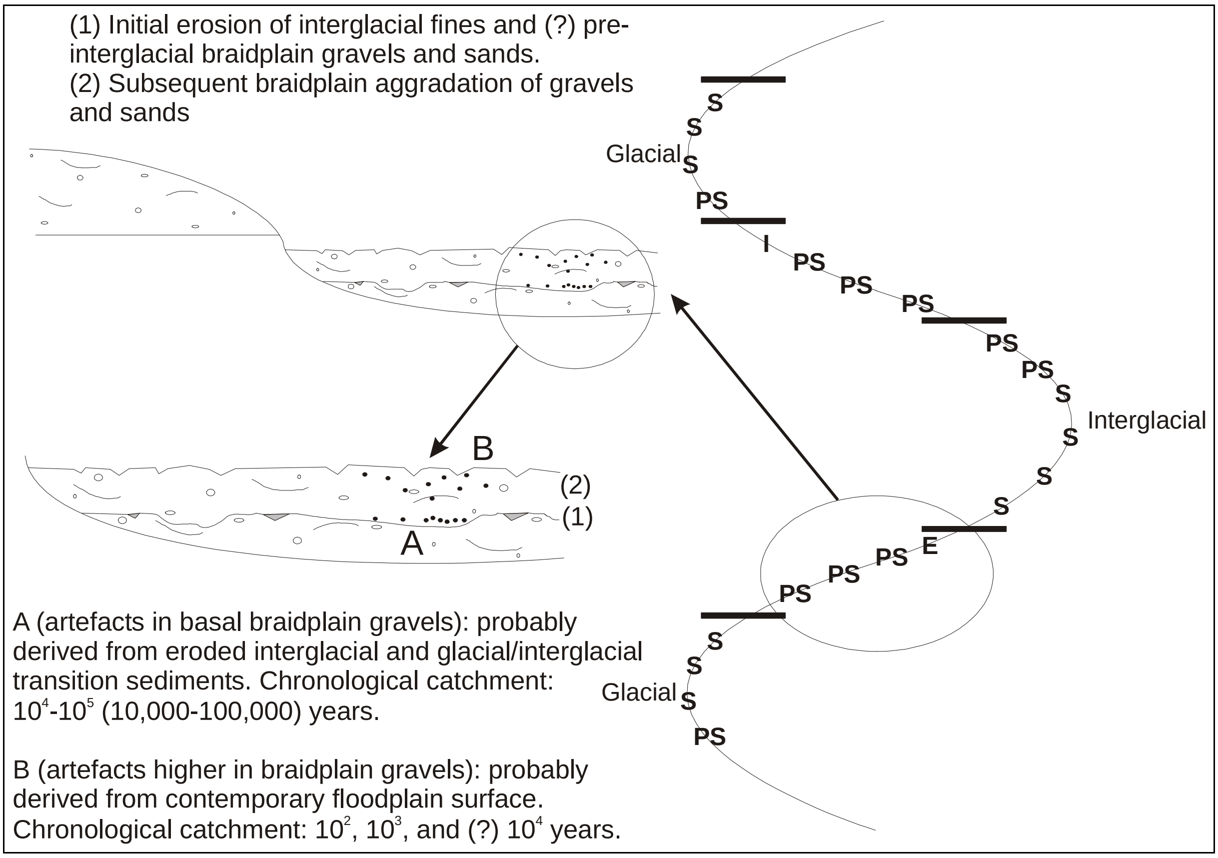

Figure 234: model of artefact re-working during the interglacial/glacial transition phase

2.5.5 Phase 3B: the late interglacial/glacial transition (Figure 234B)

The river system is undergoing a major phase of aggradation across the floodplain/braidplain, involving the reworking of sediments supplied from the braidplain surface and the marginal floodplain/valley slopes (as a result of vegetation degradation, freeze-thaw activity and soil instability). The continuing coarse-grained (sand and gravel) sedimentation across the braidplain is therefore likely to consist of sediments (and potentially archaeological materials) derived from the contemporary floodplain/braidplain and adjacent landscape surfaces. Lithic and faunal artefacts from the upper levels of the sediments are considered to date to this later, continued phase of aggradation on the basis of stratigraphic principles. They are therefore assigned a chronological catchment of 10^2 (100), 10^3 (1,000), and possibly 10^4 (10,000) years, since they are primarily associated with the later aggradation phase of the interglacial/glacial transition. As with the previous phases, the model should be tested against the physical condition of the artefacts, whilst field evidence for erosive breaks in the sedimentary sequence would also support the emphasis placed upon later sedimentary events within this transitional climatic phase.

Phase 4: the full glacial (Figure 235)

The river system is relatively stable during this phase, with annual nival-regime floods redistributing existing surface and near-surface coarse-grained sediments across the braidplain. The sporadic coarse-grained sedimentation across the braidplain is therefore likely to consist of sediments/archaeological materials derived from the surface and near-surface of the contemporary braidplain (redistribution of more deeply buried sediments is extremely limited due to permafrost). Lithic and faunal materials from the top layers of the sediments are therefore assumed to predominantly date to this glacial phase of limited aggradation, although there is also limited potential for the re-working of artefacts from the upper layer of sediments aggraded during the terminal phase of the interglacial/glacial transition. They are therefore assigned a chronological catchment of 10^3 (1,000) and 10^4 (10,000) years, since they are primarily associated with the glacial aggradation phase (although the speed of braidplain re-working suggests that only the terminal glacial phase may be directly represented in any preserved fluvial sediments). As previously, the model would be supported by artefacts' physical condition data and field evidence for erosive contacts in the upper part of the sedimentary record.

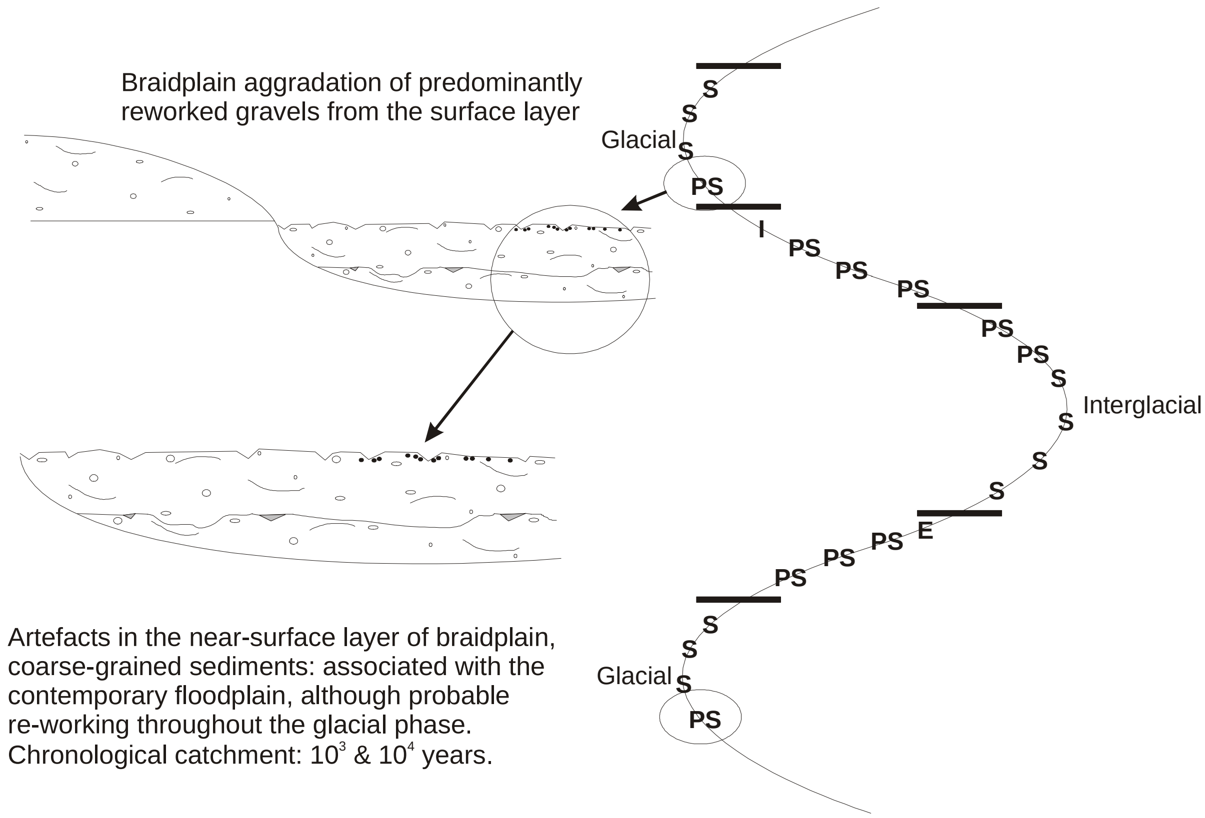

Figure 235: model of artefact re-working during the glacial phase

It is stressed that this is primarily a generic and exploratory framework, based on a current view of fluvial activity across the glacial/interglacial cycles of the Pleistocene (Vandenberghe 1993, 1995, 2002, 2003; Bridgland 1994, 1995, 1996, 1998, 2000, 2001; Maddy *et al.* 2001; Gibbard & Lewin 2002). Three specific points are also highlighted with respect to the model and its applications:

- The proposed chronological catchment estimates will also be influenced by the other factors identified above (river zones, regional/local geomorphology, and local depositional patterns). For example, all material in an upland river system is likely to have been subjected to greater temporal magnitudes of reworking than those proposed above, due to the tendency of such systems towards extensive reworking and flushing out of older sediments (e.g. Howard & Macklin 1999). This is considered further in Section 2.6 below.
- The proposed chronological catchment estimates are intended to describe the majority of any recovered assemblages, not the entirety. It is recognised that there may be temporal outliers, including material that has been re-worked over multiple glacial/interglacial cycles (this would be especially likely in upland fluvial zones — see above), and artefacts that were discarded on the contemporary landscape and derived over short timespans/distances prior to their incorporation within the sedimentary unit. However, it is argued that the physical condition of the material and the range of conditions in an assemblage should provide a valuable indicator of the presence of such outliers.
- It is recognised that the physical condition of artefacts is primarily an indicator of horizontal (i.e. down-channel) transportation distance, rather than vertical (i.e. between-terrace) transportation

distances. It is argued here that the former can certainly occur without the latter, and that considerable physical damage on an artefact is not necessarily an indicator of macro-scale chronological re-working between higher (older) and lower (younger) terraces. It is noted however that the same is not true for the reverse scenario. In other words, material that has been re-worked vertically will also have had to undergo a degree of horizontal transport. The challenge of modelling the potential for vertical re-working has been addressed throughout this section, and is summarised below.

2.6 Summary

Existing models of fluvial activity suggest that the highest, currently available geochronological resolution is in the order of 10^2 and 10^3 years in magnitude, with respect to individual fluvial sedimentary units and erosive events. Unfortunately, the chronological catchment of the derived archaeological materials occurring within these fluvial secondary contexts is much more variable, and encompasses a far wider potential time-span. It is clear that a number of factors influence the intensity of re-working and the magnitude of the potential chronological catchment, including the river zone (Section 2.2), regional and local geological factors (Section 2.3), and the final depositional position of the archaeology within the glacial/interglacial cycle (Section 2.5).

A provisional framework for the application and interpretation of these factors is proposed here:

- River zone: in those cases where a river is classified as an upland or piedmont system (following the definitions of Howard & Macklin (1999), with limited traces of terrace preservation and/or long-term sequences (based on field evidence and theoretical models where necessary), chronological catchments in the order of 10^5 years are proposed. These estimates can be reduced where there artefact typology provides a robust chronological marker, such as is the case with *bout coupé* bifaces (White & Jacobi 2002) and twisted ovates (White 1998a). However, it should be noted that there are relatively few examples of such chronologically-robust patterns in Palaeolithic artefact typology, while chronological typologies once considered robust (e.g. Roe 1981) have recently been overturned by new discoveries (e.g. Ashton *et al.* 1992; Roberts & Parfitt 1998). Finally, where the physical condition of secondary context specimens is suggestive of limited derivation and re-working, detailed field investigation of the sedimentary and depositional environment is recommended, *prior* to assumptions of a relatively brief chronological catchment.

- Regional and local geological factors (bedrock controls): in cases of lowland or perimarine systems influenced by chalk bedrock controls (resulting in limited terrace preservation), chronological catchments in the order of 10^5 years are again proposed. The above comments regarding the physical condition of the material and the presence of robust chronological marker artefacts are again applicable. It is also stressed that the extents of chalk-bedrock river systems should be assessed with respect to the potential downstream re-working of heavily re-worked artefacts over shorter and longer timespans (Section 2.3 above). Of particular importance is the re-working of heavily derived artefacts from gorge-style chalk-bedrock river valleys into terrace-staircase, Tertiary bedrock systems, as has been argued for the assemblages from Dunbridge and Wood Green in Hampshire (e.g. Hosfield 2001).

- Depositional origin within the interglacial/glacial fluvial cycle: in cases of lowland and perimarine systems with well-preserved terrace sequences, chronological catchments ranging in order of magnitude from 10^2 to 10^5 years are proposed. These vary on the basis of sub-cyclical variations in sedimentary and erosive activity, and the assignment of specific catchments to derived assemblages requires relatively detailed provenancing data with respect to the sedimentary sequence. There are currently no chronologically significant typological markers of sufficiently high resolution to influence these assignments, although as previously, the physical condition of the artefacts and detailed sedimentary evidence should be employed as an independent test of the model.

3. PALIMPSESTS IN SPACE

Assemblages of artefacts recovered from secondary context fluvial sediments immediately present the problem of whether, and how far, they have been transported. Where material is transported, these assemblages are inevitably spatial palimpsests, in other words consisting of artefacts that have been derived from a series of other places in the floodplain environment. The spatial resolution of the secondary context archaeological record is therefore concerned with determining the transportation history of these assemblages through the damage characteristics of individual artefacts, and identifying the minimum spatial resolution that can be applied to the interpretation of these data.

While the transportation of materials occurring in high energy fluvial sediments (typically consisting of gravels and coarse-grained sands) is easily demonstrated (based on the physical condition of the material, the absence of preserved spatial relationships, and the selective presence of specific artefact types), the situation is more problematic when dealing with archaeological materials in low energy fluvial sediments. These latter assemblages types receive relatively little attention here, since they represent a small proportion of the fluvial archaeological resource and have typically been regarded as primary context evidence (e.g. Singer *et al.* 1973) with respect to their interpretation. However, we would stress that even in low energy environments (e.g. fine-grained sands, silts, and clays), it is extremely unlikely that there has been no disturbance of the assemblages. Such disturbance could include the removal of the smallest débitage materials and the minor re-arrangement of spatial alignments and patterning (Schick 1986). It is therefore emphasised that even in these situations, the spatial associations demonstrated by the terminal locations of artefacts should not be immediately considered to be directly indicative of hominid discard activity, prior to assessments of artefact condition and orientation.

3.1 Assemblage and artefact transportation processes

The review of extant civil and hydraulic engineering literature (Chapter 5) has shown the relationships between particles and transportation distances to be highly complex. The movement potential of individual particles is affected by a variety of factors including their discard location within the channel or floodplain, their relative size and elevation in comparison to their neighbouring particles, and the characteristics of the contemporary fluvial environment. These complexities were demonstrated to also affect the transportation of lithic artefacts in experiments conducted by Harding *et al.* (1987), which indicated that artefacts in fluvial environments behave in the same manner as the local mobile sediment, and as such are only episodically mobile. The exact timings and duration of these phases of burial and movement are dependent on the local conditions and fluvial environment. Current experimental research (Hosfield & Chambers 2002a, 2003, 2004; Chapter 5) has confirmed the stochastic nature of artefact transportation, even between two artefacts emplaced in adjacent locations within a river channel.

Critically, it has been demonstrated that no clear relationship exists between particle (or artefact) size and the distances they are transported. To focus on archaeological examples, the experiments of Harding *et al.* (1987) demonstrated an inverse relationship between transportation distance and artefact size. These results contrast with the current experimental research of Hosfield & Chambers (2002a, 2003, 2004), where artefact transportation distances have shown no clear relationship to size, although there is a suggestion that larger artefacts travel *further* than small ones (Chapter 5). These contradictory findings support the general absence of a causal relationship between particle size and transportation distance, as has been accepted within the engineering research community (e.g. Church & Hassan 1992; Hassan & Church 2001; Malmaeus & Hassan 2002; Hunziker & Jaeggi 2002). It is therefore not possible to evaluate the transportation potential of individual artefacts based on characteristics such as size. With respect to the interpretation of spatial palimpsest assemblages, it cannot be presumed that larger artefacts will have remained closer to their original discard locations than smaller artefacts.

A range of other factors have also been identified as influencing artefact movement, although their relative visibility within the archaeological record has restricted their applicability:

- Local fluvial regimes: the micro-characteristics of a fluvial regime will inevitably have influenced the potential for Palaeolithic artefact transportation (e.g. reflecting flow velocities and channel depth variability across a channel cross-section). However, these micro-characteristics are not stable, reflecting the fact that fluvial regimes are both spatially and temporally variable (e.g. between shallow riffles and deep pools over tens of metres, and between winter and summer flow regimes over an annual cycle). Unfortunately, these micro-scale, local variations cannot be fully reconstructed (if at all) from archaeological secondary contexts. This remains the case even when extant sedimentary sections are available (e.g. as at Broom), due to Quaternary erosion of sediments and the limited representation of a 4-dimensional floodplain within 3-dimensional sections. For example, the presence or absence of sediment armoring, local bed forms, and scouring, relative elevation, current velocities, viscosity, and specific gravities have all been demonstrated to influence particle movement, yet most of these variables cannot be known archaeologically. They certainly cannot be reconstructed for each episode of biface movement. It is therefore not possible to reconstruct fluvial palaeoenvironments to the degree where high resolution predictive models of particle movement, as developed by civil and hydraulic engineers, can be applied (Chapter 5). Nonetheless, where sedimentary evidence is available (e.g. in the form of extant field sections), low resolution models of sedimentary regimes and the terminal transportation and deposition of Palaeolithic artefacts can be developed. For example, clast size distributions can provide a relative indicator of flow magnitude, fabric analyses can reveal flow vectors, while local, vertical sedimentary sequences can indicate previous fluvial responses and the relative potential for artefact re-working.

- Regional fluvial regimes: at a larger scale, the geography and geomorphology of individual reaches within a fluvial system will also influence the river's regime and the potential for artefact transportation. Of particular significance are stream competence (e.g. flow energy) and dynamism of deposition/erosion processes on the floodplain. These factors show considerable variations in response to river type (e.g. upland and lowland systems), and geological bedrock characteristics. These issues are discussed in more detail in Section 2 above, but are reviewed here in the context of horizontal artefact transportation. Importantly, these variations in river and bedrock type can be reconstructed from the archaeological literature, Quaternary sediment and terrace mapping, and extant landscape features:

    - Within upland regions, rivers tend to be characterised by relatively steep gradients (> 10m km^{-1} in western and northern Britain), reflecting regional topography, high flow velocity and discharge volumes, and glacio-isostatic uplift (resulting in incision). Valley development is typified by episodic downcutting, while constricted floodplains (steep valley sides frequently merge into the floodplain without an intervening floodplain) limits both the lateral migration of the active channels and the long-term preservation of terraces (Howard & Macklin 1999). The steep channel gradients and high flow velocities inevitably increase the probability of entrained particle movement, due to the higher energy levels inherent in the system. It is therefore proposed that artefacts discarded in upland fluvial catchments and subsequently entrained by the river would be transported through these upland fluvial reaches comparatively quickly, perhaps in a less episodic manner than is characteristic of transportation histories in lowland reaches. Alongside this model of rapid artefact transport there is also a greater probability of spatial artefact reworking within the upland river reaches, due to the processes of sediment erosion and artefact entrainment. Episodic downcutting and high magnitude flood events within constrained valley systems result in the predominant re-working of floodplain and terrace sediments (where the latter have developed), and the potential re-working of archaeological materials previously deposited within those sediments. Such re-working inevitably has a temporal component (artefacts are re-worked from older sediments into younger deposits — discussed further in Section 2 above), but equally inevitably has a significant spatial dimension. In general therefore, the nature of fluvial behaviour in upland rivers promotes relatively high levels of artefact transportation and re-working.

- It is noted that the artefact reworking model referred to above is also likely to occur in chalk bedrock rivers (whether upland or lowland in type), where extensive re-working of floodplain sediments and the absence of long-term terrace preservation is common. This issue is discussed in detail in Section 2.4 above.

- By contrast with upland river systems, lowland reaches are typically characterised by relatively shallow gradients (< 2m km^{-1} in the southern UK), migrating channel systems, wider and unconstrained floodplains, enabling the development and long-term preservation of terrace features (although see comments above with respect to chalk bedrock systems (Howard & Macklin 1999)). In these low-energy systems, artefact transportation is likely to be more episodic than in the upland reaches, with significant burial phases. Moreover, the development and long-term preservation of terrace landforms and sediments (particularly prevalent in Tertiary sand and clay bedrock systems) reduces the potential for intensive spatial re-working of archaeological materials. In other words, material transported and deposited into contemporary floodplain sediments are unlikely to be subsequently re-worked into the deposits of lower and younger floodplains, as their encasing floodplain sediments are preserved as terrace deposits. The taphonomic implications of river system types upon the re-working of Palaeolithic artefact assemblages are discussed in greater detail in Chapter 5 (Section 6.1).

Given the complexities of these relationships and the practical limitations of the sedimentary record, it is therefore proposed here that the physical condition of the artefacts remains the best mechanism for assessing hydraulic transportation.

Chapter 4 reviewed the methodologies previously employed in the analyses of fluvially-transported Palaeolithic artefacts. This research advocates a more holistic approach, recognising the transport information that can be gained from consideration of the entire *état physique* of individual artefacts (Chapter 4 & Chambers in prep). By considering edge damage and overall artefact morphology in combination with a systematic assessment of abrasion damage of biface arêtes, retrospective models of transportation history can be established. For example, laboratory experiments have demonstrated that artefact raw material influences the rate of damage development, that artefact morphology influences the transportation mode, and that damage patterns can develop over relatively short distances (e.g. sub-250m). Field experiments in the Afon Ystwyth gravel-bed river in Mid-Wales (Chapter 5; Hosfield & Chambers 2002a, 2003, 2004) also recorded the stochastic nature of particle entrainment and subsequent movement and/or burial, demonstrating that artefacts emplaced in adjacent channel-bed and gravel bar locations, and subject to the same fluvial processes, displayed a wide range of different transportation behaviours.

The correlation between laboratory and field data is a challenging problem, reflecting the contrasts between the controlled laboratory environment (within which a range of experimental variables were known) and the field environment, in which the documentation of the same range of experimental variables was much more difficult. The potential correlation was therefore assessed by applying the laboratory-derived experimental model of abrasion development to the bifaces abraded and damaged during the Afon Ystwyth field experiments. For these bifaces, transportation distances were known, but transportation modes (e.g. sliding and saltating) were not. The model accurately calculated the transportation distance for 20% of the recovered replica bifaces, while 20% of the transportation distances were under-estimated, and 60% were over-estimated. In the absence of smart tracers, the transportation mode cannot currently be demonstrated for the field experiments, and it is therefore not currently possible to determine where the inaccuracies arise between the laboratory and field data. One possible source of the differential concerns the role of aquatic vegetation in arresting abrasion development on the bifaces (see Chapter 5 for further discussion of this point). It is therefore proposed that a key objective for future research concerning the Palaeolithic archaeological resource from secondary contexts is an expansion of experimental data sets exploring artefact transportation and the spatial derivation of stone tool assemblages.

Nonetheless, it is argued that the currently available experimental data does provide a generic means of assessing the mode and duration of an artefact's fluvial transportation history. A correlation of individual archaeologically abraded artefacts from the Broom Lower Palaeolithic locality with the experimental abrasion development datasets (Chapter 4) was presented as a case study application of the experimental data to an archaeological assemblage. Although the experimental datasets generate precise inferred transportation distances, exact correlation of the *état physique* between archaeological and experimental datasets is not ubiquitous (indeed, it should not be expected given the complex and stochastic nature of field processes). Typically, contrasts between the two data sets occurred with respect to:

- The thickest regions of the biface: these differences probably represent damage sustained to the exposed areas of the biface (e.g. the dorsal spine) during episodes of relative stability and/or partial burial. However, current experimental programs have not produced sufficient quantities of abrasion development data to determine the causal origins of these discrepancies.
- The effects of suspended load transportation: these processes cannot currently be modelled due to the logistical difficulties of creating high-velocity suspended load transportation of bifaces within an experimental flume environment.
- The effects of transportation within fine-grained sediments (e.g. sands and silts): these processes are susceptible for modelling and are the current focus of ongoing experimental research.

Overall, it is clear that the specific distances generated by the laboratory-based flume data models for the fluvial transportation of archaeological clasts (i.e. artefacts) are not, and cannot ever be, accurate representations of all archaeological examples from the real world. However, the robusticity of the transportation distance modelling results for the Broom assemblage (Chapter 4), and the magnitude of the correlation errors between the field and laboratory data (see Section 3.2 below) indicates that these data can be employed as a foundation for future research and analyses.

3.2. A Minimal Spatial Unit (MSU)

The minimum spatial unit (MSU) is proposed as a conceptual framework for addressing the problem of artefact derivation and re-working, and the presence of archaeological spatial palimpsest assemblages within fluvial secondary contexts. The MSU concept is borrowed from Stern (1993, 1994), who presented the minimum archaeological-stratigraphic unit (MASU) in her discussion of the Lower Pleistocene record as revealed in the Koobi Fora Formation. Stern presented the Lower Okote Member (LOM) as an example of the MASU, as it was:

"*the smallest wedge of sediment*, and hence *the smallest unit of time*, that can be used to study the distribution of archaeological debris across the ancient landscape in this portion of the Koobi Fora Formation."

(Stern 1993: 205)

Following Stern (*ibid.*), the concept of the minimum spatial unit (MSU) is therefore defined here as:

The smallest geographical area, and hence the smallest unit of space, that can be used to study the lateral distribution of archaeological debris across the ancient fluvial landscape, prior to the derivation of the debris from their pre-fluvial contexts to their place of deposition with fluvial secondary context sediments.

This definition raises two important issues:

- Pre-fluvial contexts do not necessarily equate to hominid discard activity. Material may have been discarded on valley slopes and re-worked through soil processes (e.g. erosion, solifluction and gelifluction) onto the floodplain.
- The lateral distribution of archaeological debris is only considered in terms of its location upstream from the place of deposition, not in specific 3-dimensional terms. For example, in an eastwards flowing system, the location of the debris is considered in terms of its generic east–west position, but

its exact position (e.g. within the main channel floodplain or associated with a north or south bank tributary valley) cannot, of course, be specified.

It should be immediately clear that the geographical lower limit of the MSU is the location of the secondary context assemblage within the fluvial system (following the assumption that material will not have been fluvially transported upstream). By contrast, the geographical upper limit of the MSU is much more variable, and its identification defines the size of the MSU. Three approaches are proposed here for the identification of the upper limit and the overall scale of the MSU:

1. Drainage basin (coarse-resolution) MSU: the fundamental principle of this MSU definition is that the derivation of artefacts from within different locations of the drainage basin cannot be distinguished. In other words, the relative physical condition of the artefacts provides no indication of their relative degrees of lateral derivation. This MSU type is therefore individually defined as the upstream drainage basin/catchment associated with the fluvial system within which a specific assemblage was located. In the case of the Broom Lower Palaeolithic assemblage for example, the MSU would be defined as the River Axe drainage catchment upstream of Broom (an area of *c.* 20 km channel length — Figure 236). The specific size of the MSU therefore varies between fluvial systems (e.g. consider the potential variations in MSU size between the Pleistocene Thames and the River Axe). However, the MSU size will also vary within the same fluvial system, according to the location of the secondary context assemblage for which it is defined. For example, the MSU for an assemblage recovered at Chard Junction would be smaller than that for the assemblage from Broom (Figure 236). This MSU concept is therefore more useful for derived assemblages located near the source of the river/stream system, while the MSU becomes increasingly coarse with downstream progress through the fluvial system. Overall, this definition of the MSU restricts the spatial analytical resolution to the drainage basin scale, with no potential to explore spatial variability at the sub-drainage basin scale.

2. Sub-drainage basin (medium-resolution) MSU: the previous definition of the MSU takes both an extremely pessimistic view of the potential of the data available from the physical condition of the artefacts, and also severely limits the spatial analytical frameworks available. It is proposed that it is possible to develop a minimum spatial unit that operates at the sub-drainage basin level. However, it was stressed above that the specific distances proposed for artefact transportation on the basis of experimental research (laboratory and fieldwork-based) cannot be directly transposed onto archaeological materials, reflecting the stochastic nature of the processes involved in fluvial entrainment. Nonetheless, results both from experimental research and the analysis of archaeological assemblages (e.g. Broom and Dunbridge — Chapters 4 & 5) suggest that there are potentially robust patterns that develop during the processes of artefact transportation. In both case study assemblages, the data suggested a cluster of artefacts that had been moved a few hundred metres (category b below), and a background scatter of artefacts moved greater and lesser distances (categories a, c and d). Based on these results, an MSU framework is proposed, utilising orders of magnitude categories to represent artefact transport regimes:

    a. $10^{1\text{-}2}$ m (10–100 m): bifaces transported less than 100m.
    b. $10^{2\text{-}2.5}$ m (100–500 m): artefacts derived between 100m and 500m.
    c. $10^{2.5\text{-}3}$ m (500–1,000 m): bifaces transported between 500m and 1km.
    d. 10^{3+} m (1,000 m/1 km+): artefacts transported over 1km.

    The use of increasingly wide categories reflects the importance of differentiating between *in situ* materials and artefacts that have been subjected to relatively minor derivation over short distances. This was also highlighted by the experimental research which indicated that abrasion develops relatively rapidly. The use of an open-ended forth category reflects the problems of modelling long-distance transport, namely the difficulties of laboratory replication and the dangers of extrapolating experimental trends (it is clear from the experimental research that rates of abrasion development change over time). Classification of individual artefacts to one of the categories is based on an assessment of their *état physique* (abrasion development, edge damage, and overall morphology), following the experimental research of Chambers (in prep). Moreover, we propose that the above classification utilises fuzzy categories, based on the quartile values of the category ranges, due to the recognition that the modelled distances are not precise. These fuzzy category boundaries are highlighted below:

a. 10^{1-2} m (10–100 m): modelled distances between 0 and 125m.
b. $10^{2-2.5}$ m (100–500 m): modelled distances between 75m and 600m.
c. $10^{2.5-3}$ m (500–1,000 m): modelled distances between 400m and 1125m.
d. 10^{3+} m (1,000 m/1 km+): modelled distances above 875m.

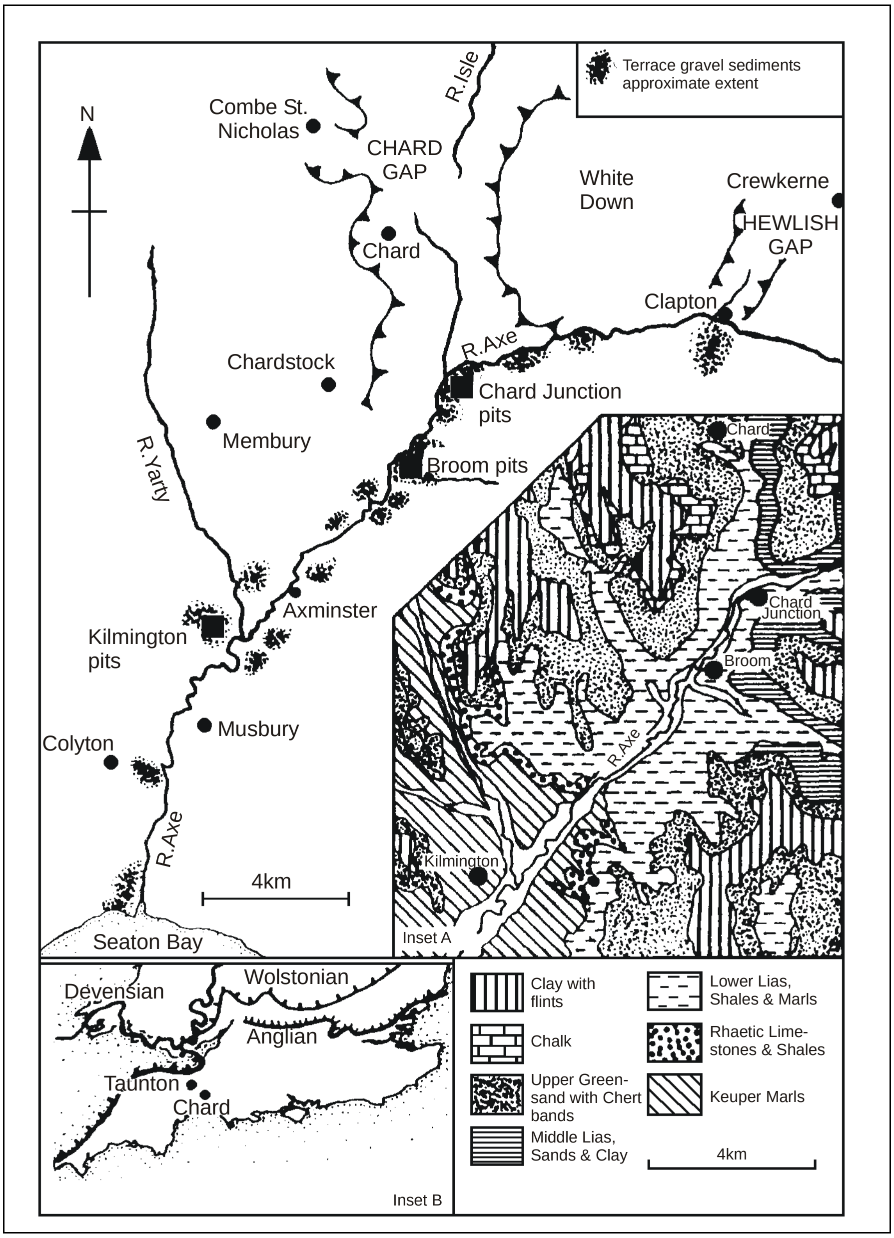

Figure 236: the River Axe valley, Devon/Dorset, UK

Although this classification approach typically results in the assignment of some artefacts to two categories, it also provides a more robust technique for characterising the transport signature of an assemblage. The classification highlights broad contrasts between the transport histories of different artefacts, based upon their physical condition, and therefore supports the classification of assemblages as spatially homogeneous or heterogeneous. It does not attempt to discuss specific distances (an unrealistic goal), but it does provide a means of comparison between different assemblages (after standardisation for sample size differences). The Broom and Dunbridge assemblages are summarised and compared below (Figure 237 & Figure 238), utilising this approach. Both assemblages are characterised as broadly homogeneous, with the majority of the artefacts having been derived from a few hundred metres upstream of the site. In both cases, there is a background scatter of more heavily derived material, but only in the Broom assemblage is there a less heavily derived component. Statistical comparison of the distributions using the Kolmogorov-Smirnov test indicates that there is a significant difference between the distributions of the artefacts across the derivation categories (at the 0.001 level of significance). Visual inspection of the distributions suggest that the Dunbridge artefacts were more heavily derived than the Broom material, although in both cases the material was relatively homogeneous (64% and 83% of the artefacts were in the modal category of the Dunbridge and Broom assemblages) and locally derived (the modal category was the $10^{2-2.5}$ for both data-sets).

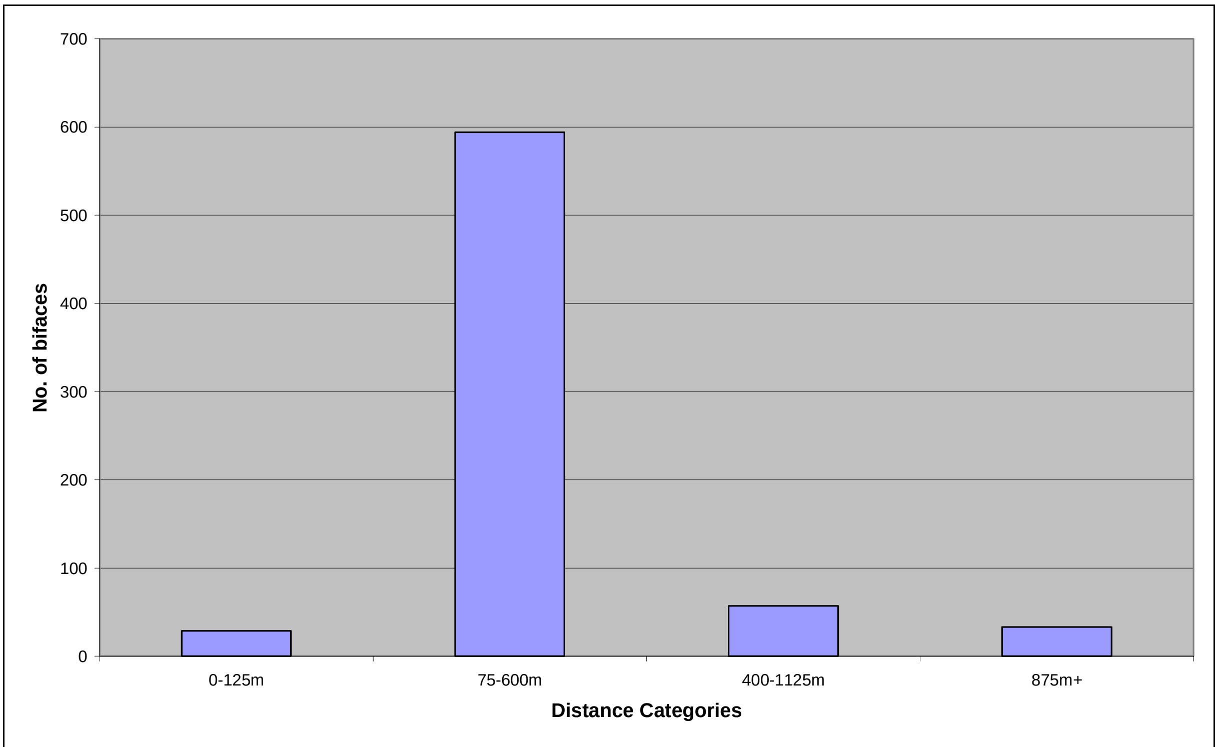

Figure 237: spatial derivation categories for the Broom biface assemblage

3. System-specific (variable-resolution) MSU: the final approach to defining the MSU highlights the geomorphological context and the structure of the fluvial landscapes within which the assemblage was deposited. Specifically, the definition focuses upon areas of terrace preservation within the drainage basin, and proposes that these zones are sedimentary catchments within the fluvial system. Processes influencing the formation of these catchments include the presence of stream confluences (resulting in the loss of stream competence and sediment deposition), and bedrock changes (resulting in the long-term preservation of terrace features and sediments). What is critical however is that these sedimentary catchment points provide a series of geographical upper limits for the definition of the MSU (the lower limit for the MSU is defined by the location of the recovered assemblage). In other words, the approach assumes that archaeological material being transported downstream will be deposited at the first sedimentary catchment that is encountered after the entrainment event. Where those sediments are subsequently eroded (prior to the present), the material will obviously be re-worked, but where the sediments are preserved it is assumed that any archaeological materials will also be present within the deposits. This model therefore enables the MSU to be defined as the distances between each sedimentary catchment with preserved fluvial sediments. In a hypothetical example from the River Axe valley (Figure

236), a derived assemblage of artefacts is recovered from the fluvial terrace sediments at Colyton. Utilising the system-specific approach, the MSU for the assemblage is defined between Colyton and Kilmington (*c.* 4 km), since it is assumed that material derived from above Kilmington would have been deposited within the preserved Kilmington fluvial sediments. This approach clearly makes two assumptions:

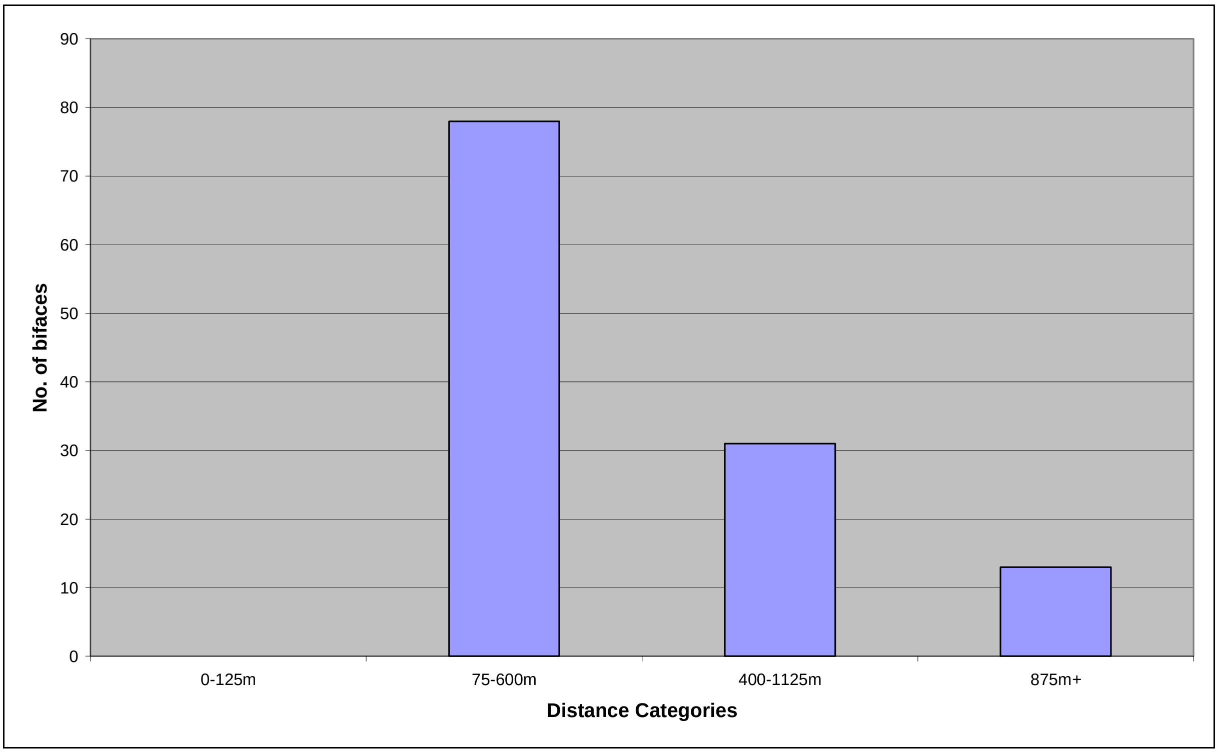

Figure 238: spatial derivation categories for the Dunbridge biface assemblage

- An MSU can only be defined between two sedimentary catchments if the terrace deposits are of the same chronological age (i.e. associated with the same interglacial/glacial cycle).
- Material would be deposited and preserved in each sedimentary catchment, *if* artefacts were discarded in the relevant stretch of river. The absences of artefacts within individual sedimentary catchments are therefore taken as an indicator of the absence of hominid activity (resulting in the discard of artefacts) within the MSU upstream of the catchment, during the time period associated with the terrace feature.

This approach to modelling the MSU can be assessed through an examination of the artefact abrasion data, with focus placed upon clear discrepancies between the two categories of evidence (e.g. the presence of heavily abraded specimens associated with MSU's less than 2 km in length). The approach has clear advantages in that it stresses the regional geomorphological context of artefact re-working in fluvial environments. However, the technique makes some fundamental assumptions which are currently untestable. Principally, it assumes that all transported artefacts will be caught within each floodplain sedimentary trap. If this is not the case, then the model is clearly seriously flawed. It also requires extensive knowledge of the fluvial system geomorphology and the sedimentary sequence, and the availability of robust geochronological models. Finally, it is not possible to apply this approach to single site investigations, as it must instead be employed in system-wide analyses.

With respect to all of the approaches outlined above, there are a series of caveats that require identification:

- It is recognised that materials discarded on valley slopes can be washed into the fluvial system.

However, in terms of the definition of the spatial distribution it is argued that the distances and directions of down-slope movement are unlikely to significantly alter the assemblage transport signature (and associated interpretations of landscape behaviour).

- The experimental modelling of artefact damage through fluvial transport requires further research, specifically with reference to long-distance transport, suspended load transport, transport in fine-grained sedimentary environments, and the development of abrasion on a wider range of raw materials (our current research has explored flint and chert).

3.3. Summary

There are relatively few extant models of artefact re-working and derivation (e.g. Harding *et al.* 1987; Hosfield 1999; Wymer 1999). These models have either focused upon experimental data (e.g. Harding *et al.* 1987) or have emphasised generic models of re-working without explicitly addressing the physical spatial component in the real world. The research presented here has suggested three approaches to identifying the spatial resolution associated with the secondary context archaeological resource, as represented by derived lithic assemblages deposited in fluvial sediments. All three of these approaches utilise the concept of a minimum spatial unit (MSU). The first of these approaches adopts a limited view, defining the MSU as the spatial zone between the assemblage findspot and the head of the river system. This approach argues that physical artefact evidence and the geomorphological structure of the fluvial system cannot be employed to assess the internal structure of spatial palimpsest archaeology. The third approach adopts a geomorphological approach, stressing the role of fluvial features (e.g. river/tributary stream confluences) in creating sediment traps upon river floodplains. The MSU is therefore defined as the spatial zone between the assemblage findspot and the nearest *preserved* sediment trap upstream. This approach is interesting, and emphasises geoarchaeological processes and the sedimentary context of the archaeological resource. However, it requires further field testing prior to its adoption for the interpretation of archaeological assemblages. It also adopts a system-wide approach, and is therefore of limited usage for single-assemblage studies. The second approach emphasises the physical condition of the archaeological assemblage, stressing the *état physique* of individual artefacts. The MSU is variably defined in terms of distance categories, organised through orders of magnitude (10^1–10^3), and based partially upon experimental laboratory work (Chambers in prep.) and partially upon extant assemblage-studies (Broom and Dunbridge). The model suggests that relatively fine spatial resolution is currently detectable, based on the notion of artefacts derived from a series of increasingly distant source ideas. The spatial resolution markedly decreases with distance from the assemblage findspot, which reflects the difficulties of distinguishing transport modes over long-distance movement histories. The model also adopts fuzzy categories, reflecting the complexity of the real world processes of artefact derivation. This second approach is favoured here, primarily because it is based upon the artefact assemblage, which provides the most direct evidence of the transport histories associated with the archaeological resource.

However, it is also vital to integrate this physical data-based model of artefact derivation with the macro-scale processes of fluvial-system behaviour (e.g. intensive erosion and re-working in the upland zone). A provisional framework for the integration of these models and processes is therefore proposed here:

- Artefact-based models: the proposed fuzzy categories ($10^{1–2}$, $10^{2–2.5}$, $10^{2.5–3}$, 10^{3+}) provide a summary for the spatial re-working signature of secondary context assemblages (based on the proportion of artefacts falling into each category). The use of these categories supports the comparison of different assemblages, both from the same and different fluvial systems (although further experimental work is favoured, exploring abrasion patterns in different raw materials, the impact of suspended load transport, fine-grained sediment abrasion, and the development of abrasion during burial and partial-burial phases).

- River system models: this framework stresses the importance of highlighting apparent discrepancies between the re-working signature of assemblages and the generic models of river behaviour in different geomorphological zones or under different bedrock conditions. For example, an assemblage characterised by local derivation, occurring within an upland river zone, or a heavily derived assemblage occurring within a lowland zone. It is argued that under such conditions, further investigation of the artefact assemblage and the fluvial landscape is recommended. At the same time, it is noted that upland/lowland river contrasts in fluvial behaviour should not be over-stressed, given the marked variations in fluvial behaviour that occurred throughout river systems across the glacial/interglacial cycles of the Middle Pleistocene.

Overall therefore, the minimum spatial unit (MSU) defined here is spatially-variable, varying from the sub-hundred metres scale (10^{1-2}) to the km scale (10^{3+}).

4. FRAMEWORKS FOR ANALYSING BEHAVIOUR

The geochronological and spatial resolutions proposed here for the secondary context archaeological resource cover a wide and variable spatio-temporal range. This variability provides a diverse set of spatio-temporal frameworks for the analysis of hominid and early human behaviour through the archaeological secondary context resource. A set of frameworks are therefore proposed, with a generic description of the spatio-temporal scales and an outline of the potential analytical approaches to the problems of early human behavioural reconstruction (Table 54). It is stressed that the frameworks are not exclusive, indeed in many cases informative behavioural analysis relies on the integration of the different, specified frameworks.

The precise analytical applications of these frameworks will inevitably vary from one archaeological investigation to the next. However, a series of examples are worked through below, and where possible, related to extant research.

4.1 Short-term temporal frameworks (10^2–10^3 years)

4.1.1 'On-site' investigations (10^1–10^2m)

The 'on-site' description used here is actually slightly misleading, because it conveys an unhelpful concept, that of the archaeological site, which implies settlements for which there is typically no direct evidence in the secondary context record. However it is intended to stress that the archaeological materials have probably been minimally derived (tens of metres) from the fluvial landscape surfaces upon which they were discarded by hominids (or were dumped onto through valley slope processes such as solifluction). It is therefore theoretically possible to explore patterns in lithic technology (e.g. artefact manufacturing techniques and raw material selectivity), typology, and local hominid behavioural activities (based on the range and combination of artefact types). These patterns are inevitably time-averaged (see also below), but they all reflect a short time period of human behaviour, perhaps occurring during a single climatic episode of distinctive character, and could potentially be mapped against palaeoclimatic data sets where this material is present (but see the comments in the previous chapter). As modelled in Section 2, these short-term geochronological resolutions are associated with the interglacial phase of the climatic cycle, and it is therefore possible that the low-energy regimes and fine-grained sedimentation processes will result in the partial-preservation of spatial patterning associated with the archaeological debris (promoting the indirect analysis of hominid activities).

However, it is vital to recall that all of these patterns are time-averaged, since the minimum geochronological resolution covers a few hundred or a few thousand years. Interpretation of the data must therefore recognise the high probability of temporal over-printing and acknowledge that behavioural interpretations are *not* reconstructing single events, but *are* dealing with short time-span patterns in hominid behaviour. Finally, it is stressed that the sediments associated with these short-term geochronological frameworks float within the sedimentary sequences, and therefore that analysis of landscape activity is restricted to the locale and its immediate environs. Comparison with other assemblages from other, geographically-distinct sedimentary sequences is not currently possible. Only in cases where two or more archaeology-bearing high resolution sedimentary units lie in superposition is it possible to compare these data sets, in this instance to explore short-term changes in hominid behaviour in and around the locale.

	Space		
Temporal	**$10^{1\text{-}2}$ (10-100m)**	**$10^{2\text{-}3}$ (100m1-km)**	**10^{3+} (kms)**
10^2-10^3 (100-1,000 years)	'On-site', short-term climatic fluctuations: > Hominid activities (temporal over-printing) > Landscape activity patterning (temporal over-printing)	'Off-site', short-term climatic fluctuations: > Hominid activities (spatio-temporal over-printing) > Landscape activity patterning (spatio-temporal over-printing)	Basin-wide, short-term climatic fluctuations: > High resolution demographic modelling > Lithic typology & technology (high resolution)
10^2-10^4 (100-10,000 years)	'On-site', single glacial/interglacial cycle event: > Warm/cold climate patterns in hominid activities (temporal over-printing) > Warm/cold climate patterns in landscape activity (temporal over-printing)	'Off-site', single glacial/interglacial cycle event: > Warm/cold climate patterns in hominid activities (spatio-temporal over-printing) > Warm/cold climate patterns in landscape activity (spatio-temporal over-printing)	Basin-wide, single glacial/interglacial cycle event: > Warm/cold climate demographic patterns > Lithic typology & technology (mid resolution)
10^4-10^5 (10,000-100,000 years)	'On-site', full glacial/interglacial cycle: > Climatic cycle patterns in hominid activities (temporal over-printing) > Climatic cycle patterns in landscape activity (temporal over-printing)	'Off-site', full glacial/interglacial cycle: > Climatic cycle patterns in hominid activities (spatio-temporal over-printing) > Climatic cycle patterns in landscape activity (spatio-temporal over-printing)	Basin-wide, full glacial/interglacial cycle: > Demographic patterns > Lithic industry typology & technology (low resolution)

Table 54: spatio-temporal frameworks for the analysis of early human behaviour through the secondary context archaeological resource

4.1.2 'Off-site' investigations (10^2–10^3m)

The 'off-site' term is employed here to stress that the archaeological materials have probably been derived over several hundred metres. As above, it is still theoretically possible to explore patterns in lithic typology and technology, and human behaviour, with the archaeology still representing relatively short-term phases of human behaviour. However, the major problem at this scale concerns the likelihood that the patterns are both time- and space-averaged. In other words, the problem of temporal over-printing has been joined by the problem of spatial over-printing, reflecting the fact that within a minimum spatial unit of several hundred metres there is a possibility or probability of multiple, and spatially-distinct activity locales. At these scales, it is recommended that analysis of lithic debris focuses on potentially robust patterns that might operate at the local river valley scale. Examples would include raw material types (homogeneity/heterogeneity could be explored against modern field observations), quality (adopting White's (1998b) approach), and nodule/pebble sizes (through artefact size ranges and modern field observations). Homogeneity/heterogeneity in artefact types (e.g. bifaces) might also be indicative of local-scale landscape exploitation strategies, with particular respect to the range and type of activities carried out. As above, in those (rare) instances where high resolution archaeological samples occur in stratigraphic superposition, analysis and comparison of these patterns would enable the exploration of hominid behavioural trends (stasis and/or change) over relatively short-term time periods. In these instances however, field observations would be vital to confirm the presence/absence of sedimentary breaks between the deposition of the two archaeology-bearing stratigraphic units. Finally, comparisons of on- and off-site data sets should be treated cautiously, since there are potentially differential degrees of spatio-temporal over-printing.

4.1.3 Basin-wide investigations (10^{3+}m)

Unlike the two categories above, analysis at this scale is restricted to the spatially-broad concept of the drainage basin. Spatial over-printing is likely to be extremely prevalent in the data, and there will of course also be temporal over-printing of the data. At these scales, it is suggested that analysis of the lithic assemblages explores robust patterns that operate at the basin-wide scale. Examples would include demographic modelling (based on the artefact-based approaches of Ashton & Lewis (2002) and Hosfield (1999)), and robust patterns in lithic typology and technology (if present). The unique value of these approaches concerns the short time-span of the patterns, enabling the investigation of high resolution demographic patterns over just a few hundred or few thousand years. For example, the potential to explore short-term demographic fluctuations (e.g. peaks and troughs) could provide insights into the sizes and structures of hominid populations. Unfortunately, the semi-floating nature of the current geochronology restricts the ability to compare patterns recorded in different river systems.

4.2 Mid-term temporal frameworks (10^2–10^4 years)

4.2.1 'On-site' investigations (10^1–10^2m)

As previously (Section 4.1.1) these archaeological materials have only been derived short distances. However, the potential for temporal over-printing (due to a minimum geochronological resolution ranging between 100s and several 1,000s of years) is considerable, resulting in assemblages that are probably heavily time averaged. In light of this, patterns in lithic technology or typology are unlikely to represent hominid behaviour from short time-spans (and are highly unlikely to be the debris of single occupation episodes). However, the geochronological resolution enables the sedimentary units (and archaeological materials) to be related to distinctive climatic phases within the glacial/interglacial cycle (e.g. warm interglacials, and the warm/cold or cold/warm climatic transitions). It is therefore proposed that analyses focus upon robust patterns in the lithic debris that could operate at the climatic sub-phases of the glacial/interglacial cycle. Examples would include lithic typology (e.g. in biface forms), where the clear dominance of particular artefact types might indicate associations with specific tasks (e.g. wood-working (Dominguez-Rodrigo *et al.* 2001)), or could indicate the imposition of social rules in tool making and mid-term cultural traditions (e.g. as argued by White (1998a) with respect to the twisted ovates of the British Palaeolithic record during MIS-11). Comparison of the archaeological debris from cold- and warm-climate sedimentary units would also support investigation of possible links between tool-making, activities, and the palaeo-environment. For example, would wood-working activities be more common during the heavily forest interglacial phases than during the warm-cold climatic transitions, and would this be detectable through the lithic record?

It is proposed that patterns in landscape activity are difficult to detect at these scales, since although the archaeology has been minimally derived, the coarser geochronological resolution introduces the problem of extensive temporal over-printing, limiting the ability to detect specific activity episodes. Nonetheless, on those occasions where the stratigraphic evidence suggests localised distributions of debris (e.g. as claimed by C.E. Bean at the base of the 1st floor level in Pratt's Old Pit at Broom), analysis of artefact types and proportions may be undertaken to explore the possible evidence for specific activities at localised points within the landscapes. Finally, it should be noted that these geochronological resolutions potentially enable the identification of comparable sedimentary units and archaeological debris from different locations both within and between single fluvial systems, with absolute dating (e.g. OSL), stratigraphic sequences and geomorphological terrace models (e.g. Bridgland 2001) providing the comparative frameworks. This supports sub-regional and regional comparisons of hominid behaviour during a single sub-phase of the glacial/interglacial cycle.

4.2.2 'Off-site' investigations (10^2–10^3m)

As previously (Sections 4.1.2 & 4.2.1), these archaeological debris are likely to have been subjected both to extensive temporal over-printing (reflecting the geochronological resolution) and spatial over-printing (reflecting the larger minimum spatial unit). It is therefore proposed that analysis of the lithic debris should focus upon patterns that would operate at the local river valley scale, over single climatic sub-phases of the glacial/interglacial cycle. Examples would include raw materials (e.g. type, quality, size), since the geochronological resolution would enable the testing of models proposing variable raw material availability under different climatic conditions (e.g. Wenban-Smith's (1998) model of flint-rich landscapes associated with the early temperate stages of post-glacial periods). Robust patterns in lithic typology (and potentially technology) could be indicative of mid-term trends in tool-making (e.g. imposed standardisation or cultural traditions), and could also be potentially related to climatic conditions. It is also important to stress that these mid-term patterns reflect relatively small spatial areas (and are potentially time- and space-averaged indicators of localised landscape activity). As stressed above however (Section 4.2.1) it is possible to undertake intra- and inter-regional comparisons, based on the identification of comparable sedimentary units in different locations, which may enable the homogeneity/heterogeneity of landscape behaviours to be tested.

4.2.3 Basin-wide investigations (10^{3+}m)

With analysis restricted to basin-wide scales, there is a high probability of extensive temporal and spatial over-printing evident in the archaeological patterns. Given the extensive time- and space-averaging of the data, it is recommended that analysis is restricted to the robust patterns in the lithic debris that operate at the river basin level. Examples would include artefact-based demographic modelling and macro-scale trends in artefact typology and technology. Critically, the geochronological resolution of these data provides the potential to explore macro-scale data patterns in relation to the climatic sub-phases of the glacial/interglacial cycle. For example, the exploration of mid-term fluctuations in demographic data (e.g. peaks and troughs in population sizes) can be linked to model testing with respect to hominid palaeo-environmental tolerance and colonisation (e.g. Roebroeks *et al.* 1992). Equally, robust, basin-wide patterns in lithic typology and technology (e.g. Clactonian/Acheulean variations) can be linked to palaeoclimatic and palaeoenvironmental conditions, and utilised to test extant models (e.g. Mithen 1996, Wenban-Smith 1998, White 2000). Finally, the geochronological resolution supports inter-regional comparisons, enabling the homogeneity/heterogeneity of hominid demographic structures and tool-making traditions to be tested over large areas, with respect to generic (e.g. warm/cold) palaeoclimatic factors.

4.3 Long-term temporal frameworks (10^4–10^5)

4.3.1 'On-site' investigations (10^1–10^2m)

Although these materials have been subject to minimal derivation, the potential for temporal over-printing at the identified geochronological resolutions is clearly extremely considerable. Given the high probability for heavy time-averaging of the assemblage, it is noted that any patterns in lithic technology and/or typology will almost certainly not represent single occupation episodes. Moreover, since the geochronological resolution (several 10,000's years) covers full glacial/interglacial cycles, it is noted that the accumulated (and mixed) archaeological debris has the potential to represent hominid activity under a range of different palaeoenvironmental and palaeoclimatic conditions. There is currently little understanding of the types of lithic artefact patterns that might operate at these macro-scales (Stern 1993). It is therefore recommended that there is a need for exploratory analysis, which seeks for patterns in the data against which to test a series of basic hypotheses. For example, the range of lithic industry types and the variability of artefact forms (e.g. bifaces) and morphology (e.g. dimensions and weight) could be used to explore notions such as: i) do lithic tool-making traditions vary over evolutionary time (e.g. between glacial/interglacial cycles) in terms of the types and range of artefacts produced?; ii) when do the major developments in lithic technology occur?; iii) do lithic industries and traditions vary in response to the relative frequency and magnitude of glacial/interglacial cycles? Some of these approaches have been widely utilised (e.g. with respect to the appearance of Levallois technology in the British Palaeolithic (Bridgland 1996)), but it is stressed that new advances in dating (e.g. in luminescence-based approaches) offers new potential since they provide artefact-independent chronological frameworks (avoiding the circularity problem associated with artefact-based frameworks). Finally it is emphasised that at the glacial/interglacial cycle scale, there is considerable potential for extra-regional/national level comparisons of locale-based patterns in lithic technology and raw material exploitation.

4.3.2 'Off-site' investigations (10^2–10^3m)

At these scales, the problems of both temporal and spatial over-printing are considerable, producing severely time- and space-averaged assemblages. As above (Section 4.3.1), it is recommended that focus should be placed on robust patterns in lithic industries, with the geochronological resolution supporting analyses of technological trends between glacial/interglacial cycles, and intra- and inter-regional comparisons of local river valley patterns in time- and space-averaged lithic assemblages. At these scales, robust patterns in palimpsest lithic assemblages will (where they exist) inevitably reflect the majority of tool-making activity, yet the presence of 'outlier' tool-types and tool-making techniques can be explored with respect to robust spatial and temporal variables such as landscape morphology (e.g. fluvial uplands and lowlands), longitude/latitude based-climates (e.g. maritime and continental conditions), and temporal variations in the severity/mildness of glacial/interglacial events. These types of approaches have been explored by Gamble (1997) with respect to the similarities of the widely-separated Olduvai Gorge (Masek Beds) and Swanscombe archaeology, but there is also potential to pursue them at a national and regional level.

4.3.3 Basin-wide investigations (10^{3+}m)

At these scales the spatial and temporal over-printing of the archaeological assemblages is considerable. With such extensive time- and space-averaging of the data, analysis is inevitably restricted to broad-scale patterns in the lithic data, operating at the river basin level (spatial) and across the glacial/interglacial cycles (temporal). The two key examples are artefact-based demographic modelling (e.g. Hosfield 1999; Ashton & Lewis 2002) and patterns in lithic industries and manufacturing traditions. The spatial and temporal scales support the investigation of large-scale processes and provide robust (albeit time-averaged) data sets. For example, the exploration of demographic patterning between glacial/interglacial cycles can be linked to palaeo-landscape evolution (e.g. the breaching of the Dover–Calais landbridge), and palaeoclimatic change (e.g. increasing continentality), as demonstrated by Ashton & Lewis (2002). The use of a glacial/interglacial cycle geochronological resolution also supports the practical, long-term comparison of regional demographic data, supporting the exploration of landscape factors that may have influenced colonisation processes and demographic structure (e.g. the location and evolution of major river systems). These approaches and comparisons can also be applied to lithic technology and patterns in the long-term stasis/change of particular lithic industries and technologies.

4.4 Summary

Overall therefore, these frameworks offer a range of spatio-temporal scales through which to explore a wide range of high and low resolution patterns in lithic technology (e.g. manufacturing techniques), lithic typology, and artefact-based demographic signatures. These patterns can be investigated with reference to a range of factors including socio-cultural (e.g. imposed standardisation, the presence of homogeneity/heterogeneity in assemblages), processual/functional (e.g. raw material exploitation patterns, subsistence strategies and activities), landscape (e.g. river system evolution, raw material availability) and environmental (e.g. long-term fluctuations in the magnitude and frequency of glacial/interglacial cycles, cold/warm climatic contrasts, and habitat types). It is vital to stress that these frameworks are not independent. Indeed it should be apparent that the frameworks and their analytical approaches feed back into one another to provide a fuller understanding of the evidence. For example, population patterns associated with individual cold- and warm-climate events will support interpretation of demographic structure data at the glacial/interglacial level. Similarly, patterns in lithic typology and technology at the individual sedimentary unit level should inform interpretation of long-term patterns of technological change or stasis. Finally, it is stressed that these secondary context frameworks will both inform and be informed by, the evidence that is available from the primary context archaeological record. Although the primary and secondary context data sets ostensibly deal with separate data and issues, there is considerable interaction between the two contexts. For example, on-site evidence of a marginal, scavenging hominid would support a secondary context-based demographic model that revealed unstable, fluctuating populations. To illustrate theses linkages, the analytical frameworks highlighted above are illustrated within Gamble's tacking model (1996; Figure 239), modified to incorporate the approaches outlined here (Figure 240).

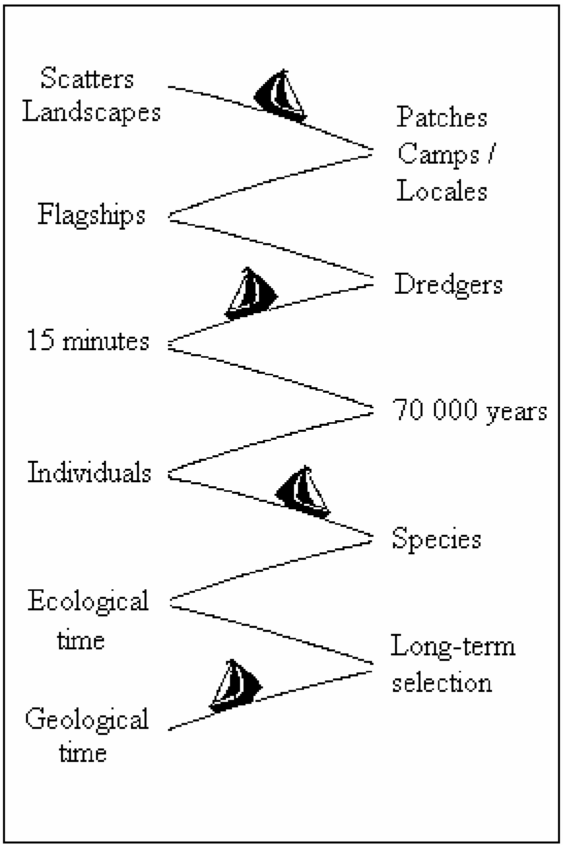

Figure 239: 'Tacking' as a strategy for interpreting the Lower Palaeolithic (Gamble 1996: Figure 7.1)

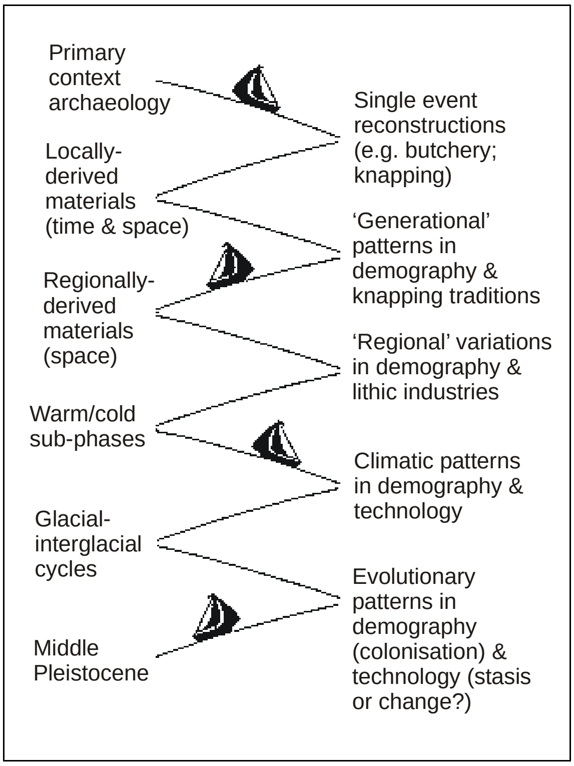

Figure 240: spatio-temporal frameworks for the interpretation of the Lower Palaeolithic (after Gamble 1996: Figure 7.1)

5. REVISITING EXISTING RESEARCH QUESTIONS

The previous section identified a range of spatio-temporal frameworks for the analysis of the secondary context archaeological resource. It also referenced a range of extant Palaeolithic research which has dealt with a number of the same questions (although not always employing secondary context archaeological data to do so). These research themes and questions are returned to here, with a view to the ability of secondary context data to contribute to the resolving of the issues. However, it is obviously vital to reiterate at this point (following Hosfield 1999; Ashton & Lewis 2002), that the interpretation of patterns in secondary context (and sometimes in primary context data) must first consider and assess the potential collection biases associated with the material evidence. Four recent and current themes in of Palaeolithic research are highlighted here:

1. Modelling of hominid demography (e.g. Hosfield 1999; Ashton & Lewis 2002).
2. Identifying colonisation routes and occupation histories (White & Schreve 2000; Ashton & Lewis 2002).
3. Spatio-temporal trends in artefact typology and technology (Mithen 1996; Wenban-Smith 1998; White 1998a, 2000; & Jacobi 2002).
4. Alternative models of technological production, incorporating raw materials (e.g. White 1998b; Ashton *et al.* 1994; McNabb & Ashton 1992), situational contexts (e.g. Ashton *et al.* 1991), and cultural traditions (e.g. Mithen 1996; Wenban-Smith 1998).

5.1 Demographic modelling

In many respects the demographic models of Hosfield (1999) and Ashton & Lewis (2002) have the strongest affinity to the frameworks presented above, since these models employed primarily secondary context lithic assemblage data to model Middle Pleistocene populations in the Solent River basin and the Middle Thames respectively, utilising real world values (Hosfield 1999) and proxy values (Ashton & Lewis 2002). A brief review of the two models is provided here:

- Hosfield's model (1999, 2001) used bifaces as the primary unit of analysis and was driven by assumptions of artefact function, use-life and the frequency of behavioural episodes in which those artefacts were used and discarded. Modelling of the variables generated a range of hypothetical estimates with respect to the accumulation of artefacts over the duration of the Middle Pleistocene occupation of Britain. Hominid group sizes of 25 were assumed, while territory ranges were calculated from raw material transfer distances for the European Lower and Middle Palaeolithic. These hypothetical estimates were compared against the observed archaeological data, which was statistically modelled to account for the partial sampling of the archaeological record, and the comparative differences were interpreted in terms of population densities and the duration of continuous hominid occupation.

  Retrospectively, this model is clearly limited since many of the variables were hugely over-simplified and the approach falls into the trap of over-modelling the data. Moreover the absence (at that time) of suitable geochronological frameworks for the Solent River basin terraces greatly limited the potential geochronological resolution that could be achieved. However, many of the faults of this model were removed by the subsequent work of Ashton & Lewis (2002).

- Ashton & Lewis' model (2002) utilised a simpler and more effective methodology than Hosfield (1999), and was grounded in the MIS-terrace framework developed for the Middle Thames by Bridgland (1994). Artefact densities were calculated for combined totals of bifaces and Levallois material, with the latter artefacts compensating for the reduced prevalence of bifaces in Middle Palaeolithic assemblages. The material was divided into a series of chronological units, following the river terrace units on the River Thames (the Black Park, Boyn Hill, Lynch Hill, Taplow and Kempton Park terraces). The chronological duration of the deposits associated with each terrace unit followed Maddy & Bridgland (2000), and enabled the artefact densities to be standardised by time unit (of

100,000 years duration). The artefact densities were also standardised by terrace (surface) area, urban growth, and quarrying extents (with the last two categories accounting for local variations in archaeological sampling histories). These standardised artefact densities indicated a robust pattern of population decline, using artefacts densities as a population proxy, in the Middle Thames valley during the Late Middle Pleistocene.

Overall, these models highlight the potential value of secondary context data sets for the modelling and interpretation of Palaeolithic demography. The model of Ashton & Lewis (2002) emphasises a basin-wide approach at a glacial/interglacial scale — thus duplicating the lowest resolution example of the spatio-temporal frameworks highlighted above (Section 4.3.3). However, it is suggested that these types of demographic models would also benefit from the exploration of basin-wide patterns at the higher resolution scale of cold/warm sub-phases of the glacial/interglacial cycle (Section 4.2.3). These approaches would reduce the time-averaging of the modelled demographic signal, and also provide a means for testing potential demographic variations in response to climatic variability.

5.2 Colonisation models and occupation histories

Ashton & Lewis (2002) applied their demographic modelling to explore the processes of colonisation and occupation of Britain during the late Middle Pleistocene, and along with the previous work of White & Schreve (2000), these papers provide two of the main discussions of the potential mechanisms influencing the occupation and colonisation of Palaeolithic Britain. A brief review of these works is therefore provided:

- Ashton & Lewis (2002) argued that the formation of the English Channel influenced the cycle and stability of the hominid occupation of Britain, due to the interplay of sea-level and climate change. While they recognise themselves that many of the following factors require further investigation, Ashton & Lewis highlighted issues including the timing of the English Channel breach (a later breach, perhaps in MIS-6, provides a better explanation of the relatively high population levels of MIS-11 and 9 compared to those of MIS-7 and 5e), and changes in the climatic and habitat preferences of hominids during the Middle Palaeolithic. Much of the evidence cited in support of the change in habitat and climatic factors is primary rather than secondary context — including on-site evidence of butchery and hunting strategies, lithic transport and technological mobility, and local habitats and environments. However, the breach timing model does incorporate potential secondary context data, in the form of faunal assemblage comparisons.

- White & Schreve (2000) developed a biogeographical framework of human colonisation, settlement, and abandonment. They proposed mechanisms that linked these patterns with regional palaeogeographical evolution and global climatic change. The framework was tested against the archaeological record and it was concluded that not only were there distinct, chronologically-defined manufacturing traditions, but also that they could be interpreted through the differential ebb and flow of separate, regional populations. Specifically it was argued that the Clactonian represented the early expansion of European populations into Britain during the early post-glacial period (after abandonment during the glacial maxima), while the Acheulean was introduced during a later, secondary phase of colonisation. Finally, during periods of high-sea level isolation, endemic tool-making traditions developed, resulting for example in the twisted ovates of MIS-11. This model utilised a wide range of lithic and biological data, both from primary and secondary contexts, with particular focus upon interglacial assemblages, the presence of Clactonian and Acheulean assemblages, distinctive technological features, and the development of sub-MIS scale chronological frameworks.

As previously, these models highlight the potential of the secondary context data for the interpretation of colonisation patterns and occupation histories. In the case of the Ashton & Lewis (2002) model, secondary context data is primarily employed in the construction of the population model (see above), rather than in the interpretation of the patterns. However, it is argued that higher-resolution demographical modelling approaches (see above) could be employed to test the proposed explanation of changes in habitat and climate preferences during the Late Middle Pleistocene. By contrast, White & Schreve (2000) pre-empt many of the approaches explicitly discussed here, with the usage of secondary context data sets to test their colonisation framework. The model highlights the applications of these data sets and illustrates a range of approaches with respect to lithic technology and typology. However, it is noted that the model focuses primarily on interglacial data sets (MIS-9 and MIS-11), and it is proposed here that secondary context data from the entire glacial/interglacial cycle can yield valuable evidence.

5.3 Lithic industries

Analyses of assemblage composition can be used to identify spatio-temporal trends in the technology and typology of lithic artefact production through the identification of marker artefacts. For example, Levallois technique is widely regarded as having been introduced into Britain during late MIS-9/early MIS-8, as it first occurs in the Lynch Hill/Corbets Tey Formation of the Lower Thames (Bridgland 1996). Both primary and secondary context assemblages can be examined for the presence or absence of such marker technologies, and whilst their presence in secondary contexts can be complicated by factors of both spatial and temporal derivation, resolution to the MIS level is commonly achievable. Due to the historical biases towards the disproportionate collection of bifacial artefacts, it may be argued that secondary context assemblages are of particular use in the search for trends within biface manufacturing techniques (e.g. White 1998a; & Jacobi 2002). Additionally, the examination of secondary context assemblages may assist in the resolution of continuing archaeological debates, for example the temporal relationship between the Clactonian and Acheulean industries (Mithen 1996; White & Schreve 2000). Examples of these approaches are included below, with relevant background to the archaeological industries and technologies:

- Twisted ovates occur in low frequencies in many British biface assemblages, and can be regarded as accidentally created during normal biface manufacture. However in assemblages where they are more common it has been argued that their manufacture was both deliberate and intentional (White 1998a). High proportions of twisted ovates have been recovered from both pointed (e.g. Foxhall Road & Hitchin Lake Beds) and ovate (e.g. Swanscombe, Bowman's Lodge) dominated assemblages, and from both primary and (to a lesser extent) secondary contexts (*ibid*: Table 14.1).

  Assemblages with concentrations of twisted ovates appear to demonstrate a strong chronological correlation. Twisted ovates are virtually absent from sites of a pre-Hoxnian age, such as High Lodge (Ashton *et al.* 1992), Boxgrove (Roberts & Parfitt 1998) or Warren Hill (Wymer *et al.* 1991). They also do not appear to occur in significant numbers in assemblages younger than MIS 11/10, such as those recovered from Purfleet, Stoke Newington, Wolvercote and Furze Platt (White 1998a). The demonstrated chronological trend for greater numbers of twisted ovates within late MIS-11/early MIS-10 appears to be geographically limited to British assemblages, as the record from northern France shows substantial numbers of twisted ovates occurring in MIS-12/11 at Cagny-La Garenne, MIS-10/9 at Cagny-l'Epinette and potentially in MIS-8 at Rue de Cagny (*ibid.*; Callow 1986; Tuffreau & Antoine 1995).

  White (1998a: 103) suggests that twisted ovates may represent a distinctive tradition of manufacture, temporally restricted to sites dated to late MIS-11 to early MIS-10. Whether this tradition occurred as a result of social or technological pressures may be debated, though White suggests that it most likely arose through a combination of factors, and advices against bipartite divisions. As White (*ibid.*) acknowledges, this chronological correlation is based on a small number of sites, and may be subject to revision as dating resolution increases. Therefore the presence of twisted ovates alone cannot be advocated as a chronological marker. However, such a study highlights the ways in which primary and secondary context data sources can be used in conjunction to enhance our understanding of lithic behaviour and variation during the Middle Pleistocene.

- As a typological category *bout coupé* bifaces have been the subject of much debate, with descriptions of their precise characteristics (and the status of individual specimens) varying between researchers. The most rigorous definition was provided by Tyldesley (1987: 155), stating that a *bout coupé* biface is a medium sized cordiform or rectangular biface with a symmetrical planform, straight or slightly convex butt, slightly convex sides and a rounded tip (Figure 241). There should also be marked discontinuity of curvature at the intersection of the sides and butt. Applying these criteria, 75 'true' *bout coupé* bifaces have been recovered from British findspots, of these 37 are unprovenanced, with others recovered from rivers and beaches with some marked only with town or parish data. Despite these problems, *bout coupé* artefacts are considered indicative of the Middle Palaeolithic, particularly Neanderthal settlement during the late Last Interglacial Complex/Early Devensian, in Britain (Gamble & Roebroeks 1999).

The Middle Palaeolithic can be generally categorised by a dominance of flakes and flake-tools manufactured on both Levallois and non-Levallois blanks, with local variations defined by specific forms of biface (e.g. Mousterian of Acheulean Tradition A of south-west France (Mellars 1996). The presence of *bout coupé* uniquely within Britain can be regarded as a further regional variation in Middle Palaeolithic behaviours (White & Jacobi 2002).

In the light of recent dating programs (e.g. Jacobi *et al.* 1998) suggesting a British occupational hiatus from the penultimate glaciation (MIS-6) to the Middle Devensian (MIS-3), the correlation of *bout coupé* artefacts with Last Interglacial/Early Devensian merits re-evaluation (White & Jacobi 2002). This re-evaluation has focused on those *bout coupé* artefacts that are well provenanced, in either primary or secondary context. Of those in primary context, radiocarbon dates are available for Coygan Cave and Kent's Cavern, which while not directly associated with the *bout coupé* artefacts themselves provide dates in the range of 38,684–30,220 BP (*ibid*: 114). These dates are not without contention, but their association with a Pin Hole mammal assemblage type indicates MIS-3 age (Currant & Jacobi 2001). The 'true' *bout coupé* artefacts recovered from fluvial contexts also support a Middle Devensian age in most cases, as exceptions such as the *bout coupé* recovered from Great Pan Farm, Isle of Wight, tend to be poorly provenanced.

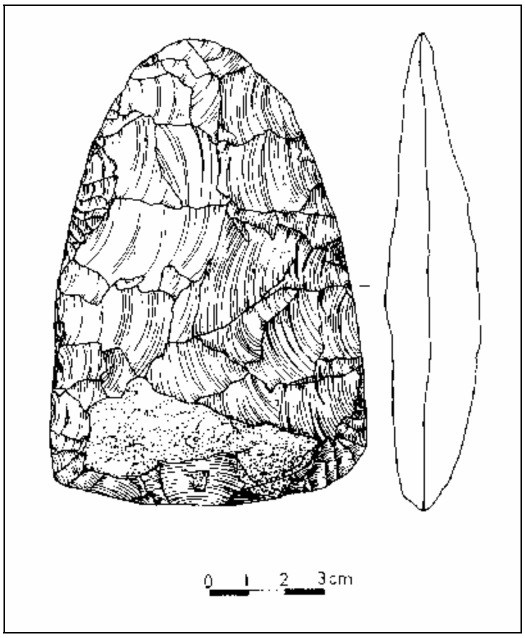

Figure 241: bout coupé *biface (after Coulson 1986: Figure 12.1)*

The research by White & Jacobi (2002) has demonstrated that 15 of the 'true' *bout coupé* findspots are of definite Devensian age, of which 10 can be attributed to the Middle Devensian (MIS-3):

> *"These data strongly suggest that the 'true' bout coupé is strongly associated with the late Middle Palaeolithic in Britain, but it should not be used uncritically as a Mousterian marker fossil…The same situation holds for the wider bout coupé class"*
>
> (White & Jacobi 2002: 123)

The *bout coupé* biface has proved difficult to define both in typological and chronological terms. White & Jacobi (2002) adopted the most rigorous definition of the type available (Tyldesley 1987), looking at the depositional context of all well provenanced 'true' *bout coupé* artefacts, regardless of whether this provenance was to a primary or secondary context. By considering all available data in this manner a revision of the chronological associations of *bout coupé* artefacts has been proposed:

> *"Although many bout coupes must be removed from consideration due to contextual inadequacies with the data, those with adequate information clearly showed a chronological trend which suggests to us that the bout coupé is associated with a recolonization of the British Isles during OIS 3 by Neanderthals making a MTA type assemblage…The Middle Palaeolithic of Britain can thus be split into two broad groups: an early Middle Palaeolithic dated to the Middle Pleistocene, with a high Levallois index and probably Acheulean type handaxes; and a later Middle Palaeolithic marked by MTA that included bout coupes, but in which Levallois was rare."*
>
> (White & Jacobi 2002: 128)

- Mithen (1996) explored the classic typological division between Acheulean and Clactonian industries in the British Lower Palaeolithic through the mechanism of knowledge transfer and social learning. The model stressed that interpretation of early lithic tools through notions of tradition rather than function and adaptation. It also argued that these early technologies were passive reflections of ecological constraints, and were not actively employed as means of restructuring the ecological context (they were therefore markedly different to modern human technologies). A key link was drawn between the sizes of early human groups and the nature of social learning and the strength of cultural traditions. It was proposed that in small groups the opportunities for social learning would be relatively limited. Consequently, knapping practises would be highly diverse due to the weakness or complete absence of cultural traditions (which it is argued would be propagated through social learning). By contrast, in large groups, social learning opportunities are greater, leading to the development of common knapping practises and the reproduction of consistent artefact forms.

  The model was tested against lithic industry patterns in the Lower Palaeolithic, characterised by the distinction between the Clactonian (core and flake) and Acheulean (predominantly biface-orientated) assemblages. These Clactonian and Acheulean assemblages (from both primary and secondary contexts) were argued to have been produced in markedly different palaeoenvironments: Clactonian technologies were associated with interglacial climates and well-forested habitats, while Acheulean industries were linked to glacial conditions and the open tundra. It was suggested that the glacial, tundra environments supported large groups, resulting in strong social learning and the development of social traditions expressed in the technological uniformity of the Acheulean. By contrast, the wooded environments of the interglacials were associated with small groups, low level of social learning and unstandardised, highly variable (Clactonian) technologies.

All of the three models discussed above utilise both primary and secondary context data to explore spatio-temporal issues of technological variability and innovation. It is suggested that the analytical frameworks proposed previously (Section 4) can contribute to all of these case study approaches, both at the interglacial/glacial cycle-scale (e.g. with respect to the macro-chronology identification of marker artefacts), and at the sub-cycle scale. At these finer scales, secondary context data offers the potential to relate patterns in technological production to shorter-term climatic fluctuations (e.g. exploring the patterning proposed by Mithen (1996)), and identify the duration of distinctive phases of tool-making (e.g. as suggested by White (1988a) with respect to the production of twisted ovates).

5.4 Technology and factors of production

Models exploring the factors influencing lithic production (e.g. raw material quality and availability, cultural traditions and situational needs) have typically relied both upon primary and secondary context data sets, focusing upon artefact forms, spatial patterns in primary context data sets, and the structure of archaeological landscapes. A selection of the key concepts with respect to lithic production are summarised below:

- White (1998b) stressed the importance of raw material quality in influencing the outcome of biface form, arguing for a relationship between ovate bifaces and high quality, fresh chalk flint nodules. By contrast, pointed bifaces tended to be produced upon river cobble flint. The model was grounded in the notion that ovate bifaces are primarily produced from flake blanks, which can only be produced from fresh flint. River cobbles are generally unsuitable for the production of large flake blanks due to factors of size and damage during fluvial processes. The model also argued that the ovate was a more desirable form of biface, due to the presence of a circumferential cutting edge, and therefore ovates would typically be produced when high quality raw materials were available. The less desirable points were produced when it was not possible to create ovates from the poorer-quality river cobble flint. The model was tested against both primary and secondary context data sets, set within the context of the contemporary Pleistocene landscape (it was assumed that the nearest available flint resource would be used, irrespective of its quality). The key element of the model was its emphasis upon the constraints imposed by raw material quality, over issues of cultural/industrial traditions which had dominated much of the traditional literature (e.g. Roe 1968b, 1981). However, this model has recently been challenged by Wenban-Smith *et al.* (2000), who noted the presence of pointed bifaces at Red Barns, near a chalk flint outcrop.

- Wenban-Smith (1998) combined issue of raw material availability with notions of *ad hoc* technologies to explain the presence of both Acheulean and Clactonian industries in the British Lower Palaeolithic. The model argued that the flake and core tools of the Clactonian were produced as an *ad hoc* cutting technology, manufactured as needs demanded. Such strategies required flint-rich landscapes (in which a source of raw materials was constantly available), which are proposed to have been characteristic of the early temperate stages of the post-glacial period. As the interglacial progressed, raw material availability became more localised, as fluvial gravels were buried with silts and other sources were covered with vegetation. Under these conditions, the *ad hoc* Clactonian technologies became less viable, and were replaced by portable, curated Acheulean technologies. This model stresses temporal change in tool-making, in response to landscape evolution, rather than focusing upon social factors (e.g. Mithen 1996) or the influx of new populations and cultural traditions (White & Schreve 2000). However, it does assume that the Acheulean and Clactonian are distinctive technological entities within the Lower Palaeolithic record.

- In contrast, Ashton and McNabb (Ashton *et al.* 1991; Ashton *et al.* 1994; McNabb & Ashton 1992) have stressed the importance of the situational context with respect to lithic production. They suggest that the Acheulean and the Clactonian represent different elements of the same technological repertoire, based partly on the recovery of bifaces from assemblages that have traditionally been classified as Clactonian (McNabb & Ashton 1992; McNabb 1996). The potential association of 'Clactonian' and 'Acheulean' elements was demonstrated at Barnham, where artefacts from both traditions were recovered from the same horizon, and it was argued that perceived Clactonian/Acheulean variability reflected the undertaking of different activities in different parts of the contemporary landscape rather than discrete industries. The notion of a baseline technological repertoire (from which both 'Clactonian' and 'Acheulean' artefacts were produced) was also stressed with respect to the production of simple, expedient tools (e.g. flaked flakes) in response to immediate needs and (unknowable) circumstances.

Although some of these models (e.g. White 1998b) stress secondary context data, the spatio-temporal frameworks (Section 4) have a limited potential for contributing to many of the outlined concepts. This reflects the focus upon tool-making variability within local landscapes (Ashton *et al.* 1994), emphasis upon mobile technologies (e.g. Wenban-Smith 1998; Ashton *et al.* 1994), and the discussion of expedient tool-production. These approaches require a degree of data resolution that is unavailable in the secondary context record. However, it is possible to utilise secondary context data to explore broad-scale patterns in biface types (e.g. testing White's (1998b) raw material model) and the potential Acheulean/Clactonian division (e.g. exploring Wenban-Smith's temporal model through patterns in assemblage types over the duration of the glacial/interglacial cycle).

Overall however, it is clear that a number of recent and current research themes in British Palaeolithic studies are amenable to investigation through the analysis of the secondary context archaeological resource. Preliminary case study examples of such approaches are presented in Chapter 9.

6. THE VALUE OF THE ARCHAEOLOGICAL RESOURCE

The secondary context archaeological resource dominates Britain's early prehistoric archaeological record, in terms of the quantity of material, and the spatio-temporal coverage of the assemblages. In many cases, the resource is represented by collections of stone tools (e.g. bifaces), for which relatively little precise provenancing information is available. A key stage in the evaluation of these data is therefore the assessment of the scales of spatio-temporal resolution associated with the assemblages. Given the widespread absence of accurate field data, these assessments are primarily based on the artefacts themselves (with respect to their spatial derivation and re-working) and broad-scale geomorphological mapping of fluvial terrace systems.

The spatio-temporal models presented in sections 2 and 3 proposed a series of analytical scales, based on the relative degree of horizontal and vertical re-working to which the components of the secondary context archaeological assemblages had been subjected. These scales do not identify specific timescales or exact distances in space, reflecting the complexity of the processes being modelled. The analytical scales were based instead upon orders of magnitude, within which the resolution decreased in proportion to the degree of horizontal and/or vertical re-working. The key advantages of these frameworks are that they can be reconstructed on the basis of relatively limited contextual information. The spatial models utilised artefact data (the *état physique*) while the temporal models exploited generic river system behaviours (e.g. upland/lowland contrasts), current models of terrace formation, and low resolution provenance data (e.g. the recovery of artefacts from basal gravels).

The models of spatio-temporal resolution provided a matrix of analytical frameworks, across which different elements of hominid behaviour could be investigated. The frameworks stressed the time- and space-averaged nature of the data, but unlike the majority of existing approaches, exploited these characteristics to explore robust patterning. For example, three frameworks are presented for the exploration of demographic patterns, all at the basin-wide scale, but ranging from short-term traces (lasting a few hundred or a few thousands of years and potentially associated with uniform palaeo-environmental conditions) to long-term signatures, accumulating across single glacial/interglacial cycles. By contrast, the series of locale-orientated frameworks enable short- and long-term patterns of raw material exploitation and its impact upon tool-making to be explored. These approaches therefore provide a long-term perspective upon early prehistoric archaeology and behaviour that cannot be achieved from higher-resolution data.

These secondary context data are dominated by lithic evidence (predominantly core tools and large flakes — although the impact of selective collection histories must always be considered with respect to these data). There are also occurrences of biological data (predominantly large mammal fauna, although other material does occur), although this evidence is more localised, reflecting preservation factors (e.g. soil chemistry). These data have clear, practical applications with respect to the problems of site formation (which is fundamental to the interpretation of secondary context data), through the *état physique* of the lithic data, and the range of lithic and biological artefacts within the assemblages. By contrast, the use of the biological data for palaeoenvironmental reconstructions is more problematic. In those instances where high resolution palaeoclimatic indicators (e.g. beetle assemblages) occur within secondary context sequences (e.g. in localised fine-grained silt lenses within the gravels), it is not possible to relate it to the derived archaeology occurring throughout the sequence. The palaeoclimatic reconstructions based upon these data can provide an indication of possible habitat types that existed at some point during the deposition of the complete sedimentary sequence, but it is not possible to explicitly populate these habitats with either artefacts or hominids. With respect to lower-resolution palaeoenvironmental data (e.g. large mammals) occurring within coarse-grained, gravel units, the same problem exists, namely that direct associations cannot be made between derived lithic materials and derived fauna. However, it should be noted that the two data sets operate at the same order of temporal magnitude, and therefore that provisional comparisons of these time-averaged data sets can be made.

Unlike these palaeoenvironmental questions however, the secondary context resource has clear applications to a range of current behavioural questions in early prehistoric archaeology, as discussed for the Lower and Middle Palaeolithic in Section 5. Inevitably these applications tend towards research themes that operate at the lower-resolution analytical scales, reflecting the minimum chronological and spatial resolutions that are achievable for these data (Sections 2 and 3). Examples include demographic patterning and artefact-based analysis (raw material patterning, industry variability, diagnostic morphologies, and manufacturing processes and traditions). It is stressed that these data can be explored at a series of different spatial and temporal scales, and the interplay between these analytical frameworks provides a more comprehensive understanding of the processes at work:

- For example, demographic models at the glacial/interglacial scale (10^4 and 10^5 years) reveal long-trends in hominid colonisation and population dynamics over the course of the Middle Pleistocene, but reveal little about the ebb and flow of populations over the course of a single warm/cold cycle. These gaps in understanding can be explored through demographic data at the sub-cycle level (e.g. derived artefacts from different sedimentary units in a single terrace sequence, following the Bridgland (1996) sandwich model), which may document fluctuations in occupation histories and therefore reveal hominid habitat and climate preferences. Comparison of river system data may also reveal regional variations in occupation histories, potentially highlighting the importance of a range of factors including habitat preferences, raw material and other resource availabilities, and the role of different networks (e.g. the Thames/Rhine system) in hominid mobility and the ebb and flow of populations.

- With respect to artefact-based analysis, patterns in typology at the glacial/interglacial cycle level may reveal long-term trends in lithic technology (e.g. stability or change), while higher-resolution patterns may indicate shorter-term trends in lithic production, perhaps in response to palaeo-climatic factors. These trends can also be linked to behavioural models of tool-making, for example at Broom the homogeneity of the lithic record over a cold–warm–cold sedimentary cycle (perhaps MIS-9/8/7) is highly suggestive of a typologically diverse, but stable lithic technology. At the higher-resolution scale of the individual units within the sedimentary cycle, the repetitive diversity of the assemblages (Chapter 4) appears to indicate an absence of imposed standardisation upon tool-making activities.

Overall, it is proposed here that the secondary context archaeological resource has a clear, unambiguous value with respect to the investigation of early prehistoric archaeology. It enables the identification of archaeological patterns and behavioural elements that operate at coarse-chronological and spatial levels, and which cannot be identified from high resolution, primary context site investigations. However, it also generates data which can be related back to high resolution studies of hominid behaviour, while the varied spatio-temporal frameworks identified here provide a robust mechanism for the integration of on- and off-site archaeology in time and space.

However, the successful interrogation of this resource is therefore reliant upon:

1. Future field testing of geoarchaeological models of sediment and artefact re-working.
2. Continued refinement of absolute chronological dating methodologies, including optically stimulated luminescence and amino-acid techniques.

3. Ongoing development of geomorphological models of terrace formation and river valley evolution, including improved interaction between the geomorphological and archaeological communities.
4. Further development of geoarchaeological models of artefact transportation in a variety of sedimentary regimes.
5. Targeting of field monitoring of aggregates extraction sites, with specific reference towards sediment dating, geoarchaeological models, and recording of key sedimentary phenomena.

All of these issues relate to the question of how the secondary context archaeological resource is managed, recorded and (potentially) protected — and this theme forms the core of the next chapter.