Neanderthal biogeographic patterns over the Eemian-Weichsellian cycle

Derek Wood

PhD

Archaeology

May 2008

Neanderthal biogeographic patterns over the Eemian-Weichsellian cycle

Abstract

Recent research on Neanderthal extinction has considered the role of climatic and environmental changes during Marine Isotope Stage (MIS) 3 (*ca.* 59-25 ka BP). This thesis explores Late Pleistocene Neanderthal population trends and responses to climate change across four European study provinces and considers the role that climate and environmental change played in their extinction. It is argued that regional population histories are complex; phases of expansion and contraction occurred across a range of climate states. It is concluded that traditional nomenclature i.e. climate stages such as stadial and interstadial are unsatisfactory in themselves for understanding concepts such as migration, extinction and culture change. An alternative model termed *condition: resource variation* is set out in this thesis and its emergence rests principally on the observation that many faunal and floral configurations from the last glacial period have no exact analogies with modern fauna and flora. During the post-Eemian oscillations ecological disruption was restricted to the higher latitudes of Europe and coincided with a time when Neanderthal population levels were low. A further phase during MIS 3 resulted in ecological disruption across the lower latitudes (e.g. parts of the southern province and the Mediterranean basin). In this light the MIS 3 disruptions were not unique, but part of a process operating across the interglacial-glacial cycle. Neanderthal population levels appeared to have increased after Heinrich event 6 (*ca.* 60 ka BP) and continued to rise across a series of major Dansgaard-Oeschger events and Heinrich event 5 (*ca.* 47 ka). Neanderthal population decline did occur during Heinrich event 4 at *ca.* 38 ka prior to a further phase of recovery. It is tentatively concluded the central province offered less-restrictive condition-resource dynamics and this could have been a significant factor leading to the central province serving as a core occupation area for anatomically modern humans, while the adjacent southern and Mediterranean provinces served as the core areas for Neanderthals over MIS 3.

Table of Contents

Chapter 1

Chapter 2

Chapter 5

Chapter 6

Chapter 7

List of Figures

List of Tables

Acknowledgements

I would like to thank my supervisor Geoff Bailey for his enthusuiastic and motivating discussion, his patience and support which has remained as constant and enthusiastic throughout the course of this study as I could have hoped. I also thank my Mother, Margaret Ellen Wood for her patience and words of encouragement, for her gestures and sacrifices, the accumulation of which made this work possible. Without them, this work could not have happened. I dedicate this work to the memory of Luke Tunstall and to my Mother, Margaret Ellen Wood.

Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners. I understand that my thesis may be made electronically available to the public.

Chapter 1
The Neanderthals

1.1 Introduction

The Late Pleistocene marks the terminal stage of the Pleistocene epoch; it encompasses a full interglacial-glacial cycle (Eemian-Weichselian), a period of some 120,000 years. It was truly an extraordinary period of time which witnessed not only the emergence of vastly more elaborate behaviour across parts of the Old and New World, but also a unique event in the anthropological record. For the first time since the evolution of the Genus *Homo*, one of their number, *Homo sapiens sapiens* would go on to successfully populate the globe, while other species of the genus disappeared. It is now largely accepted as fact that parts of Europe and Asia during the Middle and Upper Pleistocene were populated by a closely related (in terms of morphology and behaviour) species to us – the Neanderthals. Early dated Neanderthal sites include Ehringsdorf, (Germany) *ca.* 230 ka (Blackwell and Schwarz 1986), Pontnewydd Cave, (Wales) *ca.* 200 ka ± 25 and Biache-Saint-Vaast, (France) *ca.*175 ka ± 13: (Stringer and Gamble 1993). Their zenith lasted over most of the last interglacial-glacial (IG-G) cycle though they are best known by the 'classic' Würmian north European Neanderthals from France (e.g. La Chapelle-aux-Saints, La Ferrassie and Saint-Césaire), Belgium (Engis and Spy), and the Near East (Amud, Kebara and Shanidar). Late, and in some cases more morphologically gracile Neanderthals include the specimens from Vindija, (Croatia) *ca.* 29,080 ka ± 400, *ca.* 28,020 ka ± 360 (Smith *et al.* 1999), Mezmaiskaya, (Caucasus) *ca.* 29,195 ka ± 965 (Ovchinnikov *et al.* 2000), Zafarraya, (Spain) *ca.* 29,800 ka ± 600, *ca.* 31,800 ka ± 550 (Hublin *et al.* 1995) and Buran-Kaya III, (Crimea) *ca.* 28,520 ka ± 460, 28,840 ± 460 (Pettitt 1999). More recent excavations by Finlayson *et al.*, (2006) on the inner part of Gorham's Cave (Gibraltar) suggest Neanderthal occupation to at least 28 ka BP and most probably down to 24 ka BP. Despite the fact that Neanderthals appear to have shared some behavioural similarities with *H. sapiens sapiens* (e.g. Farizy 1994) fossils attributable to a Neanderthal status are archaeologically invisible after *ca.* 25 ka. Interpretations of these quintessential cavemen have been cast and re-cast for as long as human palaeoanthropology and anthropology have existed as academic disciplines. And despite over a century of intense scientific and public interest, the significance of the Neanderthals in human evolutionary terms still remains equivocal. Certainly almost a century has passed since Boule's (1908a,b) treatment of the La Chapelle aux Saints Neanderthal remains in which he claimed that the Neanderthals were a primitive side branch of the Genus *Homo*. Boule's depictions of the Neanderthals had the unfortunate effect of developing the caricature of the brutish and animalistic cave man, a stamp which has remained synonymous with the Neanderthals ever since (see Hammond 1982 for a review of this theme). Boule's anatomical description was overturned, but the notion that the Neanderthals were socially and behaviourally primitive compared to their Cro-Magnon counterparts remained, and indeed has resonated across the academic literature for much of the 20th and 21st century.

With the onset of the second half of the 20th century, the viewpoints and perceptions of the Neanderthals, at least in evolutionary terms, had begun to change. Hooton (1949) after Drell (2000) had shown that Neanderthals were in fact a geographically widespread and morphologically highly variable population, and this theme was developed further by F.C. Howell (1957) who suggested that Neanderthals were but a 'phase' in the evolution of modern humans (a position he later went on to reverse). However, other proponents of the evolutionary synthesis perpetuated the view that Neanderthals were indeed the precursor phase to European modern humans. In an important paper Brace (1964) captured this view by arguing that continuity between robust to gracile *Homo sapiens* (i.e. Neanderthals to modern humans) was not only possible but indeed occurred. For Brace, the progressive reduction of the Neanderthal midface and dentition toward the modern-looking form was the result of culture i.e. refinements in cutting tools which bypassed the need for a robust paramasticatory structure. In this sense, the *Human Revolution* was to start cutting and stop chewing.

More recently, a number of key symposiums and publications have explicitly attempted to address the 'position' of the Neanderthals in evolutionary and behavioural terms. One important meeting in this respect was the *Origins and Dispersal of Modern Humans* conference held at Cambridge in 1987. This occurred at a time when developments in molecular genetics were providing additional and independent support for new models accounting for modern human evolution and Neanderthal disappearance including the Out of Africa (OOA), or Recent African Origin (RAO) model (e.g. Stringer and Andrews 1988; Stringer 2002b). Arguably the conference volume (Mellars and Stringer 1989) established a strong intellectual consensus and pointed the direction for subsequent research on the foundation that modern human anatomy and behaviour originated in Africa, and dispersed from there to replace archaic populations around the world. The intervening period has witnessed the efforts of many researchers to establish a broadly acceptable mechanism, to say nothing of a demonstration, of why and how replacement occurred. To date, replacement scenarios rely heavily on the idea that social or behavioural differences, typically mediated by a cognitive edge, in a sense propelled modern humans across the globe. In the face of direct competition with cognitively disadvantaged or socio-behaviourally less-advanced populations it is envisaged that modern human culture (i.e. technology, subsistence practises etc) was more efficient and flexible, and that it was a competitive advantage employed by modern humans in the face of competition with archaic groups. Similarly, modern humans are believed to have adopted more sophisticated social networks which are viewed by some workers as the key to unlocking resources from more challenging environmental contexts (e.g. Gamble 1984). Indeed, one of the major aims of those involved in Late Middle Palaeolithic archaeological research has been to demonstrate this mechanism, and in an European context, to specifically show that the Neanderthals were socially and behaviourally primitive to such a degree that they were out-competed by modern humans. One of the major foundations for the cognitive dichotomy argument is in fact an inherent working assumption - that the cognitive differences between Neanderthals and modern humans are reflected in the archaeological record. The longstanding convention, widely accepted by some archaeologists, is that the Aurignacian industry was an integral part of early modern human culture (Mellars 1989a; Kozlowski 1990; see also Bricker 1976 for a useful historical review of the Upper Palaeolithic) and a broad cultural difference between modern humans and Neanderthals. It is thought to have provided modern human populations a suite of behavioural advantages which facilitated the colonization of more challenging palaeoenvironmental contexts particularly during the later stages of Middle Pleniglacial. Historically, the cognitive/behavioural dichotomy debate has been rather inflexible. Traditional approaches partitioned Neanderthals and modern humans into Mousterian and Aurignacian categories respectively, and having done so, the scene was set for a battle of wits, or not, as it turns out, as the respective populations competed (where they met), tracked familiar ecological settings or ventured into new ecological settings. Gradually, the scenario was played out; the Neanderthals ceding territory and resources, and all the while failing to break the inertia of their social landscape. We view this process through rather coarse and oversimplified palaeoclimatic norms (glacial, interglacial, stadial and interstadial) which are used *en bloc* to illustrate the 'the realities' of the Middle and Late Pleniglacial environments. The underlying rationale for replacement, then, is quite clear. The cognitive dichotomy argument (Mousterian versus Aurignacian) serves as a proxy for highly contentious and still unresolved palaeoanthropological argument which contends that Neanderthals and modern humans were different species. By adopting this position, it is easier to partition rigid population units with quite different behavioural potentials. On the one hand modern humans are viewed as behaviourally explosive – they were capable of innovating novel behaviours which were apparently rapidly translated across the species resulting in little or no fundamental differences within or between their regional populations; *the modern condition* fusing and reinforcing anatomically modern human populations over vast areas of Europe. Neanderthals on the other hand were compelled by their own inherent cognitive inadequacies to utilise only a limited range of socio-behavioural responses; their populations boxed-in, restricted and viable only during a narrow range of 'temperate-stadial or interstadial' contexts, increasingly marginalised by competition with modern humans. When climate and environmental change occurred, their *habitats of habit* were disrupted. They were socio-behaviourally incapable of surmounting new environmental circumstances.

The notion that the Aurignacian package provided its authors the flexibility required to adapt to the worsening environments of Early and Middle Pleniglacial European regions arises from observations that indigenous non-Aurignacian Eurasian humans (i.e. the Neanderthals) disappeared, while African migrants equipped with Aurignacian culture, seemingly without biologic safeguards against the hostile pleniglacial environments of northern Europe, survived. This dichotomy is advanced as fact and constitutes a major theme prevalent throughout much of the recent and current literature (e.g. Mellars 1989, 1996; Langbroek 2001) but which in my view is an over-simplification. In a sense it shares the underlying generalisation of the *Human Revolution model* which originally purported that modern human anatomy and modern human behaviour arose synchronously in space and time. Despite the fact that one of its strongest proponents, Paul Mellars, as early as 1987 began to question this position, and the fact that behavioural innovations arose at different times and in different places across Africa (summarised by McBrearty and Brooks 2000), a strong, intellectually hostile climate has buffered any serious consideration that the Neanderthals may have had a far closer relationship with the Aurignacian than is currently conceived. This is a remarkable situation, especially when one considers the essential flimsiness of the supporting evidence in favour of a strict modern human/Aurignacian relationship. This basis for this relationship is clearly worthy of much greater focus. The key assumptions in the debate, as I see them, are as follows. Firstly, Neanderthal behavioural *potential* is perceived in largely pre-modern/pre-social terms. More recently, archaeologists have begun to question this position which accords strict biological/cultural associations while others dismiss the idea as outdated and simplistic (e.g. Finlayson 2000). Secondly, there is an implicit notion that the Aurignacian is a uniform technocomplex; thirdly, that the Aurignacian was demonstratively more advantageous than the Mousterian/Early, or Transitional Upper Palaeolithic; and lastly, that it is indelibly associated with modern humans only (refer to Conard *et al.* (2004) for a critique of this last point).

In competitive exclusion, then, (whether mediated by biologic and/or technological advantages) we have perhaps the most popular mechanism of Neanderthal extinction, a topic which is currently the subject of great interest in Palaeolithic research. This theme has influenced a range of other potential mechanisms of Neanderthal extinction. Again, many models tacitly presume that African human populations were cognitively more advanced than their Eurasian counterparts thus were able to innovate and employ a broader range of socio-behavioural responses in a greater variety of environmental and social contexts. By emphasising major behavioural, social and cognitive dichotomies between African and Eurasian populations this is effectively underscoring the notion that the Neanderthals were a different species.

There are many novel and interesting hypotheses of Neanderthal extinction. Some workers have argued that Neanderthal populations were absorbed into the supposed incoming, larger African populations (Smith 1994; Zilhão and Trinkaus 2003). Other more controversial models state that there were no major behavioural or biologic distinctions between African and Eurasian populations; rather, the evolutionary process was a global phenomenon as Neanderthals and indeed all 'archaic' hominids evolved into *H. sapiens sapiens* (e.g. Brace 1995), or that *Homo sapiens sapiens* emerged as a distinctive species in Africa and replaced all other archaic species by *ca.* 30 ka with negligible levels of interbreeding (Stringer and Andrews 1988). Soffer (1992) suggested that the African migrant’s more developed social-structure provided advantages in, amongst other things, resource acquisition and that this may have led to a competitive advantage. Stringer and Grün (1991) suggested that Upper Pleistocene climate changes disrupted the Neanderthal’s preferred ecological systems, displacing and removing food sources which eventually caused a terminal population decline. Others believe that Neanderthals were components of a megafaunal extinction 'event' that occurred during MIS 3 and MIS 2 (Stewart 2004). These models, as well as more recent explanations with a palaeoclimatic emphasis for Neanderthal disappearance remain far from unequivocal in their conclusions and have proved only one thing: that there is still considerable room for alternative explanations and refinement of existing hypotheses.

More recently, however, non-human causes such as the role of climate in Neanderthal extinction have been considered from a range of new perspectives. Indeed, climate change was considered the core hypothesis by perhaps the most comprehensive treatment explicitly focussing on modern human and Neanderthal population movements within an environmental context - the Stage 3 Project. In the words of Tjeerd van Andel, the project co-ordinator:

> "...the Stage 3 Project...was, and probably still is, the most far-reaching attempt to consider Old Stone Age humans and their cultures in an environmental context"
>
> (van Andel 2003: 257)

This publication has been accompanied by a raft of new models and data both directly and indirectly associated with the issue of Neanderthal extinction (van Andel and Tzedakis 1996, 1998; van Andel 2003a,b,c; van Andel *et al.* 2003a,b; Arnold *et al.* 2002; Mellars 1998; Barron and Pollard 2002; Burke *et al.* 2000, 2004; Davies *et al.* 2000; Shackleton *et al.* 2000; Sánchez Goñi *et al.* 1999, 2000, 2004; Watts *et al.* 1996, 2000; Willis 1996; Willis *et al.* 2000, 2001; d'Errico and Sánchez Goñi 2003, 2004; Sánchez Goñi and d'Errico 2004; Finlayson 2004a,b; Finlayson *et al.* 2004; Gamble *et al.* 2004; Patou-Mathis 2004; Stewart 2003, 2004, 2005; Burke 2006). Many of these discussions have approached the issue of Neanderthal disappearance within the context of the Marine Isotope Stage 3, a period roughly corresponding to the Middle Pleniglacial of the last glaciation between *ca.* 65 to 30 ka (see table 1.1 for the duration of marine isotope stages). Some particularly fruitful and illuminating new thinking has emerged from such research into later Pleistocene population dynamics partly because better chronological resolution is available via radiometric methods which are unsuited to earlier periods. Some of the more notable studies (e.g. Finlayson 2004) have approached the issue of Neanderthal disappearance from the perspective of a single region (e.g. Iberia) but such projects, owing to their local scale of analysis, provide only a partial account of a process that may have been in operation over a much broader temporal and geographical span. We know that Neanderthals existed across broad areas of Europe and Asia during both interglacial and glacial climates for at least 200 kyr thus it seems unlikely that a regional study conducted through a relatively narrow temporal window will illuminate any more than part of the process of Late Pleistocene demographic changes in Europe.

The Stage 3 Project was a large scale, multi disciplinary endeavour that saw climatologists, geologists and archaeologists come together to explore two main themes: firstly, did environmental changes, extreme cold or a failure to implement new means of exploiting cold-adapted fauna result in Neanderthal extinction? Secondly, did modern humans play any part in Neanderthal extinction?

To approach these themes a series of climate simulations for representative periods of the Middle Pleniglacial were carried out. These were (1) a mid-glacial warm event between 45-38 ka which it is claimed was also 'representative' of the 15 kyr phase between 60,000 and 45,000 ka (2) a cold event at 30 ka (3) the last glacial maximum at *ca.* 25 ka BP. According to the study, simulations (1) and (3) worked; however, (2) did not, as it failed to reflect the many cold spikes of the period between 37-25 ka BP. Van Andel and co-workers felt that the open woodland predicted by the model output for this phase was dubious based on the criticism of geologists who argued that permafrost was widespread north of 50°N and palynologists who said that coniferous/deciduous taiga was unlikely to have been as common as the model suggested. So (2) was rejected, and in its place (3) was ‘stretched’ and extrapolated over a much wider time-frame encompassing 37 ka through to the glacial maximum. This was perhaps a contentious decision, as various pollen data situated in the more central and continental regions of Europe (e.g. Füramoos) testify to the persistence of coniferous and/or deciduous taxa throughout temporally pronounced 'stadial' episodes of the later Middle Pleniglacial. By van Andel's own admission, the second of the three simulations was a period characterised by oscillatory climate and a variety of climatic and environmental parameters no doubt fluctuated, for example, precipitation, CO_2, edaphic conditions etc. The complex interplay between these factors would have led to the differential expression of e.g. permafrost features and evidence for thermal improvement e.g. forest expansion throughout such a climatically diverse phase. Moreover, one of the main conclusions drawn from the study, and emphasised by van Andel (2003:259) was that the glacial climate was not as hostile as previously thought. North of the trans-European mountain barrier summer conditions were comparable to those in, for example, northern Canada around Hudson Bay (ibid.).

In the Stage 3 Project modern human and Neanderthal response to climate change was assessed against data from the Greenland ice cores. It was explicitly stated that any attempts to track or measure modern human/Neanderthal response to millennial scale climate change are unrealistic, because in many cases the error margins associated with many archaeological dates exceed the duration of the events themselves. This is a sobering fact, and one that is difficult to come to terms with, particularly when the focus of interest is how past human populations, faunal and floral communities responded to change, or how adaptations, cultural and biological, emerged or were influenced by episodes of rapid climate change. So instead, archaeological dates were analysed against a far broader temporal backdrop encompassing phases of 4-5 kyr or so. Some important findings, summarised in brief include the following:

1. Migrations took place across the northern Mediterranean and throughout Europe south of 0°N during the post-MIS 4 phase.
2. A two-pronged withdrawal occurred westward to the Atlantic shore and southeast to the Black Sea after 37 ka.
3. Modern humans and Neanderthals used similar migration routes between 48-38 ka.
4. Modern humans and Neanderthals were adapted to temperate conditions - at best.
5. The Mousterian and Aurignacian people all show similar tolerances to wind-chill, temperature and snow.
6. The so-called hyperarctic Neanderthal body form provided only a modest advantage, and in order to survive MIS 3 winters additional artificial insulation would have been necessary.

The theme of whether or not the demise of the Neanderthals was due to climate and environmental change will be examined in more detail in chapter 3. Suffice to say, not a great deal is ventured in terms of a hard and fast explanation for Neanderthal disappearance in climatic and environmental terms (but see Stringer *et al.* 2003 Chapter 13). In the end van Andel suggests (and not perhaps without a note of regret),

> "Perhaps we must turn...to looking modern humans straight in the eye and say 'What did you do'?"
>
> (van Andel 2003:262)

The Stage 3 Project relied principally on the GISP2 ice-core catalogue for its palaeoclimatic reconstruction as well as a means to infer in what ways European environments were disrupted. But there is now a growing corpus of research questions whether the palaeoclimatic changes reflected in proxies such as GISP2 are suitable proxies from which to infer palaeoenvironmental change on a much wider European scale. In other words, is terrestrial environmental change across broad areas of Europe closely related with the Greenland records in terms of synchronicity, frequency and magnitude? A further problem relates to the exactitude at which any such events can be securely correlated and dated when one acknowledges that the uncertainties in the exact timing of the fluctuations are comparable with the durations of the fluctuations themselves (Braüer *et al.* 2000). To complicate the picture further, archaeological dates from MIS 3 range beyond dendrochronologically calibrated ^{14}C, and extend into a period when ^{14}C production was highly irregular. All of these factors thereby serve to seriously undermine any hard and fast claim, or attempt to correlate human presence with specific millennial-scale climate changes, and from this, to similarly infer that population decline occurred as a consequence a particular palaeoclimatic episode or even series of centennial/millennial-scale episodes. Even if such a claim can be substantiated, it should not deter us from examining the palaeoclimatic and palaeoenvironmental trends that influenced Neanderthal habitats over a broader timeframe than has been hitherto conducted to date in the literature. This is not to say that palaeoclimatic reconstructions have not been made and applied to questions of Neanderthal adaptations. They have; however, in most cases the resultant palaeoenvironmental reconstructions have been rather vague and born out of broad, coarse-grained descriptions of palaeoclimatic entities such as interglacial and glacial. Clearly, any assessments of human behaviour conducted across such backdrops are vague and fail to convey the underlying complexity which characterised the last glacial period. There is also an emerging theme becoming more and more prevalent in the archaeological literature which seems to convey the notion that rapid palaeoclimatic changes were a phenomenon synonymous with MIS 3, however, as we shall see, this position may be overstated. Global climate between 120 ka and 10 ka BP experienced at least 23 well-expressed warming and cooling cycles known as Dansgaard-Oeschger (DO) events (Rahmstorf 2002). Not all of these occurred during MIS 3, nor were they all recorded in the Greenland ice-cores, while some may have resulted in greater palaeoenvironmental disruption than others. Some regions at a point in time may have been characterised by, for example, mosaic ecological settings with a diverse fauna and flora with only a limited resilience to climatic variation. When major climate oscillations to cold or warm states occurred such settings would have witnessed more disproportional levels of disturbance than those regions comprised of more resilient and flexible ecological variables (i.e. ecological settings with faunal and floral variables better suited to the direction of the new climate state). At another point in time, the population structure, faunal and floral diversity of a given region may have been quite different, and by implication the disruption potential. Underlying all of this is the fact that human population structure was no doubt a fluid quantity, marked by variation in birth, death, immigration and emigration variables, from one climate event to the next. Thus it is too simplistic to infer a simple iterative decline in 'population' based on a pre-conceived idea that the transfer from one 'stadial' to 'interstadial' (and vice versa) was, at all times and in all places accompanied by environmental disruption of a scale to threaten the existence of regional human populations.

1.2 Rapid Climate Change

Rapid palaeoclimate changes have been defined as,

> "Alternating cold and warm conditions on centennial to millennial time-scales"
>
> (van Andel 2002:3)

Palaeotemperature reconstructions based on $\delta^{18}O$ variations from ice cores suggest warm oscillations during the Middle Pleniglacial resulted in 7°C increases, (only 2°C below the Holocene mean) with cold conditions close to glacial maximum temperature (Grootes *et al.* 1993). Warm events, or Dansgaard-Oeschger (DO) events, seem to have lasted a few millennia while cold events lasted only a few centuries, with transitions between the cold to warm states occurring over decades (Rahmstorf 2002: Fig. 3). Sarnthein *et al.* (2002) stressed that amelioration on this scale occurred over a few decades or less, again based on $\delta^{18}O$ variations in the Greenland ice core data. These findings are in line with Pailler and Bard (2002) who reported that DO oscillations are features of MIS 4 as well as MIS 3. Hinnov *et al.* (2002:1213) characterize the DO events as,

> "Strong and abrupt changes in atmospheric conditions over the [Greenland] ice sheet and in the North Atlantic peripolar regions in sea surface temperature [at] lower latitudes, DO oscillations are manifested as alternations between dry and humid hydrologic states in both continental and marine proxies".

Hinnov *et al.* also recognised that DO events occurred during MIS 4 but noted that they increased in spectral power between 38 ka and 30 ka. Sánchez Goñi *et al.* (2000) see climate instability particularly DO events as 2000-3000-yr oscillations related to the instability of the Nordic coastal ice sheets.

> "[We] expect, therefore, that these dramatic events could influence the continental environments and, thus, the regional vegetation"
>
> (Sánchez Goñi *et al.* 2000:394)

But they go on to provide a caveat with the following,

> "However the continent's response to these high-frequency climatic changes is still poorly known" (ibid)

One attempt to measure the impacts of Middle Pleniglacial DO events on terrestrial settings was made by Müller *et al.* (2003). They found that if climate deteriorations were not long or severe enough to completely extirpate boreal forest refugia situated north of the Alps, then even short-lived phases of amelioration would have acted on these forest remnants resulting in reforestation of open areas on timescales of centuries. Such findings have important implications for those workers such as Finlayson (2004) who seek to demonstrate that the 'Neanderthal Niche' (mixed, rich ecotones) was encroached on and replaced by a vast carpet of barren steppe-tundra during the Early and Middle Pleniglacial, a process which Clive Finlayson views as a strong factor in Neanderthal extinction. Other approaches such as Stringer and Gamble's (1993) treatment used broad palaeoclimatic packages each with their own distinctive sub-set of conditions such as a 'representative' mean annual temperature to illustrate the range of environments inhabited by Neanderthal populations. Indeed, this widely cited treatment is illustrative of the willingness of archaeologists to rely principally on the glacial, interglacial, stadial and interstadial nomenclature for their palaeoenvironmental reconstructions. These are often vaguely or generally applied as entities that resulted in distinctive and predictable environmental outcomes over time (e.g. Stringer and Gamble 1993). As we shall see, stadial and interstadial phases were at times comprised of similar ecological components such as comparable faunal and floral configurations, or were temporally and geographically variable from one interstadial or stadial to the next. In other words, stadial and interstadials were not simply replicated and hence comparable temporally and/or spatially. The current glacial, interglacial, stadial and interstadial vocabulary does not always reflect this complexity and this serves to obscure an understanding of the true nature of the environments inhabited by Palaeolithic humans.

1.3 Thesis Aims

- To broadly assess Neanderthal biogeography and to examine whether climate change was a key driver in their disappearance from Europe.
- To see how successive stadials and interstadials may have remodelled European landscapes, and whether or not stadials and interstadials specifically, in their current application, are meaningful units of measurement from which to assess Neanderthal climatic adaptation.
- To throw new light on the responses of Neanderthal biogeography to the effects of discrete episodes of palaeoclimatic/environmental change over the Late Pleistocene (*ca.* 130-30 kyr).
- To outline an alternative methodological approach to palaeoenvironmental reconstruction.

1.4 Thesis Objectives

- To review the biological and behavioural evolutionary frameworks and the role played by climate and environment in shaping these processes.
- To assess Neanderthal biogeographic patterning to explore themes of co-existence and competition; to determine if and when palaeoenvironmental circumstances were ever suitable for competitive exclusion to take place.
- To use palaeoclimatic and palaeoenvironmental proxies to understand the diversity of terrestrial settings in the study provinces over the IG-G.

- To examine Neanderthal biogeographic patterns over the broad timeframe of the last IG-G in order to provide context to the supposed demographic changes in late MIS 3.
- To understand the nature of rapid climate change by examining Heinrich events 6 to 3 as well as selected DO events and Neanderthal biogeographic responses to these events.
- To use archaeological data as a proxy for Neanderthal populations and to determine associations, synchronicity or trends between these populations and selected palaeoclimatic regimes, changes and transitions.
- To identify environmental variables associated with both stadial and interstadial climate phases in order to show that a bipartite application of these systems may be unwarranted in terrestrial contexts.

1.4.1 Why investigate these issues over an interglacial-glacial cycle?

There is no doubt that MIS 3 was a significant period of time during which several considerable episodes of palaeoclimatic change occurred and which were strongly registered in the northern hemisphere proxies (e.g. GRIP 1993). Yet it would be premature for archaeologists to infer that MIS 3 witnessed unique palaeoclimatic and palaeoenvironmental configurations relative to earlier phases of the IG-G. Detailed palaeoenvironmental reconstructions are now emerging that point to a far more complex palaeoenvironmental picture than has hitherto been appreciated. Before we can accept claims that Neanderthals were ill-suited to episodes of MIS 3 palaeoclimate disruption, we must first attempt to assess Neanderthal biogeography over a much broader timeframe. Indeed, the aims and objectives of this thesis are geared to address the very suitability of the climate change hypothesis by looking at the broader pattern of Neanderthal response to climate change. There is now a significant corpus of archaeological, palaeoclimatic and palaeoenvironmental data covering much of the IG-G cycle and this requires a more detailed analysis. The IG-G timeframe is interesting for several reasons: firstly, it encompasses a major palaeoclimate and palaeoenvironmental transition - the Saalian to Eemian (*ca.* MIS 6 to 5e); secondly, it includes what I have termed the 'post-Eemian oscillations' (*ca.* MIS 5d-a to 4); thirdly, it covers the transition to the Weichselian glacial as well as the Middle Pleniglacial oscillations (*ca.* MIS 3); lastly, it covers the disappearance of the Neanderthals and the appearance of anatomically modern humans. These time frames are shown below in table 1.1.

Table 1.1 Climate Phase

Climate Phase	**~Kyr**
Saalian/Eemian Transition (MIS 6/5e)	130-129
Eemian (MIS 5e)	128-107
Post-Eemian Oscillations (MIS 5d/5a)	106-73
Early Weichselian (MIS 4)	72-60
Middle Weichselian (MIS 3)	59-30
Appearance of AMH	?55-35

The Eemian

MIS 6/5e transition: This represents the end of the long Saalian glacial phase and the onset of the Eemian. This transition from glacial to interglacial climate may be the highest-magnitude event of the last 140 kyr. I will investigate the nature of this change and attempt to assess Neanderthal biogeography over this phase.

MIS 5e thermal optimum: At this time vast areas of Europe were fully forested. If regional Neanderthal populations were present during the Eemian optimum, we can suggest that they were equipped with a specific suite of socio-behavioural adaptations, and posit that some groups had managed to adapt to more challenging conditions. If this can be demonstrated, then notions of the Neanderthal's inability to adapt to 'hard environments' (e.g. Gamble 1999) require revision.

Post Eemian Oscillations

MIS 5e/d transition: It is probable that the deterioration of the closed-Eemian forests into the subsequent stadial (?open) landscapes was a heterogeneous process both in space and time due to local and regional factors. This phase is important because we should begin to see the development of sub-regional refugia, both for humans, flora and fauna in the archaeological record. This should provide our first opportunity to test the compatibility between marine-based reconstructions and other more detailed indicators such as pollen evidence (i.e. to explore the connections between marine/ice-core data that point to cold/treeless landscapes, and the terrestrial evidence which may suggest otherwise).

MIS 5d/c transition: Some proxies e.g. marine and ice-cores suggest fluctuations between mid-glacial and interglacial climate occurred on centennial scales. If these can be coupled with clear palaeoenvironmental responses, then we are some way to demonstrating that environmentally heterogeneous study provinces may have obtained. This phase may be analogous to MIS 3 type disruptions.

MIS *5c/b transition*: Marine/ice-core data suggest that the northern hemisphere ice-sheets were well-developed and that much of Europe was characterised by cold and open conditions. This phase is important as it again provides an opportunity to develop an understanding of the palaeoenvironmental responses to a major interstadial-stadial couplet in a pre-MIS 3 context, and to test whether inferences based largely on ice-core $\delta^{18}O$ fluctuations are supported by terrestrial pollen data.

MIS 5b/a transition: This phase offers an insight into the nature of the transition into the Early Pleniglacial. Was the transition gradual and earlier in some regions and later and more abrupt in others?

MIS 5a/4 transition: In general terms MIS data suggest that Early Pleniglacial Europe was marked by cold and open conditions. However, some provinces may have maintained forest refugia. The integrity of the marine-based cold and/or open projections will be tested in this reconstruction.

The Early and Middle Pleniglacial

MIS 4: For the purposes of this study the Weichselian proper will be examined under headings Early and Middle Pleniglacial (*ca.* 70 to *ca.* 60 ka & *ca.* 59 to *ca.* 25 ka respectively). By this time Neanderthal distribution across most of Europe is generally believed to have been minimal, with occupation largely restricted to refugia in the south, or further east in the Levant (Lahr and Foley 2003). It will be interesting to explore the palaeoenvironmental evidence to see in what way MIS 4 amelioration improved the environments of the higher latitudes and whether Neanderthals tracked such changes.

MIS 3: The Middle Pleniglacial appears to have witnessed a series of palaeoclimatic changes that resulted in complex palaeoenvironmental outcomes with no modern analogues (van Andel 2003; Stewart 2004). Some workers believe that low-magnitude, high-frequency events may have been equally, or more stressful than high-magnitude, low-frequency events that occurred earlier in the IG-G cycle. In both cases there is still considerable uncertainly with regard to the timing, synchronicity and extent of terrestrial disruption. A broad view will be taken, and a qualitative reconstruction will be made based on pollen profiles with good chronological controls such as Lago Grande di Monticchio (Mediterranean province), La Grande Pile, Les Echets (southern province), Füramoos, Jammertal and Samerberg (central province). Pollen sequences can provide a far more accurate realisation of how environments responded to climate change whereas ice-core catalogues such as GRIP/GISP2 provide only locally applicable palaeotemperature values from which more general palaeoenvironmental reconstructions can be inferred.

1.5 Thesis structure

In chapter 1 I set out to introduce the dominant conceptions of *Homo neanderthalensis* (sensu Stringer & Andrews 1998) or as some authors prefer, *Homo sapiens neanderthalensis* (sensu Finlayson 2004b). I discuss models and mechanisms of Neanderthal disappearance and highlight some of the longstanding difficulties bound up with notions including competitive exclusion, acculturation or cognition. I contend that a simplistic palaeoclimatic terminology is generally ill-applied to the reconstruction of Neanderthal habitats. As a result these units of measurement are probably too coarse to identify conditions and resources which I hypothesise may have characterised both stadial and interstadial events. I show via the aims and objectives how I will approach current climatic and environmental models; how I intend to critically evaluate these later in the thesis and the rationale behind the call for a new theoretical approach to the issue of hominin response to palaeoclimatic/environmental change.

Chapters 2 and 3 deal with two of the major strands of human evolution research relevant to this study: a) evolutionary frameworks and; b) extinction mechanisms. Chapter 2 is a review of the current state of the art with regard to human evolutionary frameworks (e.g. Recent African Origin and Multiregional theory); I discuss models and mechanisms of Middle and Late Pleistocene hominin dispersal; the emergence, both in space and time of modern anatomy and behaviour; the degree to which palaeoanthropological and genetic evidence can be used to support or refute ideas of speciation, assimilation and gene flow between Late Pleistocene Eurasian and African populations. I review the evidence and offer my own thoughts on this extremely contentious debate.

In chapter 3 the principal concern is to address those models which view the singularity of MIS 3 as the major factor involved in Neanderthal extinction.

Palaeoclimatic explanations are a relatively novel and recent hypothesis for Neanderthal extinction, and represent a clear departure from the dominant theory i.e. their demise was the direct result of modern humans having some competitive, cognitive, behavioural or technological edge (e.g. Pettitt *et al.* 2000).

In chapter 4 I examine the *Palaeoclimatic and palaeoenvironmental background.* It appears that some notable past and recent approaches have approached the issue of Neanderthal extinction from rather narrow regional and temporal windows e.g. Iberia (Finlayson 2004b; d' Errico and Sánchez Goñi 2003) and MIS 3 (Stage 3 Project 2003) respectively. This section is intended to provide a detailed review of the literature so that reconstructions can be made for four European study provinces (northern, central, southern and Mediterranean) which are shown below in fig 1.0.

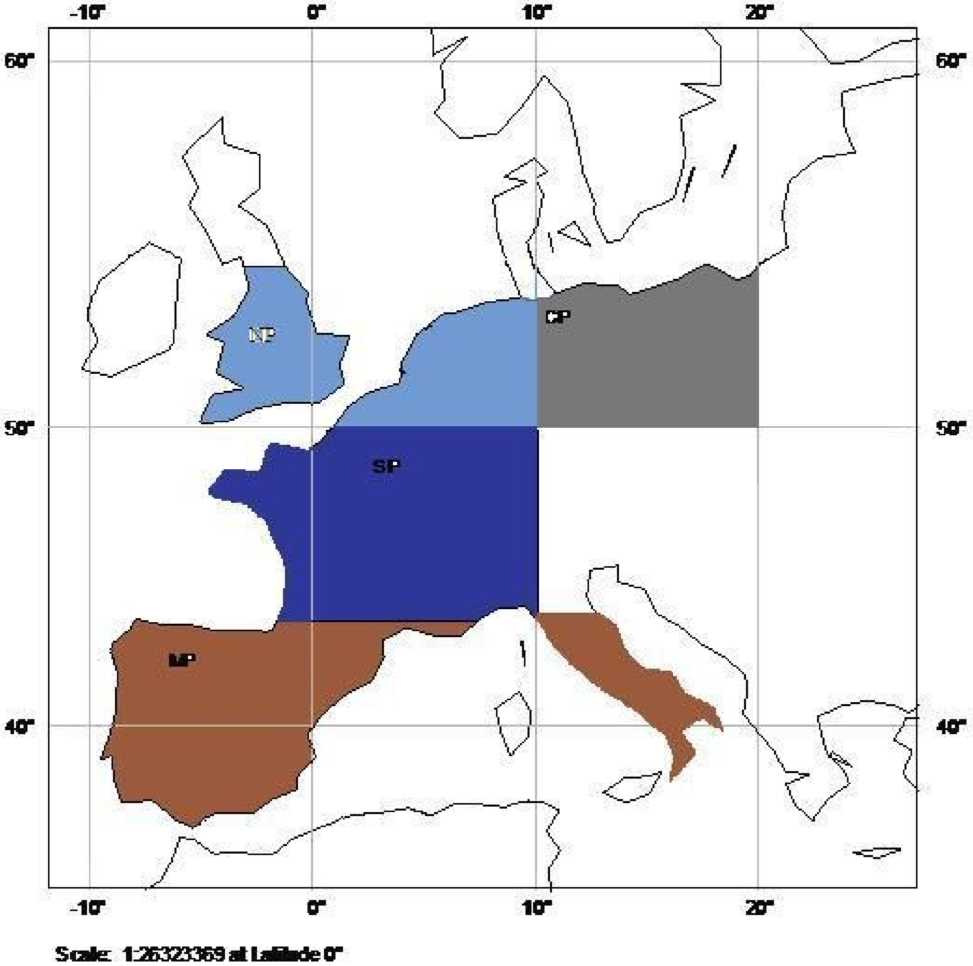


Fig. 1.0 the Study Provinces

The argument I set out to convey is that climate phases such as stadials were not in fact comprised of the same ecological components repeated from one event to the next, and aim to show that stadials and interstadials are associated with significant environmental heterogeneity across time and throughout the study provinces. One of the main ideas stressed time and again throughout the thesis is that palaeoclimatic nomenclature reconstructed from high-quality catalogues may not convey the palaeoenvironmental reality. Indeed, there appears to be a strong assumption that palaeoenvironmental responses to palaeoclimatic stimuli (e.g. over successive interstadial events) were duplicated over time. For example the southern province was not always characterised by boreal parkland during interstadial events; stadial events, for instance, did not in fact lead to analogous palaeoenvironmental responses from one stadial event to another. The final aim is to identify episodes of rapid climate change precedent to MIS 3, as many workers seem to operate on the untested assumption that Neanderthal populations faced such changes for the first time during MIS 3.

Chapter 5 reconstructs Neanderthal biogeography in the study provinces over the course of the last IG-G. It centres on the following issues: What were the Neanderthal palaeoenvironmental optima? How did the Neanderthals cope with change? Can we define more closely the palaeoclimatic and palaeoenvironmental tolerances of Neanderthal populations and theorise the where and when of population decline? Can we identify regional patterns in terms of growth (expansion), core areas and decline? Is it possible to explore and reconstruct Neanderthal biogeography and does this shed any new light on the models set forth in Chapter 3? To approach these issues the following was carried out. Firstly, a comprehensive archaeological database gleaned from the literature was assembled. These archaeological data were used to develop insights into Neanderthal population centres over time. A variety of different scales of analysis were employed. For example, archaeological dates were analysed against the traditional MIS framework, while other analyses compared the same data against a range of $\delta^{18}O$ values, Heinrich events and DO events with the aim of investigating how population response may have varied at the regional scale.

In chapter 6 I introduce the condition-resource hypothesis and discuss its implications for socio-behavioural change, palaeoenvironmental reconstruction and Neanderthal biogeographic changes and the implications for extinction. Condition-resource variability proposes that traditional approaches to palaeoclimatic and environmental reconstruction are self-restricting in their continued use of terms such as stadial and interstadial as clear, separate entities comprised of different e.g. temperature and precipitation regimes, as well as different floral and faunal configurations. My aim is to show that this was not always the case, and to flesh-out the hypothesis that stadials and interstadials in particular, shared some affinities both in time and space. The first implication of this model questions the notion that more frequent palaeoclimatic change, particularly during the second half of MIS 3 resulted in clear *a priori* palaeoenvironmental changes across Neanderthal habitats. The second implication is for those models that use palaeoclimatic catalogues such as GRIP/GISP2 to infer that clear and repeated episodes of palaeoenvironmental change were the cause of Neanderthal extinction without first demonstrating that such events have clear terrestrial equivalents.

Chapter 2
Evolutionary Frameworks

2.1 Introduction

> *Did modern behaviour and anatomy emerge gradually over time and space, or did they both emerge in close synchrony at a discrete location?*

For decades, archaeologists and palaeoanthropologists have approached these themes via the two most dominant paradigms in human origins research: *Out of Africa* and *Multiregional theory*. On the one hand, palaeoanthropologists in support of their respective theory have equated varying levels of importance to (predominantly) cranial traits of Pleistocene hominin remains, leading to major differences of opinion over what constitutes a 'modern' or 'archaic' trait (Stringer and Gamble 1993; Trinkaus and Shipman 1993). On the other, hand archaeologists have become embroiled in similar controversies relating to timing and location, as well as the significance of behavioural innovations as expressed in the archaeological record. Much of this debate has centred on what is referred to as the Middle/Upper Palaeolithic transition and this has not been without criticism (e.g. Lindley & Clark 1990). As we shall see, terminology such as 'Modern', 'Archaic', 'Upper Palaeolithic' and 'Middle Palaeolithic' represent biologic and cultural constructs that are meaningful only on a very general level, and which are greatly reduced in their explanatory potential as anatomical and behavioural changes are examined at closer resolution. Added to this are uncertainties regarding an agreement on the operational definitions of terms such as *'anatomically modern humans'* and *'behaviourally modern humans'*. There is no doubt that these concepts have served to crystallize methodological approaches and in doing so provided sign posts from which to determine or estimate the direction of change in the archaeological and palaeoanthropological records. As useful as such terms may be by serving as a handy way of systemising methodological approaches, it is at the same time reasonable to enquire whether the continued use of such terminology serves to obscure more subtle relationships, or the embracing of more novel approaches to what is now a longstanding issue – the fate of the Neanderthals. Are the morphological and behavioural differences between Neanderthals and modern humans really that vast? Did the humans of the Late Pleistocene understand, share and experience similar notions of 'difference' that are viewed today by archaeologists and anthropologists in the material record and interpreted as intrinsic points of departure between Cro-Magnon and Neanderthal?

2.2 Interaction: some theoretical considerations

Before discussing the evolutionary frameworks and 'explanations' for the disappearance of the Neanderthals, it is necessary to explore the theoretical basis for Neanderthal and modern human interaction. Undoubtedly, the *potential* for interaction between Neanderthal and modern humans would have been far greater than the meagre clues of the archaeological record currently suggest. Contentious or purported 'associations', depending one ones viewpoint, between the Aurignacian and Châtelperronian people (irrespective of their biological affiliation) in a few western European archaeological sites tells but a fraction of the story (or none at all) of the human dynamic operating between Africa and Europe. Certainly the potential for interaction would have existed throughout all climate regimes and not just as part of biogeographic changes driven by glacial episodes that resulted in periodic encounters between European Neanderthals and African *Homo sapiens* at the triple-junction of a few Levantine cave sites every few tens of thousands of years. Not only would the potential for interaction change with time, but so too no doubt, the nature of the interaction. Let us envisage a situation where population (a) and population (b) shared morphological similarities alone but where quite separate at the socio-behavioural level. In these situations it is quite possible that negligible interaction between the populations would have taken place. In another instance, this time where similarities between populations (c) and (d) exist, say, for example, that mate recognition was comparable, then greater levels of integration could have occurred inspite of morphological, or other socio-behavioural differences. The point is that we cannot infer that the contact dynamics between Eurasian and African populations was governed by the same 'rules' across the Middle and Later Pleistocene. It would be unwise to assume anything but the contrary in light of the deep time-depth of archaic *Homo* in general both in Africa and Eurasia. In an interesting paper, Graves (1991) reached the conclusion that Neanderthals and modern humans shared gross behavioural similarities (as recognised from archaeological evidence) and this would have led to situations where small, vulnerable groups interacted to reduce inbreeding. There is no doubt that Neanderthals and modern humans did share some important behavioural parallels such as similar subsistence strategies; for example they seem to have hunted much the same faunas and utilised similar environments (Burke 2000, 2004; d' Errico *et al.* 1998). Graves (1991) also suggested that Neanderthal females were more robust and active participants in the hunting and gathering process, and that modern human males may have recognised this advantage over the presumably more passive and gracile Cro-Magnon females.

A common argument used to support the idea that Neanderthals diverged into a separate species is that they were restricted in the periphery of western for much of the Middle and Late Pleistocene. However Simmons (1994) has questioned the notion that regional populations, particularly western European and Near Eastern ones were frequently isolated over this timeframe. Simmons maintained that human populations were diffuse, but linked via changing migration routes and contact zones, all of which was driven by the broader pulse of climate and environmental change. Implicit in this idea is the suggestion that Eurasians were not in fact disarticulated isolates, but had a mutually reinforcing genetic and cultural affiliation with African and Asian populations.

Graves (1991) and Simmons (1994) convey the sense that a human dynamic underlies the overarching evolutionary and cultural frameworks and that terminology such as 'archaic' and 'modern' at least from a theoretical perspective may obfuscate a more subtle process. Ideas such as these, as novel as they are, represent but two examples of a clear departure from the consensus view. But before I turn the evolutionary theories which are the main focus of this chapter, I will first introduce the Neanderthal history of interpretation. Henceforth the terms *Homo sapiens neanderthalensis*, Eurasians and Neanderthals will be used interchangeably yet their meanings are analogous unless otherwise stipulated i.e. when discussing different evolutionary models.

2.3 Historical Perspective

In 1829 the fossilised remains of a child were discovered at Engis (Belgium), and in 1848 a second fossilised human was recovered from Forbes Quarry (Gibraltar). However the antiquity and significance of these fossils insofar as they represent what we now know to be the earliest Neanderthals was not appreciated until much later. In 1856 workmen at the Feldhofer grotto in the Neander Valley (Germany) discovered the remains of what they initially believed to be a bear. These remains were brought to the attention of Johann Carl Fuhlrott, a teacher from the nearby town of Mettmann. He recognised that the bones were in fact human, and enlisted the help of Professor Hermann Schaffhausen from the University of Bonn in describing the specimen. Following Schaffhausen's anatomical analysis of the remains, the discovery was jointly announced as an ancient human in 1857. Despite the fact that Schaffhausen had clearly recognised the antiquity of the find, his interpretation of the fossil was less inspired. The supposed primitive nature of the skull shape drew Schaffhausen to the conclusion that it was extremely ancient, with no ancestral relationship with modern Europeans whatsoever.

In 1864 the Irish anatomist William King announced that the Feldhofer remains represented a new species which he coined *Homo neanderthalensis*, after the valley in which they were found. Hence it was the Feldhofer remains, despite being the third discovery of their sort, which became the type fossil for the species. King's contention was fiercely opposed by the influential German professor of anatomic pathology, Rudolf Virchow. Virchow argued that the Feldhofer bones were the remains of a modern human, and that the peculiarities of Feldhofer remains were pathological hence non-evolutionary. Virchow's interpretation prevailed, largely because of his standing at the centre of German science as much for the rationality of his argument (Trinkaus and Shipman 1993).

The early 20th century saw a rash of other Neanderthal discoveries. Most are the fragments of skulls jaws and teeth however there are some well-preserved and near-complete specimens e.g. Le Moustier, La Chapelle-aux-saints, La Ferrassie and La Quina (France), Shanidar (Iraq) and Krapina (Croatia). But it was the analysis and description by Marcelline Boule (1911, 1913) of the La Chapelle aux saints specimen that was to fix the importance of the Neanderthals in the evolutionary debate for the first half of the 20th century. Boule's detailed studies, centered on the La Chapelle-aux-saints specimen, were accepted as representative of the quintessential Neanderthal morphology. The skull endocast was so simple as to indicate only the most basic of cognitive capacities, while its poor posture relative to Australian Aborigines (what he viewed as a 'low-race') indicated that Neanderthals were undeniably a separate species and not part of our recent ancestory (Stringer and Gamble 1993). His unflattering description, based upon many features which were in fact pathological such as arthritis, was used to illustrate the primitive nature of the Neanderthals and their evolutionary proximity to the apes. These misrepresentations were propagated widely during the early 20th century as a series of images (e.g. Stringer and Gamble 1993: plate 3), that were taken as representative reconstructions thereby creating a long-standing assumption that the Neanderthals were crude, cave-dwelling creatures and subsequently disregarded as a 'side-species'. In 1911 the anatomist Arthur Keith re-appraised the anatomical evidence and concluded that the Neanderthals locomotive ability was the same as that of modern humans. He commissioned a radically different portrait of the Neanderthals, one characteristically human, showing a cultured 'man', wearing a necklace of animal teeth, contemplating, carefully manufacturing stone tools as he sits by a controlled fire (Stringer and Gamble 1993: plate 2). But Keith himself was later to reverse his viewpoint (Keith 1915, 1929 cited by Stringer and Gamble 1993) following the discovery of the now discredited fossils of Piltdown (Hooton 1931) and Fontechevade (Boule and Valois 1957) that suggested fully modern humans had a truly ancient origin.

By the second half of the 20th century the belief that fully modern humans had a truly ancient origin was being abandoned with the realisation that the fossil specimens used to substantiate the claim were,

> "…evidence which was either dubious or downright
> flimsy and equivocal"
>
> (Howell 1957:341)

Indeed this period ushered in a much needed revision of the Neanderthal reputation. For example, Hooton (1949) recognised that Neanderthals were a geographically widespread species and one characterised by far more anatomical variation than the 'classic' French specimens, while Howell (1957) argued that the western European lineage was but one of several demes that had a varied temporal and spatial distribution. The mid 20th century also witnessed a reappraisal of Boule's La Chapelle aux Saints interpretation where it was subsequently recognised that the Neanderthal skeleton was comparable to modern humans, and the proposed simian gait was unfounded and better explained by arthritis (see Trinkaus and Shipman 1993 for discussion). With the correction of these positions came the realization that humanity may have in fact varied from the 19th century belief in western cultural superiority, and that other lineages of the Genus *Homo* could have lived along side modern humans. By 1943 the position had changed considerably, and the question was not so much *did* Neanderthals play a part in modern human evolution as much as *what* part did they play? Some workers had begun to approach the issue of continuity at the regional level and one particularly influential figure with this regard was Weidenreich, who, in 1943 argued that modern humans emerged from archaic hominins such as *Homo erectus* in Asia. Such was the importance of these ideas that they directly led to the development of one of the most popular though contentious paradigms of human evolution: regional continuity (Brace 1964). Other workers namely Wolpoff *et al.* (1984) have modified regional continuity into what is known as multiregional theory, which will be looked at more closely below.

2.4 Recent Developments

One of the central aims of both palaeoanthropology and evolutionary biology is to reconstruct the phylogeny of the Genus *Homo*, that is to say, the evolutionary history and the relationships of species and sub-species of this genus. The evolutionary structure of *Homo* is commonly expressed using phylogenetic trees (e.g. Stringer and Gamble 1993:63). The basis for establishing phylogenetic relationships is called *systematics*. An understanding of systematics is important prior to drawing inferences on the relationship between Neanderthals and modern humans based on their gross morphological similarities alone. This is because anatomical similarities may have a non-evolutionary explanation. For example unrelated species may, via convergent evolution, adopt similar biological adaptations and in doing so, resemble one another relatively closely. These similarities are known as *homoplasies*. Conversely, similar biologic responses in two species that are traceable back to a common ancestor are known as *homologies*. Hence, it is only through the identification of homologies that one can *begin* to argue that a possible biological affinity exists between two similar looking organisms thus argue that an evolutionary relationship exists. This is because homologies can be *recently derived* (apomorphic) or *ancient-retained* (plesiomorphic) features. Only shared-recent homologies (known as *synapomorphies*) can indicate a close evolutionary relationship. The method used to group organisms via shared derived characteristics is known as *cladistics*, and this is a common though contentious treatment applied to the fossil record in general in the attempt to understand our evolutionary trajectory more accurately.

Scientific methods of skeletal analysis and the dating of palaeoanthropological and archaeological material have established the African continent as the birthplace of the earliest hominins. The Australopithecines (*ca.* 4 myr), *Homo habilis* (*ca.* 2 myr) and *Homo erectus/ergaster* (*ca.* 2 myr-1 myr) attest to Africa's unparalleled hominin time-depth (Klein

1999). These same scientific methods indicate that between *ca.* 1.7-1.9 myr the first major detectable migration out of Africa occurred as *H. erectus/H. ergaster* reached parts of China and Indonesia. This dispersal has been coined *Out of Africa 1* (Stringer and Gamble 1993:35), but see Dennell and Roebroeks (2005) for alternative viewpoints to the Out of Africa 1 model. In 1976 W. W. Howells suggested that Africa was again the source of a second major dispersal, this time by *Homo sapiens.* This migration, it was argued, provided the stock for later human populations across Asia and Europe but it did not implicitly or explicitly make the claim that the dispersal of African humans was linked to or the result of a speciation event.

Boule and Valois's 'Pre-*sapiens*' theory considered both *H. neanderthalensis* and *H. sapiens* as contemporary populations with European fossils such as the Fontchevade specimen representitive of the modern human line. However, this model was rejected by Stringer (1974) who demonstrated that the morphological features from fossils such as Fontchevade used to infer modernity were inapposite. Stringer, in the same publication, also rejected the *Unilinear* or *Neanderthal Phase* model proposed by Hrdlicka, Weidenrich and Brace. Stringer argued that the metrical differences between the crania of *H. neanderthalensis* and *H. sapiens* were too large to support the idea of evolutionary continuity from the former to the latter over such a small period of time. This realisation was born from important breakthroughs with regard to the chronological relationships of early Late Pleistocene fossils from the Levantine (Skhül, Amud) and Moroccan (Jebel Irhoud) fossil record, of which the former in particular have a considerable history of interpretation. For example an early interpretation by McCown and Keith (1939) saw the Mount Carmel remains (Skhül and Tabun) as a single-species characterized by lots of anatomical variation,

> " [As] different breeds of humanity…but breeds of the same stock"
>
> (McCown and Keith 1939:265)

In 1981 Stringer and Trinkaus compared the Shanidar Neanderthal with Eurasian Neanderthals and concluded that there was a close phylogenetic relationship both in terms of both shared-primitive and shared-derived features. The only similarities between the Neanderthal samples and the Skhül/Qafzeh sample were unimportant in evolutionary terms i.e. they were plesiomorphic features. Conversely, the apomorphic features of the Skhül/Qafzeh samples displayed more affinities to modern humans than the Neanderthals. This suggested comparable features between Neanderthals and early modern humans were retained features, while those of cladistic significance to *H. sapiens sapiens* were absent from the Neanderthal samples. This view was supported by Valledas *et al.* (1988) who interpreted the Skhül and Qafzeh specimens as examples of the first fully modern African migrants and a different species to other penecontemporary humans that inhabited the same region e.g. the Tabun and Amud Neanderthals. By 1998 Stringer was firmly of the view that both modern humans (e.g. Skhül, Jebel Irhoud and Amud) and Neanderthals (e.g. Tabun) had inhabited the Levantine regions during the Late Pleistocene.

Further transitional-looking fossil discoveries such as Omo Kibish 1 (Ethiopia) as well as specimens from Border Cave and Klaises River (South Africa) are considered representatives of perhaps the earliest anatomically modern humans, and were used to refute the Neanderthal Phase and Spectrum Hypothesis models (ibid.). The evidence for transitional fossils akin to the Levantine and African specimens was (and still is) lacking in parts of Europe and Asia, and while fossils such as Maba (Guandong, China) and Ngandong (Indonesia) though modern looking, are not preceded by any obvious archaic, transitional forms akin to those observed in Africa (e.g. Broken Hill etc). This was interpreted as evidence for absence of in-situ evolution in non-African contexts and led to Stringer (1992) coining the *Out of Africa II model* (OOA II) (also called the *Recent African Origin*, *African Replacement hypothesis* or the *Replacement hypothesis* hereafter referred to as *RAO*). This hypothesis contends that *H. sapiens sapiens* emerged in Africa as a new species between 200 to 100 ka, before migrating into Asia and Europe and rapidly replacing archaic populations with negligible or no levels of interbreeding having occurred at all. The real controversy with the model and which draws the distinction between it and Howells 1976 proposal is that the morphological differences between Late Pleistocene African *H. sapiens* and Eurasian *H. sapiens* are of the order to split these populations into separate species (*cf.* Rigaud 2000). Such a claim relies principally on the cladistic approach and this is not without its critics. For instance the modern human phenotype is characterised by significant variation and this has created uncertainties regarding what level of morphological variation in fossil samples constitutes a new species (Tattersall 1986). Moreover, many of the morphological traits viewed as 'unique' to Neanderthal populations (known as autapomorphies) such as the occipital bun, suprainiac fossa, supraorbital torus, are in fact present in other populations but just positioned differently (Lieberman 1995). Also, demographic patterning and structuring both in Africa and Eurasia was in all likelihood dynamic across the course of the Pleistocene resulting in blurred and/or diffuse population boundaries, sub-populations, as well as varying degrees of gene flow (Simmons 1994). Hence, one of the classic pre-requisites for speciation – geographical isolation, remains extremely difficult to demonstrate. To date there is no evidence that conclusively shows that the late Upper Pleistocene populations of Africa and Eurasia were incapable of inter breeding because of inherent biological constraints.

In an attempt to address this issue, genetic studies were directed toward palaeoanthropological research in the 1980's as an independent measure of the strength of fossil-based evolutionary models. Early work on beta-globins displayed patterns consistent with ideas that modern humans had a recent African origin (Wainscoat 1986). Other work carried out on Mitochondrial DNA studies from 140 diverse modern individuals displayed two main phylogenetic branches, African and all others. The African branch displayed the greater number of mutations which are thought to have taken 200 kyr to form; hence the African branch was said to have originated at *ca.* 200 ka. No older mtDNA sequences were discovered, hence Neanderthals and *H. erectus* genetic contributions to extant populations of modern humans were deemed negligible (Cann *et al.* 1987). These advances in human genetics, combined with palaeoanthropological evidence led Stringer and Andrews (1988) to emphatically claim that all modern humans originated in Africa and that multiregional theory and geneflow could be discounted as meaningful evolutionary processes. However the genetic data that Stringer and Andrews claim largely rested on was shown to be inconclusive when the same data were used to produce other non-African rooted phylogenetic trees (Templeton 1993). Despite this, the original study by Cann *et al.* (1987) has *still* been used in a variety of recent publications and combined in various degrees with palaeoanthropological evidence as a reference supporting a recent African origin for modern humans (McBrearty 1990; Ambrose 1998; Disotell 1999; Sykes 1999; Stringer and Davies 2001). By 1993 Stringer had softened the RAQ model to an extent by accepting that gene flow may have been more significant than 'negligible'. This shift in position came in part from the realisation that late central Eurasian Neanderthals displayed more progressive features, while early modern humans displayed high incidences of Neanderthal-like anatomical features (Smith 1994). Other variants of the RAO model include the *Afro-sapiens hypothesis* of Braüer *et al.* (1989, 2004). In this scheme it is still hypothesised that modern humans evolved in Africa, with the process observable via early archaic *Homo sapiens* (Bodo, Broken Hill and Ndutu), to late archaic *Homo sapiens* (Laetoli, Omo 2 and Florisbad) and finally to anatomically modern *Homo sapiens* (Omo 1 and Klasies River) (Bräuer 1989). However this hypothesis contends that anatomically modern humans entered Eurasia gradually as part of a long-term process, with ongoing co-existence between resident and migrant populations that would have resulted in hybridization with varying levels of regional continuity and replacement (Bräuer 1984b). Accordingly there was no complete replacement of indigenous Asian and Eurasian populations. The Assimilation Model discussed by Snith (1994) contends that varying processes of gene flow, demic diffusion and assimilation are the,

> "Responsible way to look at the phenomenon of modern human morphology"
>
> (Smith 1994:244)

Smith (1994) believes that Neanderthal genes may have been important contributions in quantitative terms to subsequent human populations and that a smaller contribution of Cro-Magnon genes could have been responsible for driving quantitatively significant morphological changes and the impression of a replacement scenario during the Late Pleistocene. This model attempts to reconcile the cultural and biologic divide (implicit in RAO) between 'Neanderthals' and 'modern humans' with the adoption of a largely theoretical position based on equivocal genetic grounds. Nevertheless, this model does indeed find some support, particularly from the central European Neanderthal samples, which appear to be transitional between Neanderthals and early modern humans. Despite the softening of the RAO 2 position since 1993, advocates still maintain that any so-called transitional morphological characteristics in Late Pleistocene archaic fossils are retained plesiomorphies or are not homologous. They argue that the morphological characteristics of *H. sapiens sapiens* are so distinctive, only a putative, discrete episode of local evolution may sufficiently account for them. Indeed, more recent scientific breakthroughs in evolutionary genetics may have swayed the argument back in favour of the pure replacement advocates. The sequencing results of mtDNA analysis from the Neanderthal type-specimen discovered at Feldhofer cave in 1856 (Krings *et al.* 2000), as well as specimens from Mezmaiskaya Cave (Ovchinnikov *et al.* 2000) and Vindija 75 (Krings *et al.* 2000) have all shown Neanderthal mtDNA to be well outside the range of variation observed in modern human mtDNA. This was interpreted as further proof that the Neanderthals were characterised by an evolutionary trajectory adjacent to our own.

The RAO hypothesis is quite straightforward in its claim that the earliest modern humans evolved in Africa somewhere between 200 ka and 100 ka. According to Stringer (1988, 2002, Stringer and Gamble 1993) some 'modern' anatomical traits first emerged in Middle Pleistocene African populations of *Homo rhodesiensis* or *Homo heidelbergensis*, which appear to have been geographically quite well spread e.g. Broken Hill (Zambia) dated between *ca.*300 ka and 125 ka (Klein 1983) and Bodo (Ethiopia) at *ca.* 600-400 ka. Transitional *H. sapiens* dated to the late Middle and early Upper Pleistocene may include Zuttiyeh (Middle East), Florisbad and Ngaloba (South Africa), Jebel Irhoud (North Africa) Omo Kibish 2, Guomde and Eliye Springs (East Africa). The so-called transitional *H. sapiens* do not display any unique set of defining characteristics because modern traits and archaic traits are present in different frequencies across all specimens. Some of the earliest candidates for fully modern human ancestry include the Omo Kibish 1 (Stringer and Gamble 1993:129) and the Herto specimens (Clark *et al.* 2003) both from Ethiopia. Other fragmented and geographically widespread modern human remains include those from Klasies River Mouth which date to *ca.* 120-70 ka and Border Cave (South Africa) which may be as old as *ca.* 80 ka (ibid.). The earliest evidence for extra-African modern humans is as we have seen the Levantine fossils which include the Skhül and Qafzeh remains.

However, the antiquity, as well as the species attribution of the South African and Ethiopian fossils as modern humans has been criticised by the proponents of multiregional theory. For example it has been reported that there are considerable uncertainties regarding the dating and provenance for Omo Kibish 1 and Border Cave respectively (Wolpoff 1989). While it is accepted that the human fossils from KRM shelter 1a and 1b have a secure chronological setting dating between 60 ka and 120 ka (Deacon 1989) the modernity of the specimens has been questioned. Commentary from Wolpoff (1989) addressed the reduced or absent mental eminences (chin) on KRM 13400, 21755 and 41815 which makes these fossils, in Wolpoff's eyes, comparable in form to the Neanderthal specimens 206/231 from Vindija (Croatia). The reduced or absent mental eminences on most Neanderthal fossils is indeed one of the most defining characteristics, while conversely, they are viewed as synonymous traits in modern humans. Only KRM 16425 displays a developed mental eminence but even this could be a function of its adolescence (Wolpoff and Caspari 1996) in which case it would be comparable to the Vindija juveniles e.g. 279/274. Wolpoff and Caspari (1996) argue that if KRM is indeed representative of the earliest anatomically modern humans, similar 'transitional' humans should not be observed in other temporal and spatial contexts as modern morphology would only appear in one place,

> "[prior to] a superior group sweeping around the world
> [which] explains the spread of modernity".
>
> (Wolpoff and Caspari 1996:168)

Wolpoff argues that if the idea of a recent African origin is correct, then specimens from geographically disparate locales such KRM and Qafzeh displaying different degrees of *modernity* (in the sense Stringer implies) is in fact an absurd concept and is better explained by an accretionary evolutionary process. In this light the modernity of KRM would be better interpreted as a function of gracility which is in turn a consequence of the size or youth of the specimens in question. Wolpoff believes that the ascription of modernity, determined from ambiguous samples which are then extrapolated as benchmarks to measure against other human populations is unsound. It is suggested instead that 'modern' features varied in their numbers and frequencies in Late Pleistocene human populations and that this has been incorrectly interpreted by RAO proponents as proof that *archaic* and *modern* populations were *co-existing, interbreeding* or being *replaced*. The reality, Wolpoff thinks, is that such nuances reflect a variable, single population. This theme will be discussed in more detail in the following section.

2.5 Multiregional Theory

An altogether different evolutionary mechanism to that of a recent African origin is favoured by the proponents of *Multiregional Theory (MRT)*. The seeds of this approach can be traced back to Weidenreich (1943) who suggested that modern human evolution was a global phenomenon. This is to say that *Homo sapiens sapiens* emerged from several loci namely Asia Minor, eastern or southern Africa, north China and the Sunda Islands via an orthogenetic process. This model has been criticised for its apparent teleological prediction that anatomically modern humans were in a way the 'final' stage in the evolutionary process. The Multiregional Theory was developed in part as a response to this criticism and differs from the orthogenetic stance by emphasizing the importance of inter-regional gene flow in the evolution of *Homo sapiens sapiens* (Wolpoff, Wu and Thorne 1984, Relethford 2001). In contrast to the orthogenetic process, regional populations were not separate entities directionally bound to become anatomically modern but part of the 'whole'. Proponents of this model argue that anatomical variation between the centre and the edge of this single entity is normal, and that this provided the basis for regional variability i.e. ethnicities or races. Indeed, they argue that morphological variation is to be expected and can be observed in both extinct and extant human populations. MRT does not predict 'modern human origins' and believes the quest for this objective is futile (Wolpoff and Caspari 1996, Wolpoff *et al.* 2000); instead it seeks to account for the *pattern* of human evolution. Hence 'multiregional' does not mean independent multiple origins, nor does it mean parallelism i.e. the coeval appearance of modernity across distinct regions (Wolpoff *et al.* 2000). Rather, all regional populations were maintained by gene flow from the 'centre' towards the 'edges' against local selection and drift. However supporters of RAO argue that the levels of gene flow required to facilitate MRT are implausible (Stringer 1989). Genetic evidence suggests however that modern human mtDNA has a long evolutionary history with no single source (Templeton 1993) supporting the notion that ancestral populations may have been linked together in the past via a process of gene flow. Recently, Wolpoff and co-workers stated that, "*less than one migrant per generation is sufficient*" (Wolpoff *et al.* 2000:134) to maintain viable genetic connections between populations.

MRT views morphological variability in the Pleistocene fossil record as a function of natural differentiation of a widespread species (Wolpoff 1989). Anatomical differences between populations were further influenced by local environmental effects yet this was moderated by genetic drift and gene flow. Both neutral traits and non-neutral traits of the human phenotype were influenced by various evolutionary forces differently. Neutral traits were influenced by drift, population size, mutation rates, gene flow, and the changing frequencies of alleles and not necessarily new alleles while non-neutral traits were influenced by natural selection (Relethford 2001). It has also been argued that natural selection operated at the level of the genome, and that this would account for the apparent absence of Neanderthal mtDNA in modern human populations. This is an interesting caveat to consider for those who argue genetic evidence does not support a Neanderthal contribution to present day modern populations.

MRT contends that certain anatomical traits present in archaic regional Pleistocene populations were carried on into some modern populations, thereby proving that a structured, regional evolution has taken place (but see Lahr 1994 for a critique on the morphological basis of this claim). However, proponents of this model dismiss the notion that overriding similarities between some Pleistocene fossils with modern human populations means that the latter arose solely from the former, or that modern humans have a single African origin. They argue instead that a higher incidence of Pleistocene African traits were carried into modern populations simply because Pleistocene Africa housed a larger population than adjacent regions, a contention that is even supported by proponents of RAO e.g. (Stringer 2001). Simply stated, the classification of non-African Palaeolithic humans into 'modern' or 'archaic' classes rests on whether they portray similarities with present day humans. Those which do not are removed as candidates for ancestry. This approach has been criticized on the basis that many modern traits are not ubiquitous in Pleistocene humans (Hawks and Wolpoff 2001).

The Multiregional and Recent African Origin theories are compatible in a limited sense as they agree that the process of evolution, from archaic to modern, occurred somewhere. But these models are diametrically opposed in terms of the nature of inter-continental population dynamics during the Middle and Late Pleistocene. On the one hand, MRT advocates archaic-modern continuity in central European Late Pleistocene Neanderthal populations, as well as between Australasian *H. erectus* and modern humans. RAO on the other hand envisages a strictly African origin for all extant populations. To resolve this stand off, palaeoanthropology has turned to evolutionary genetics as an impartial means of assessing the respective merits of the current evolutionary paradigms. By no means however does the genetic evidence speak for itself and the proponents of the competing theories emphasise the strengths and weaknesses of the genetic data in different ways. Proponents of RAO emphasise how modern African populations are characterised by greater numbers of mtDNA mutations than non-African populations such as the modern European groups. This degree of variability is thought to reflect the time elapsed since population members shared a common ancestor, hence the higher degree of variability suggests a greater antiquity for the African material (McBrearty 1990). According to the proponents of RAO the immaturity of non-African mtDNA relative to African MtDNA was caused by a population crash that occurred in Africa resulting in a drop in mtDNA variability, or a genetic bottleneck at *ca.* 120 ka (Stringer 2002). It is presumed that the remnants of this population crash migrated and spread into Australasia and Eurasia while the sister branch maintained its presence in Africa. However Wolpoff (1989) believes these conclusions are equivocal and are based on dubious causes and assumed mtDNA mutation rates. For example, mtDNA mutation rates of between 2% and 4% per million years are required to marry archaeological and genetic evidence for the colonization of New Guinea and the Americas. These rates, extrapolated linearly back in time, suggest that the human and chimpanzee divergence occurred at *ca.* 2.7 ma. Few palaeoanthropologists would agree with a divergence date of 2.7 ma and indeed this date contradicts the available fossil, blood protein and genetic evidence which points to a date of 5 or 6 ma. MtDNA mutation rates of 0.71% per million years were favoured by Nei (1987) which in turn places the human and chimpanzee split at *ca.* 6.6 ma, an altogether more accurate correlation with the fossil evidence. These mutation rates would also push back the divergence of *H. erectus* populations to *ca.* 850 ka and in doing so support the notion that they were viable ancestors for subsequent regional populations of *Homo sapiens*.

As we have seen earlier, the mtDNA from several European Neanderthal fossils was sequenced and the apparent differences between these and modern humans were enough to place them well outside the range of variation witnessed in modern human populations. It is on the face of it surprising that these findings are supported by vocal proponents of MRT such as Relethford (2001). He agrees that the average number of sequence differences between Neanderthal and modern human mtDNA exceeds the differences within both modern human populations and *single* chimpanzee species. However the differences between Neanderthals and modern humans are less than those between chimpanzee sub-species. As he points out, two out of three chimpanzee sub-species are capable of interbreeding. If we accept that closely related species with greater mtDNA differences than Neanderthals and modern humans can interbreed, then it at least suggests admixture could have occurred between these Pleistocene populations. So it seems that the question of whether or not the Neanderthals were a different species cannot be answered satisfactorily one way or the other based on our current understanding of mtDNA variation alone. Current evidence does not rule out the potential for Neanderthal and modern human interbreeding because no satisfactory, objective handle can be established over what measure of mtDNA variation constitutes speciation. A second issue concerns the relative genetic contribution made by Neanderthals to modern European populations. In simple terms, if Neanderthals are genetically closer to their immediate descendents - European modern humans (i.e. there is an evolutionary relationship between the two) then regional continuity could be argued. Again, this scenario of Neanderthal contribution to modern humans (particularly modern Europeans) has been rejected by Krings *et al.* (2000) because Neanderthal mtDNA is no more similar to modern Europeans than it is to any other regional population whether European, Asian or African. This lack of regional affinity between ancestral and descendent groups is seized on by supporters of RAO as it apparently indicates that Neanderthal mtDNA differentiation occurred prior to modern human mtDNA regionalization, or in other words, before the emergence of our species. Yet Relethford (2001) argues that MRT does not predict that Neanderthal mtDNA will be any more similar to living European mtDNA than mtDNA from other regions, only that there will be no significant regional affinities. Presumably this is because interregional gene flow has prevented any one region from genetically drifting too far outside Wolpoff's 'whole'. These data cast doubt on MRT only when human evolution is viewed as separate, regionalized components – a recurring misrepresentation of MRT as Wolpoff *et al.* (2000) emphatically stress.

2.5.1 Levant

It was mentioned earlier that the interpretation and evolutionary significance of the Levantine hominins (Skhül, Qafzeh, Tabun and Amud) has undergone several revisions and re-interpretations over the last several decades. In keeping with this trend, Kramer *et al.* (2001) have questioned the anatomical distinctions accorded to the Late Middle and Early Upper Pleistocene Levantine sample. They argue that it is impossible to satisfactorily demonstrate that a unique set of anatomical features distinguishes one portion of the Levantine sample from another, and that the absence of any real behavioural distinctions between the Skhül and Qafzeh and their Tabun and Amud 'counterparts' provides additional support for the null hypothesis that a single human species occupied the Levant at the onset of the Late Pleistocene. Instead Kramer *et al* argue, rather vaguely it must be said, that 'climate oscillations' i.e. glaciations in Europe and desertification in Africa could have resulted in what may be visualized as demographic buffer zones, principally situated in the Levant (see also Foley 1989; Simmons 1984 who discuss similar themes) where populations of eastern/northern Africans as well as western European populations retreated to, during glacial episodes. Surprisingly, Kramer *et al.* brush-over the emerging chronological resolution available which seems to suggest the Tabun and Amud fossils significantly post-date the Skhül and Qafzeh remains and go on to infer that,

> "In fact there is no reason to expect that a significant influx of European (or other) populations only happened once, since the climatic conditions influencing population movements and human range expansions and contractions were multiple and cyclic throughout the Pleistocene".
>
> (Kramer *et al.* 2001:61)

For sure, this hypothesis is eminently plausible. However current chronometric dating of the sites does not in any way suggest that these Levantine specimens were co-existing (Valladas *et al.* 1988). If by way of 'interaction' they believe that Tabun was coeval with or pre-dated Skhül and Qafzeh, Kramer *et al.* perhaps overlook some important dating and stratigraphic problems (see Stringer 2001 for a review of these issues). Hence the conclusion reached by Kramer *et al.* (2001), that the Skhül/Qafzeh/Tabun/Amud hominids are demonstrative of African and Eurasian population co-existence across the late Middle and Upper Pleistocene is tenuous at best. It is, nonetheless an interesting hypothesis and there is some merit in the idea of a behaviourally similar though anatomically varied population(s) inhabiting the Levantine region which may have been more stable in ecological terms than the adjacent European and African continents. Perhaps this hypothesis has some merit after all in that it side-steps an absurd situation: that the demarcations between Neanderthal and modern human populations were such that they *each* exercised a cultural preference for a specific cave in the Mount Carmel complex not only once but over many tens of millennia.

2.5.2 Australasia

It was noted by palaeoanthropologists in the "*Origins and dispersal of modern humans: behaviour and biological perspectives*" volume (edited by Mellars and Stringer 1989), as well as in other publications (Bar-Yosef and Vandermeersch 1981; Valladas *et al.* 1988; Smith 1982, 1984; Wolpoff *et al.* 1984), that the recent fossil record from the Near East, central Europe, China and Australasia does not fit neatly into any single evolutionary scheme. More recently, workers have highlighted that the course of recent human evolution is still poorly known across south-east Asia and India (Shea 2006). Some workers, led by Wolpoff, have argued that the morphological differences between African, Asian and Chinese *Homo sapiens sapiens* are such that they do not support a single African origin. As such it is these fossils which are used to provide the main thrust of MRT, and which are said to demonstrate clear evidence for regional continuity. Indeed Simmons (1994) has supported this position by arguing that if modern humans did evolve in Africa and spread from there into other parts of the world, then African fossils such as Omo 2 (eastern Africa), Ngaloba (southern Africa), Florisbad (southern Africa) and Jebel Irhoud (northern Africa) are the candidates against which ancestral-descendant relationships should be measured. However Simmons (1994) concludes that none of these African fossils have any obvious morphological similarities with their Asian counterparts, and that the fossil record especially in eastern Asia displays some *ca.* 0.5 myr of evolutionary continuity from *Homo erectus* at Sangiran, Sambungmachan, and Ngandong through to Kow Swamp and Coobool Crossing, culminating in later specimens such as Willandra Lakes (perhaps a source of modern aboriginal populations). Wolpoff, Wu and Thorne (1984) invested heavily in the idea that the early Australasians are characterised by clade characteristics so different from contemporary African fossils that they represent a unique regional evolutionary trajectory from an archaic to modern morphology. This position built on the work of Larnach and Macintosh (1974), who argued that of the 18 'unique' traits found in Ngandong humans, six of these were absent in all modern Australian, New Guinean, Europeans and Africans while nine of the twelve other features were found more frequently in the Australians and New Guineans than any other population while a tenth feature (frontal flattening) is observed only in modern Australians (Wolpoff 1989). More recent work, notably from Hawks *et al.* (2000) and Wolpoff *et al.* (2001) has attempted to tackle the RAO hypothesis head on with the aim of explicitly rejecting it as an explanatory model for human origins in Australasia and Europe. In this two-pronged assault, Hawks *et al.* approached the issue by assessing the anatomical similarities between African *Homo sapiens* with several Asian *Homo erectus* specimens from Ngandong before finally assessing the 'position' of a terminal Pleistocene modern human, the WLH-50 specimen from the Willandra Lakes area of Australia, within this scheme. Wolpoff *et al.* compared early European modern humans (Mladeč 5 and 6) with specimens from Skhül, Qafzeh and European Neanderthals. They concluded that morphological similarities linked all of these fossils together and explained this by a mechanism of gene flow which operated between African, Asian, Australasian and European populations. It must be said that both Hawks *et al.* and Wolpoff *et al.* proceed strongly on the basis that RAO does not in any way allow for interbreeding between migrant and resident populations, hence, having demonstrated that it did in fact occur, RAO can be rejected. That Hawks *et al.* (2000) and Wolpoff *et al.*

(2001) adopt this extreme position is unusual for they must surely be aware that proponents of RAO have for two decades conceded that instances of regional gene flow between African and European populations could have occurred (Bräuer 1984; Stringer and Bräuer 1994; Stringer 2002; Bräuer *et al.* 2004). In a response Bräuer *et al.* (2004) voiced their criticism over the choice of the WLH-50 specimen, questioning whether this is even representative of early Australians because of its apparent robusticity and that it also apparently suffered from hyperostosis, a phenomenon which results in abnormal levels of bone growth.

> "WLH-50 fits with the great morphological variation in robustness seen among final Pleistocene/early Holocene Australians, which is likely due to drift effects as well as adaptation to changing climatic conditions and diet...it [is] a poor specimen on which to base a test of the African Replacement hypothesis since it is hardly representative of early Australian *H. sapiens*".
>
> (Bräuer *et al.* 2004:702)

This is an interesting point that Bräuer *et al.* (2004) make but one that ultimately adds more confusion to the debate. Is the deviation amongst some of these very Late Pleistocene Australian *Homo sapiens* comparable to the variation observed in the latest central European Neanderthals, which are nonetheless, explicitly termed *Homo neanderthalensis*? It seems difficult to argue that on the one hand, modern human morphological variation can be explained by drift and climatic adaptation, yet on the other hand propose with extreme caution that similar levels of variation reflect at the very most limited amounts of genetic exchange and admixture amongst 'final' Neanderthals and migrants. Bräuer *et al.* (2004) went further in their criticism based on Hawks *et al's* interpretation of the Mladec sample. Several charges were levelled and these include: predominant use of only partial specimens when more complete specimens (Mladec 1 & 2) were available for analysis and a failure to incorporate any of the Mladec facial traits into their analysis (perhaps therefore side-stepping any modern traits which may have diluted the potency of Hawks *et al's* conclusions). Bräuer *et al.* (2004) argue that these methodological shortcomings in Hawks *et al*'s (2000) and Wolpoff *et al's* (2001) contribution undermine any claims that RAO theory has been disproved. One is left, after reviewing these contributions with only one certainty. All of these studies serve to remind us of the nature of the debate, where a few specialists continue to place different emphasis and attach varying importance to any number of anatomical traits from a limited number of specimens, every so often examining these materials with a new methodology yet always within the restriction of their respective paradigms.

2.5.3 China

Weidenreich (1943) was the first to propose the idea that regional continuity occurred in China based on the similarities between the 'Peking Man' *Homo erectus* remains from Zhoukoudian, and modern Mongoloids. Further work by Wolpoff (1989) complemented by a more recent summary by Wu (2004:132 table 1) builds on the initial idea with a broader range of fossil data. The current model contends that Early and Middle Pleistocene *Homo erectus* (e.g. Yuanmou dated to 1.7 Ma; Zhoukoudian 578 ka to 230 ka) evolved into *Homo sapiens* with the latter stage being marked by an early (e.g. Dali, 209 ka; Maba, 135-129 ka and Xujiayao, 125 ka-104 ka) and late phase (Zhoukoudian Upper Cave, 34-29 ka). Wu (2004) argues that the mechanism of this process, gene flow, is demonstrable based upon the presence of some anatomical features such as the chignon or 'bun' (located on the occipital region) which is generally rare in Chinese fossil samples but common in Neanderthal specimens. This leads Wu (2004) to argue that some assimilation occurred between some Chinese and western European populations, and that modern human origins in China is best accounted for by continuity with hybridization. This is in fact the same process proposed by Wolpoff *et al.* (1984). A further strand used in support of the continuity argument is purely archaeological. It appears that there is no evidence of 'introduced culture' such as the Mode 3 technology widely adopted by both Levantine and some African hominins during the first half of the Late Pleistocene. Such industries could feasibly provide indirect evidence to support the idea that modern human populations migrated out of the Levantine areas into Asia during the Middle or Late Pleistocene. This is not the case however, and archaeological industries in China appear to conform to Mode 1 over wide geographical areas and for much of the Early to Late Pleistocene (Wu 2004: 136 table 2). These observations have prompted Wolpoff (1989, 2001; Hawks *et al.* 2000) to favour a 3-stage evolutionary process in China and Australasia. They envisage a scenario of gradual evolution, with *Homo erectus* evolving to 'archaic' *Homo sapiens* before culminating in modern *Homo sapiens* and thus refute the notion that speciation occurred and replacement took place on a global scale.

Wolpoff *et al's* (2004) contribution represents the most comprehensive and multidisciplinary effort to date with the express aim of demonstrating a Neanderthal contribution to Later Pleistocene populations, and more controversially, extant Europeans. That Wolpoff is associated with this idea is not new: he is after all the most vocal proponent of the idea that morphologically diverse evolving lineages located for instance in Africa and Europe all had important roles to play in the emergence of the modern phenotype. It is on these grounds that proponents of MRT dismiss the idea that fossils such as Herto, which at present appears to be the oldest, securely dated archaic *Homo sapien* (White *et al.* 2003) is in itself the beginning of a distinct, sole evolutionary root for later modern human populations which left Africa and replaced archaic groups such as the Neanderthals during the Late Pleistocene. To be sure, Wolpoff *et al.* (2004) implicitly acknowledge the contribution of fossils such as Herto to modern humans, however this is a separate issue to that of whether they were the *sole* lineage leading to all extant human populations, and more akin the question of *to what degree* did they and other archaic groups such as the Neanderthals contribute, either via lineal evolution or via admixture to later European populations. To support the latter idea, they point out that 19 of the so-called derived Neanderthal characters (autapomorphies) unique to the Neanderthal lineage proposed by Stringer (1984) are neither common nor unique to the Neanderthal lineage. They argue that autapomorphies such as the retromolar space, taurodontism and the suprainiac fossa are all variable in frequency between the Neanderthals and later Europeans. Controversial support for this hypothesis was made in a report by Duarte *et al.* (1999) following the discovery of an UP burial at the Abrigo do Lagar Velho site (Portugal). At this site the remains of a largely complete ~ 4 year-old child buried in association with pierced shell and red ochre were found. Dated to *ca.* 24,500 years B.P., it is said that the cranium, mandible, dentition and postcrania all display a mix of Neanderthal and modern human traits. To add weight to this claim, Wolpoff *et al.* (2004) argue that some of the earliest European modern humans, namely the Mladec 5, 6 and 8 specimens all display Neanderthal traits.

Wolpoff *et al.* (2004) have side-stepped the observation noted by RAO proponents that there simply wasn't time for Neanderthals to evolve into modern humans by arguing, and perhaps reasonably, that this was never the claim made in the first place. They argue that morphological evolution can proceed at different rates and that the level of morphological variation between Neanderthal and post-Neanderthal populations is less than that seen in non-human primate subspecies. To support this position, it is implied that late central Eurasian Neanderthals show transitional characteristics. For instance the Neanderthal specimens 225 and 259 from Vindija (Croatia) have nasal breadths 3 standard deviations below the Neanderthal mean and vastly reduced mid-facial prognathism (Smith 1994). These data, it is argued, all support the idea that population interaction and hybridization occurred in distinct regional zones between indigenous Eurasians and ?Asian/African migrants (Simmons 1994). Hawks and Wolpoff (2001) imply that such data refute a single 'centre' of origin (Stringer 2002) and that as we can observe this phenomenon in a sparse fossil record it must have been a regular occurrence throughout the course of the Pleistocene.

2.6 Out of Africa…again and again

MRT carries with it the assumption that the 'first presence' of hominins in an area such as, for example, Indonesia, is a sufficient basis to infer that such regions were occupied by viable populations in a largely unbroken fashion for much of the Pleistocene. To me this is an unsafe assumption to make. Just because *Homo erectus* was present in region X, Y or Z one million years ago does not mean that they were present as a stable population for the next million years or so. Dated hominin and archaeological sites probably more accurately attest to incipient occupations of regions during climate phases that promoted radiations from stable demographic cores. That hominins were present in China and Australia during the Late and Middle Pleistocene is not disputed here. But one cannot infer, based on presence alone, that such instances are also markers of stable demographic centers, out of which continuous evolutionary lineages would spring. Thus if vast geographical areas were incipiently colonized during favourable periods, this opens the scope further, and from a theoretical perspective provides a more fertile environment from which to hypothesise that hominin migrations occurred more frequently throughout the Pleistocene. Coarse-grained models such as OOA I and even RAO convey the idea that a 'single' exodus occurred, that it was essentially uni-directional, from Africa into Asia and parts of Europe. Similarly, MRT is also coarse-grained to a degree in that it implies events such as OOA I created regional demographic cores in discrete regions of the world out of which modern, regional populations emerged. After reviewing the main arguments used in support of RAO and MRT it seems both models (particularly MRT) open little theoretical scope to the idea that a finer-grained theoretical approach to the issue of migration may be necessary. Perhaps movements varied in their frequency and magnitude, while different migration routes may have been used at different times between different parts of Europe and Asia, for example. Similarly, Late Middle Pleistocene Africans (e.g. Herto/KRM/Omo 2) may well have migrated out of Africa into parts of Eurasia and Asia earlier than has hitherto been considered, and it is these population movement(s) which may have provided the stock for subsequent regional lineages of modern-looking people. In other words, the 'pre-modern' ancestors of for example, Skhül and Qafzeh humans (table 2.1) migrated and consolidated their demographic presence in Asian regions such as northern China.

As we have seen, a polycentric appearance of the modern anatomical package in Africa would, according to Wolpoff be an inconsistency in the RAO model; yet in reality such apparently variable populations may be an artefact of finer-grained demographic shifts suggested above. Late Pleistocene climate changes may have facilitated this subtle, complex demographic dynamic, leading to a highly complex pattern of inter-regional associations. This could explain for example the contradiction noted by Wolpoff (1989) of KRM being 'too late' on the evolutionary ladder because modern humans were already present in the Levant e.g. Skhül and Qafzeh and in China e.g. Jinniushan (Pope 1992).

It is from these micro-migrations that we trace regional ancestry, the success of which would have varied depending on the relative character of the setting i.e. indigenous population structure, palaeoenvironmental and climatic factors. Hence human migrations did not occur as distinct (momentous) events (e.g. RAO) but instead we can visualise subsequent African migrations, or even Asian to Eurasian migrations (and vice versa) resulting in an elusive, recondite process involving derivatives of earlier, 'less modern' human groups interacting with varying intensity with indigenous contemporaries. Such a model allows for, in a sense a degree of quasi-continuity at the regional-scale and incorporates at the same time a basis from which to include the replacement with or without interbreeding of lineages such as the Neanderthals and other populations.

There are two tests that immediately spring to mind for this hypothesis: firstly, we would need to determine whether the *appearance* of modern humans during the Late Pleistocene was the result of demographic factors, specifically population growth across core areas of Eurasia which were already inhabited by ancestral groups to those listed in table 2.1, or whether this was the result of a modern human migration sourced ultimately from the African continent sometime during the Early or Middle Pleniglacial (*ca.* 80-60 kyr). To test the former idea would require a more detailed understanding of the factors involved in demographic growth, expansion and more detailed palaeoenvironmental reconstructions for the regions of Eurasia deemed as candidates for Pleistocene population centres. Current biogeographic approaches have instead approached the issue of demographic expansion from an Afro-European perspective, where cyclical glacial cycles drove African and European faunal movements in different ways. For instance, extreme cold in the higher latitudes of western Eurasia forced movements of fauna to the south, while warm phases led to east-west expansions. Conversely, directional shifts during warm phases on the African continent are believed to have followed a north-south trend (Lahr and Foley 1998; 2003). While such an approach may be suitable for the glacial phase of the cycle, it does not offer any predictions relating to how Asian populations for instance responded to the bulk of the cycle which was stadial-interstadial in character. The second test would require a broadening of the fossil database, or a more insightful methodology from which to demonstrate an African heritage for all Eurasian fossils and by implication a refutation of MRT.

Table 2.2 Archaic Homo sapiens

Site	***Homo***	**Age (Ka BP)**	**Reference**
Broken Hill	*H. heidelbergensis*	*ca.* 300	[1]
Florisbad	archaic *H. sapiens*	*ca.* 260	Stringer (2003)[2]
Singa	archaic *H. sapiens*	*ca.* 133	[3]
Omo Kibish I	*H. sapiens sapiens*	*ca.* 125	Stringer (2003)
Omo Kibish II	archaic *H. sapiens*	*ca.* 130	Rightmire (1989)
Klaises River	*H. sapiens sapiens*	*ca.* 120	[4]
Herto	*H. sapiens sapiens*	*ca. 160*	Clark *et al.* (2003)[5]

---

[1] Barham, Pinta-Llona and Stringer (2002)

[2] See also Kuman, Inbar and Clarke (1999) who reported highly retouched MSA assemblages dating to 157,000±21,000 ka BP.

[3] Mcdermott F., Stringer C., Grün R.,Williams C., T., DIN V., K. Hawkesworth C. J. (1996)

[4] Stringer and Gamble (1993:130)

[5] See also White et al's (2003) discussion of the BOU-VP-16/1 cranium

At this point let us speculate on this pattern and offer an alternative scenario. Let us envision that Early African *Homo sapiens* populations were in flux between *ca.* 150 ka and 90 ka. Some groups probably migrated further than the Levant, reaching parts of Europe and Asia. These were subtle movements that were part of a ratcheting up in the scale of demographic restructuring. But it was neither an evolutionary event, nor a migration in the RAO sense. These were 'archaic' humans (in the Neanderthal sense) sharing broad similarities in terms of behaviour with indigenous populations situated in parts of Asia and parts of Eurasia. Such a pattern is suggestive of polycentrism in some areas, namely the Levant and China, however these humans were ultimately sourced from a demographic core probably situated in Africa. This precludes a single and well defined diffusion wave involving a single human population or new species. It also precludes regional gene flow *solely* leading to regional developments of *Homo sapiens sapiens*. Ultimately this hypothesis seeks to understand human evolution using a population based approach, sidestepping theoretical constraints such as species nomenclature, or the adoption of specific evolutionary paradigms which in themselves do not satisfactorily account for the emergence and evolutionary successes of *Homo sapiens*. The driving force behind this *African-Eurasian flux* model may have been palaeoclimatic changes. Foley and Lahr (1994, 1998) have argued that the onset of glacial phases resulted in the expansion of deserts across much of Africa and that this left (some) humans little option but to migrate north, out of Africa and into Eurasia. This provides a potential mechanism to help visualize 'modern human' migration not as a singular event but instead part of on ongoing process that built on earlier human movements from African into Eurasian contexts; however, more detailed understanding of the palaeoclimatic and palaeoenvironmental record is required in order to understand what could have driven lateral movements between Europe and Asia during non-glacial climate phases.

Whether this 'process' outlined above was initially driven by palaeoclimatic and palaeoenvironmental changes will only be answerable when a more detailed recent fossil record in Asia is known. The idea that palaeoenvironmental changes may have mediated movements on intra- and inter-regional scales will only be testable with time as more accurate chronological dating of fossil, archaeological and palaeoenvironmental records is established. Evolutionary models as they are currently prescribed offer only a partial explanation for Late Pleistocene demographic changes. Models such as RAO are actually a series of hypotheses all of which are inherently reliant upon western European evidence to provide the weight of supporting evidence lacking in other regions. These hypotheses in sequential order are as follows:

(i) a speciation event in Africa
(ii) a population bottleneck in Africa
(iii) a rapid population increase to some critical demographic threshold
(iv) behavioural revolution
(v) a large-scale migration event out of Africa
(vi) rapid replacement of indigenous populations on a global scale

Indeed, the evidence in favour of replacement in China and Australasia notwithstanding parts of Europe is extremely controversial. Similarly, the nature of the transition from *H. erectus* to *H. sapiens sapiens* in China and Asia is far from certain and even Stringer (2002) concedes that local evolution from archaic to modern humans may have occurred in China. The sites of Yunxian, Nanjing, Jinniushan and Dali have provided archaic/transitional *H. sapiens* and even Xujiago and Maba seem to bear a close resemblance to the Neanderthals of Europe. Nevertheless, Stringer prefers the explanation that African *H. sapiens sapiens* 'arrived' in China between *ca.* 70 ka (e.g. Liugiang) and *ca.* 30 ka (Zhoukoudian Upper Cave). But it seems equally plausible that these Asian archaic *H. sapiens* may be the progeny of earlier African population movements. Their apparent anatomical differences with early European modern humans between *ca.* 40 and 30 ka may be a consequence of drift – thereby explaining the disparity Wolpoff (1989) notes between the fossils. To stress again this does not necessarily support the claim of MRT proponents that Asian *H. sapiens sapiens* arose from *H. sapiens erectus*. The hypothesis I outline does not preclude the possibility that they had an African origin: on the contrary, it is entirely consistent with an African origin but at an earlier date.

RAO attempts to accommodate data from a range of temporal and spatial settings into a coherent explanatory framework tackling a diverse array of processes and events ranging from speciation to extinction and acculturation to replacement. This framework relies on correlating selected evidence, specifically the emergence of modern-looking humans in Late Middle Pleistocene Africa, apparent differences in morphological trajectory between Eurasian *H. sapiens* with Levantine and African *H. sapiens* and archaeological data from western Eurasia to infer a migration and replacement event on a global scale. By relying on selected archaeological and palaeoanthropological aspects from a broad spatial and temporal span it does not offer a satisfactory explanation of process. In this sense the model can perhaps be viewed as self-reinforcing. To answer some of these criticisms archaeologists favouring RAO have turned to the archaeological evidence to generate ideas concerning the *why* and *how* of population replacement. Archaeological evidence can tell us more about what our ancestors were doing and thinking, or as several workers would argue, not really thinking at all. With this in mind it is now necessary to turn to the archaeological evidence to assess the merits of meaningful behavioural and cognitive differences between human groupings and investigate in what ways it can illuminate the behavioural potential of our ancestors.

2.7 Socio-behavioural implications

There is a strong consensus in the current literature that the changes from the Middle to Upper Palaeolithic in Europe and the Middle Stone Age (MSA) to Late Stone Age (LSA) in Africa were so significant, they could only have emerged alongside important cognitive and social changes (Mithen 1996; Klein 2000). For example Mithen (1996) has argued that the cognition of both archaic *sapiens* and Neanderthals was characterised by modular intelligence, with specific domains of the brain being task-specific, much like the tools of a Swiss army knife. But the link between these domains – or what Mithen terms *cognitive fluidity* (Mithen 1996) occurred with the Big Bang of human culture during the Late Pleistocene. Such cognitive changes are thought to have occurred locally in space and rapidly in time (Mellars 1989, 1996, 2005; Gamble 1999). In Europe there is a longstanding debate surrounding the issue of whether or not the emergence of traits such as blade and bladelet technology, more diversified tool forms, complex bone and antler technology, personal ornamentation (e.g. perforated teeth and beads) and even changes in subsistence practice such as specialized hunting were autochthonous changes within European Neanderthal populations or whether they were allochthonous, that is to say they were introduced by external African or Asian modern humans (d'Errico *et al.* 1998, Mellars 1996). To tackle these questions one must assess the underlying basis of the competing hypotheses of whether these features can be demonstrably associated with a specific African population which in turn demonstrably spread these innovations over space and time, or whether these emerged as adaptational requirements to changing palaeoenvironmental contexts across several populations divided by time and space.

For workers such as Mellars (2005) it is to him inconceivable that the Neanderthals after some 200,000 years of cultural stability independently invented the Upper Palaeolithic traits at the same time as behaviourally advanced anatomically modern humans first appeared in Europe. Mellars has strongly argued that Europe saw a revolution in the truest sense:

> "[The] Upper Palaeolithic transition is marked by changes in effectively all of the archaeologically visible dimensions of behaviour".
>
> (Mellars 2005:16)

For Mellars, these shifts in human behaviour first arose with the Proto-Aurignacian and Aurignacian industries, the earliest instances of which he can be traced to the Middle East at Boker Tachtit (Israel) and Ksar Akil (Lebanon) at 45-47 ka before reaching Bacho Kiro and Temnata (Bulgaria) by 40-43 ka BP (Mellars 1998, 2005; Conard & Bolus 2003). Certainly one of the most intriguing aspects of the MP/UP transition is the manner in which many of these features such as blades, bladelets and ornamentation appeared relatively quickly in the European archaeological record. This is in contrast to East Africa, where similar changes in the archaeological record appear to have been far less localised or temporally discrete. For example, blades and microliths have been recorded in late MSA contexts at Enkapune Ya Muto rockshelter (GtJi12). Here, the oldest LSA type technology (the Nasampolai industry) is older than 40 ka and probably 50 ka old (Ambrose 2002). Other transitional MSA/LSA industries have also been discovered at sites on the Ntuku River (Ntumot) located on the western margin of the southern Rift Valley. Here, 3 sites (GvJh11, GvJh12 and GvJh13) have produced transitional industries comprised of small bifacial points and backed microliths knapped from obsidian sources located between 60 km and 90 km away. This evidence suggests that technological and social changes appear to have developed very early in equatorial East Africa during the Middle Pleniglacial (Stanley Ambrose pers. comm.). This pattern would appear to complement the belief that the earliest traces of modern behaviour are found in Africa. This is a position strongly supported by Mellars who argues that,

> "Many of the most distinctive archaeological hallmarks of the classic Middle-Upper Palaeolithic transition in Europe can be documented at least 30,000 to 40,000 years earlier

> in certain parts of Africa than anywhere within Europe itself'.
>
> (Mellars 2005:16)

Mellars argues that the Howieson's Poort industry from Klasies River Mouth and the Still Bay industry from Blombos Cave are notable examples of this trend. However, many of these blades are in fact large and relatively thick and made predominantly from local raw materials. The idea that these industries are transitional in the sense that Mellars implies has been thrown into doubt because the Howieson's Poort was replaced by traditional MSA industries during MIS 3 (60-24 Ka) (Ambrose and Lorenz 1990; Ambrose 2002). Rather than interpreting these industries as 'precocious' LSA elements or the root of modern behaviour, Ambrose (2006) put forward a powerful alternative. He suggested that the Howieson's Poort was a discrete response to changing palaeoenvironmental stimuli, an argument grounded in observation, and one that precludes the notion of some criticial typo-technological advancement. This approach provides an interesting contrast to the one generally applied to the European record. To the best of my knowledge, change in the behavioural pattern of the Neanderthals (with the exception of subsistence or migration) has never been examined in a purely ecological context. Techno-typological change in stone tools during the Early Upper Palaeolithic is currently viewed as the product of acculturation, or as the half-hearted attempt of peripheral populations already on the slide to extinction, to adapt to new circumstances which are often poorly prescribed. Rarely, if at all, is it considered a natural socio-behavioural response to changing palaeoenvironmental contexts. With this in mind it is time to examine Neanderthal archaeology in more detail.

By the latter half of MIS 3 Neanderthal culture was changing. Regional industries with clear technological and symbolic departures from the preceding Mousterian phase were widespread across Europe. To date there are at least four archaeological industries which combine new technological and typological responses attributed to or indirectly associated with the Neanderthals in some way: (i) the Châtelperronian (ii) the Szeletian (iii) the Uluzzian (iv) (more controversially) the Aurignacian. There are three general explanations for the emergence of these new behaviours (1) regional Neanderthal populations independently developed distinctive regional technocomplexes (2) these behaviours first arose within a discrete Neanderthal population and were diffused into other Neanderthal populations (3) they were introduced by incoming anatomically modern human populations either directly or indirectly via diffusion. Unusually perhaps, support for the first explanation comes from one of the strongest supporters of the RAO hypothesis, Paul Mellars.

> "…the arguments for believing that the Châtelperronian industries are the product of entirely indigenous, Neanderthal, populations in western Europe can be supported strongly on the basis of both the direct skeletal associations of the industries (at Saint Césaire and Arcy-sur-Cure) and the basic technology, chronology and spatial distribution of the industries themselves".
>
> (Mellars 1996:414)

Taken literally this passage implies that all of the components, whether artefactual, technological or symbolic were independently created by Neanderthals. However this is not the case. Mellars and others argue that it is only the "*basic technological roots*" (ibid.) that have any demonstrable link with the preceding Mousterian industries. Workers such as Harold (1989) and Mellars (1989a) argue that the appearance of more sophisticated traits in the European archaeological record and more specifically, changes in Neanderthal society were introduced by modern humans as the result of "bow-wave" diffusion, that is to say social or symbolic traits were the secondary effect of the RAO migration. It has been strongly argued that the Aurignacian should be viewed as the parent industry of these so-called 'precocious' Neanderthal industries and therefore the first 'true' UP industry of Europe (see previous references). The Aurignacian is characterized by 'more improved' blade and bladelet technology and typologically by end-scrapers and burins and marked increases in ornaments, bone and antler tools (Bolus and Conard 2001). One of the major research strands of recent years has been to identify the timing and location and subsequent spread of the Aurignacian. As we have seen, workers such as Mellars argue that it arose first in the Levant while others e.g. Valoch (1972); Fridrich (1973 after Bricker 1976) have argued that some central European Middle Palaeolithic assemblages were directly transitional with the Aurignacian. Whether the Aurignacian arose in the Levant or in central Europe is still a point of debate.

The Szeletian industry is largely restricted to parts of Central Europe. It is characterized by leaf-points, end-scrapers, burins and a lack of organic elements (Bolus and Conard 2001). The notion that the Szeletian was in effect a Neanderthal mimicry of modern technology has been questioned. For instance Bricker (1976) points out that some Szeletian assemblages combine both MP elements, such as flakes used for scrapers, and blades used for burins and end-scrapers. On these observations Bricker (1976) has argued that the Szeletian has clear technological and typological links with the Blattspitz (foliate point) Mousterian of central Europe, suggesting by implication that the Szeletian industry represents an independent transition (carried out presumably by the Neanderthals). Such regional examples are rarely investigated as products of adaptation to local ecological change. The literature instead centers predominantly on the theme of "acculturation" and that this process had a wide regional impact across broad areas namely central Europe, Italy, France and Spain (Allsworth-Jones 1986; Harold 1989; Mellars 1989, 1996, 1999, 2000, 2005; Stringer and Gamble 1993). But it is equally plausible that even if some UP elements were introduced by modern humans from outside of Europe, this does not discount the possibility that feedback effects operated across Neanderthal society, leading to occurrences of cultural adaptation and innovation which cannot be tied directly to the primary influence or the direct result of contact with the Aurignacian. Therefore it is equally plausible that Neanderthals and not modern humans, having adopted certain behavioural traits were the main influence on other Neanderthal groups. Moreover, it is by no means certain that the Aurignacian was an industry synonymous with anatomically modern humans as there are no definitive biologic associations with the earliest Aurignacian until *ca.* 30 ka (e.g. Stetten 1, Germany). The modern human skeletal remains from Vogelherd cave in southwestern Germany, seen by many as the best evidence that modern human humans authored the early Aurignacian, have now been shown to be late Neolithic in age thereby strengthening the view that Neanderthals may have contributed significantly to the development of the Upper Palaeolithic in Europe independent of modern humans (Conard *et al.* 2004). Straus (1999) argued that data from the Iberian Peninsula show a direct transition from the Mousterian to the Aurignacian without any influence from external populations. Cabrera *et al.* (1999 cited by Zilhão and d'Errico 1999) also investigated the transition at the regional level and claimed to have "definite proof" of technological and typological continuity between sequences of La Quina Mousterian and the Aurignacian. Moreover they reported that land use and hunting patterns are essentially indistinguishable between the MP and UP in Cantabrian Spain. These discrete lines of regional continuity, from the Mousterian to the Aurignacian, coupled with the lack of unambiguous anatomically modern human and Aurignacian associations, serve to severely undermine a strict acculturation and replacement scenario.

One of the central issues to the whole debate is chronology. One major prediction of the replacement hypothesis is that occurrences of the Aurignacian should pre-date all Neanderthal transitional industries, an observation which proponents say is satisfactorily demonstrated in the archaeological record (Mellars 1999). However this contention has been heavily refuted by d'Errico *et al.* (1998; 2003), who argue that the claims for very early Aurignacian archaeology are wrong because they have been incorrectly attributed, or that these are palimpsests containing other archaeological industries. D'Errico and co-workers have it seems made a convincing argument against the antiquity of the earliest Aurignacian at the key sites in northern Spain. These include: El Pendo, Le Piage and Roc de Combe. All of these sites seem to have stratigraphical issues, which have made definitive associations between the archaeology and radiometric dates problematic. For instance, the 'archaic Aurignacian' of level VIIIB at El Pendo had a high level of Mousterian artefacts (as much as 40%), while the overlying Lower Perigordian level VIII stratum was heavily admixed making the whole sequence stratigraphically unreliable (Zilhão and d'Errico 1999). Similar problems characterize Le Piage, while the Aurignacian/Châtelperronian association in level 8 at Roc de Combe (Bordes and Labrot 1967 cited by Zilhão and d'Errico 1999) is also problematic. Initially, level 8 'outside' was interpreted as Châtelperronian over lying Aurignacian, while level 8 'inside' saw Aurignacian overlying Châtelperronian. However it seems that level 8 is not in fact a genuine layer, and is probably two different horizons (Zilhão and d'Errico 1999). Zilhão and d'Errico argue that the earliest secure Aurignacian dates of 36.5-37 ka B.P. post-date the earliest examples of the Châtelperronian. In an important challenge to the replacement camp they conclude that *H. sapiens neanderthalensis* autonomously created 'transitional' Upper Palaeolithic bone and tool technology from Middle Palaeolithic stock across wide geographic areas resulting in distinctive regional cultures such as the Châtelperronian (south west France and north Spain), the Uluzzian (Italy) the Szeletian and Bohunician (Central Europe) and the Early Upper Palaeolithic (England) (d'Errico *et al.* 1999). In this context, *H. sapiens neanderthalensis* were responsible for their own 'upper Palaeolithic revolution', moving independently toward a complexity that has been strictly accorded the hallmark of *H. sapiens sapiens*.

More recently, Mellars (2006) maintained the view espoused in a previous discussion (Mellars 1999) in which he reported that the instances of the Châtelperronian post-date the Aurignacian. In the 1999 publication the results of the analysis of a range of Châtelperronian and Aurignacian dates obtained from southwestern France and northern

Spain were reported. For the purposes of the study it was suggested that C^{14} dates underestimate calendrical age by *ca.* 3 kyr, thus for comparative purposes, calendrical dates obtained via methods such as thermoluminescence (TL) and electron spin resonance (ESR) were converted to radiocarbon equivalents by subtracting by 3 kyr. Mellars (1999) concluded that the early Châtelperronian levels at the sites of Le Moustier, Combe-Saunière and Saint-Césaire (which were dated by TL and ESR) all post-date 37 ka are therefore younger than the early Aurignacian of northern Spain. However Valladas *et al.* (1998) had previously reported on early Châtelperronian dates which do fit neatly into this scheme such as the Châtelperronian at Le Moustier TL dated at *ca.* 42,600 B.P, a value comparable to the earliest Aurignacian in the region. Zilhão and d'Errico (1999) have also pointed out that many of the Châtelperronian dates were obtained via traditional C^{14} techniques and that more sophisticated dating procedures such as accelerator mass spectrometry (AMS) carried out on material at Combe-Saunière produce determinations some *ca.* 5,000 yr older than traditional estimates. Atmospheric C^{14} fluctuations occurred frequently during the last glacial and these no doubt may have contributed to situations of statistically different in C^{14} dates, which are, in calendrical terms from the same calendrical period (Zilhão and d'Errico 1999). With these issues in mind it would be dangerous to follow Mellars (1999) 3 kyr 'constant' to circumvent the radiocarbon and calendrical uncertainty across the Middle Pleniglacial particularly when the line that separates hypothesis of acculturation and independent development is so fine.

In principle it should be possible to settle the acculturation debate by assessing the overall similarities in the various components of the Aurignacian and other Early Upper Palaeolithic industries. Emulation of one culture by another, at whatever scale necessarily implies a degree of co-existence. If Neanderthals independently authored Upper Palaeolithic industries, it follows that a major avenue from which to infer or demonstrate social interaction over the *ca.* 40-30 ka period has been diminished. Similarly, the basis for genetic assimilation which surely would have been higher between acculturating populations would have been reduced also. One way to approach these issues is to assess the gross stylistic and technological similarities between the industries in question. The Châtelperronian of the Grotte du Renne (Arcy-sur-Cure, France) is perhaps the earliest and most elaborate demonstration of an association between Neanderthals and 'modern' stone tools, bone tools and personal ornaments. As we have seen, workers such as Mellars (1989, 1991) and White (1989) argue that these are the products of acculturation with incoming modern humans. However several stylistic and technological differences between the content of both the Châtelperronian and the Aurignacian ornamentation suggest the former culture was not in fact influenced by the latter. D'Errico *et al.* (1998) have shown that no distinctive Aurignacian lozenge-shaped bone tools are ever found in Châtelperronian levels, while reindeer antler, often utilized for Aurignacian products was totally neglected by Châtelperronian Neanderthals. Conversely, there is over three times as much ivory products associated with Châtelperronian than the Aurignacian. Some Châtelperronian personal ornaments display conspicuous grooves on animal teeth, a feature entirely absent from ornaments from the Aurignacian layer VII at Arcy, as well as from 121 teeth from nine other Belgian Aurignacian sites. Demars (1990 cited by Zilhão and d'Errico 1999) has shown that Aurignacian cores were often large, principally under-prepared blocks while the Aurignacian blades were often wide, robust, and varied in their curvature. Some of these blades were then chosen as blanks and modified into the classic Aurignacian tools: end-scrapers on retouched blades, while thick flakes were used as cores for fine bladelets e.g. Dufour bladelets. d'Errico *et al.* (1998) reported that Châtelperronian blank selection and reduction procedures were very different to those of the Aurignacian. The Châtelperronian cores were large, thick flakes or blocks which were pre-shaped to allow the detachment of small, regular shaped rectilinear blades. Some of these were manipulated into Châtelperronian points, while the more irregular shaped blades were used as blanks for tools such as end-scrapers. These differences between the Châtelperronian and Aurignacian production procedures suggest that there may have been biologic or behavioural restrictions that led to a form of mutual avoidance between these humans after all, particularly as no Châtelperronian tools have been found in Aurignacian contexts and vice versa.

The timing of the transition between the MP and EUP in Europe also seems to have varied considerably. Bolus and Conard (2001) reported how the Middle/Upper Palaeolithic transitional sites in Croatia and Slovenia appear to have been quite protracted and occurred over 15 kyr (45 ka to 30 ka). These sites also appear to have lacked 'intrinsic' UP details such as ornamentation in a similar fashion to the sites associated with the Middle/Upper Palaeolithic transition believed to have been carried out by *Homo sapiens sapiens* in the Near East and Africa. This in turn suggests that local examples of MP-UP transitions such as the Szeletian, Bachokirian and Bohunician which also lack organic tools in the known assemblages may also be valid UP industries in their own right. The appearance of some UP elements such as certain 'diagnostic' features such as osseous artifacts (though explicitly termed Aurignacian) may in fact have been 'incidental culture' which was variably expressed during specific circumstances during what appears to have been a considerable period of MP-UP cultural experimentation. Certainly observations of modern hunter-gatherer groups have shown that technological complexity decreases from the Arctic through to the tropics. Higher latitudes experience greater and more frequent changes in subsistence options while in mid latitudes e.g. Africa, there is a relatively lower range of seasonal temperature which leads to more stable subsistence options (Henshilwood and Marean 2003). Societies existing in contexts characterised by resource unpredictability for example, tend to be more flexible, utilising curation and storage as a means to meet resource shortfall and seasonal shortage. In a similar vein we can suggest that certain behavioural innovations as they are seen in the archaeological record arose as a function of changing environmental circumstances during the Middle Pleniglacial. It seems, based upon this brief review, that it is more parsimonious to approach the cultural changes in Europe that marked the MP-UP transition from a more local perspective. Behavioural change cannot be explained as a broad-scale process that occurred rapidly in time and consistently in space. Moreover the nature and potential of any interaction between populations of Neanderthals and modern humans (whoever the Aurignacians turn out to be) still seems equivocal based upon the current archaeological evidence and when chronological and taphonomic issues are fully considered.

To conclude, it is of value to briefly mention the results of some preliminary research carried out by a research strand of the EFCHED[6] project relating to the question of *what is the Aurignacian*, *and where did it first emerge*? Preliminary results have shown that the Aurignacian, when it is characterised specifically by split-based bone points appeared first not in eastern Europe but in western Europe. This realisation has huge implications for the acculturation hypothesis and is forcing a major re-think of what constitutes the Aurignacian, and, by implication a re-consideration of the timing as well the route taken by modern humans into Europe. Bricker's (1976) caution, in this context is prescient and worth stating:

> "The greater probability of the polycentric position [referring to the emergence of the UP across Europe] seems indicated by the very specific nature of the typological continuities in certain local sequences, some with great time depth, and the general absence of such specific typological resemblances between and

---

[6] Paper given by William Davies at the *EFCHED* (Environmental Factors in the Chronology of Human Evolution and Dispersal) workshop, Newcastle 2006

> among earliest Upper Palaeolithic in different areas (the mischief done by the overextension of terminology – Aurignacian, Châtelperron point, lamelle, Dufour, etc – can hardly be overestimated".
>
> (Bricker 1976:141-42)

2.8 The ecological straightjacket

At present there is still no agreement regarding the palaeoclimatic tolerances and environmental preferences of the Neanderthals. Some workers argue that the Neanderthal cranial and post-cranial morphology arose as a specific adaptation to cold climate conditions (Holliday 1997a). What is certain is that Neanderthals existed across wide areas of Europe and parts of the Middle East where vastly different palaeoclimatic/environmental regimes prevailed. Therefore it would have been unusual for natural selection to have resulted in a cold-adapted morphology across such a wide climatic spectrum. Others argue that Neanderthals preferred temperate settings and only ventured into more northern regions during palaeoclimatic improvement (Stage 3 Project 2003; Finlayson 2004; Stewart 2004, 2005). In this light it is argued that the apparent rarity of MP archaeology in the higher latitudes of Europe during more demanding palaeoclimate phases i.e. glacial and interglacial prior to modern humans was a result of an incoherent adaptive package (Gamble 1996, 1999). Alternatively it could be suggested that Neanderthals were able to feed better elsewhere, in which case the apparent lack of archaeology in the 'hard habitats' may also be interpreted as pragmatism. It is believed that in order to fully exploit the environments of glacial and interglacial climate regimes more sophisticated social systems were required which extended beyond the local level and which linked individuals and groups together at the regional scale (Whallon 1989; Gamble 1999). More recently, intermediate, or unpredictable environments have been added to the canon of contexts that Neanderthals were unable to exploit. The underlying reason for this failure is again, social. MIS 3 climate oscillations are said to have severely disrupted Neanderthal habitats particularly in the lower-latitudes of Europe and that in order to exploit the meagre and unpredictable resources that were available a more advanced range of behaviours or a less-restrictive anatomical package was required (e.g. Finlayson *et al.* 2000). The dominant conception seems to be that the Neanderthal's cramped and attenuated range of behavioural adaptations suited primarily to idiosyncratic contexts failed to provide the flexibility to subsist in changing times; hence Neanderthal populations gradually fragmented and eventually became extinct. This hypothesis can be investigated by examining the biocultural evolutionary trajectory of the Neanderthal lineage over a much broader timeframe than MIS 3. Several themes are important in this respect:

1. Was the Neanderthal lineage particularly vulnerable to the effects of climate and ecological change in general or did Europe present intrinsic difficulties to Homo in general?
2. Was MIS 3 fundamentally structurally different to preceding phases?

We can begin to answer these questions by examining the palaeoanthropological and archaeological evidence. If Neanderthals were, as a lineage, grossly affected by climatic and ecological change then we could hypothesize several test implications:

(i) sharp discontinuities in the archaeological record on regional scales
(ii) that archaeological discontinuities should occur in conjunction with specific climate regimes and/or distinct ecological contexts
(iii) over broad geologic timeframes the evidence for population discontinuity will be reflected in the fossil record

The archaeological evidence can be used to explore regional scale population changes however there are several problems associated with this line of evidence. For example, archaeological patterning may vary as a function of in-situ cultural changes, (which may have been independent of any climate or ecological change) diffusion of ideas and replacement. Untangling these various causations is a difficult and contentious exercise. Despite this, some insights could be obtained, for instance it can be hypothesized that an archaeological hiatus observable on a regional scale may represent population scale abandonment. One the one hand, cultural diversity (e.g. in terms of the wide array of regional and sub-regional variants of the Mousterian) may reflect local cultural preferences or more subtle responses to different palaeoenvironmental circumstances. Homogeneity, on the other hand, both in space and time, may reflect either a standardised culture particularly where it is associated with relatively benign or stable palaeoclimatic/environmental circumstances. But what if the Neanderthal lineage was cognitively incapable of the internal dynamic necessary to break free from this ecological inertia? Then it is likely that episodes of major palaeoclimatic change caused the

European Neanderthal lineage to fracture into regional *groups* in the truest sense of the word. Differential recovery, and the subsequent bias in the relative contribution of these regional isolates to subsequent European populations when palaeoclimatic improvement occurred, would have surely resulted in far greater morphological variation than is currently reflected in the Neanderthal palaeoanthropological record. In the course of Neanderthal history, some 300,000 years or maybe even longer, we could envisage that sub-speciation between Neanderthal demes occurred and it is suggested here that such an outcome is consistent with the idea of a climatically/environmentally specialized species inhabiting regions that witnessed extraordinary variation throughout the course of the Pleistocene. In other words, the cultural and biological records of the Neanderthals in Europe would be demonstrably non-linear. Fortunately, the palaeoanthropological and archaeological records of the Neanderthals in Europe are sufficiently detailed enough to approach this issue.

The evolutionary story of the Neanderthals began perhaps as early as MIS 12. These early populations were geographically widespread and include Arago 2,13,21, (France) Atapuerca Sima de los Huesos 4 & 5 (Spain) and Petralona (Greece) (Condemi 2000). These fossils display several emergent Neanderthal traits including: the characteristic 'inflated' cheek bone (maxillar). Other facial adjustments toward Neanderthal morphology include the backward displacement of the mental foramen to below the 1st premolar and a lateral development of the mandibular condyle. By MIS 7 specimens discovered at Bilzingsleben (B4), Steinheim, Swanscombe, Reilingen, La Chaise as well as Biache-St-Vaast 1 & 2 suggest the clear differentiation of some key Neanderthal traits. For instance the occipital and mastoid regions are indistinguishable from the Weichselian Neanderthal populations. By MIS 5 European specimens such as Saccopastore 1 & 2, La Chaise-abri Bourgeois Dalaunay and Ehringsdorf are unquestionably Neanderthal, however their overall robusticity is less than that of their ancestor populations. Here we have over 300 kyr of Eurasian hominin evolution that points to a pattern of gradual evolution across a variety of climatic and ecological regimes. The fossil evidence does not support the position of a punctuated appearance of Neanderthal features as a package. Nor does the fossil evidence suggest that populations became isolated. This cursory glance at Neanderthal specimens from wide geographic areas shows that populations must have been in close correspondence across time and space, suggesting therefore that the Neanderthal lineages were never isolated to the point of speciation. This suggests that disparate populations were linked by mechanisms (social or cultural) that prevented meaningful divergence from occurring. This pattern of morphological consistency maintained throughout a variety of climate regimes and over such long periods of time, is quite remarkable. It is remarkable all the more because many workers (e.g. Gamble 1999) portray Neanderthal populations as socially unsophisticated. It is accepted *a priori* that pre-modern societies operated as disconnected hunter-gatherers. In no way were regional populations 'inter-connected' to the same degree as their eventual modern human successors. If Gamble's viewpoint is correct then surely we should observe Neanderthal population 'dead-ends' associated with specific regions and timeframes. Yet the contrary seems to be the case: Neanderthal morphology seems to have been the result of a Eurasian-wide evolutionary process over the Saalian-Eemian-Weichselian timeframe.

Some reconstructions dealing with the Neanderthals palaeoenvironmental preferences have been attempted (e.g. Roebroeks *et al.* 1992). Other general reconstructions cover broad areas of Europe across broad time spans (e.g. Frenzel *et al.* 1992; Harrison *et al.* 1995; van Andel *et al.* 1996). However these examples fail to define the specific variables within the environments and climate states discussed, and whether these elements were associated with other climate phases. The result is arbitrarily defined constructs where a 'stadial' etc is defined on the presence or absence of a few elements such as semi-open forest or mean summer temperature. This approach assumes stadials etc were temporally and spatially homogenous. In reality it is probable that variables transcended climate labels and that no two climate events ever resulted in wholly analogous environmental circumstances. The real focus should be on identifying the nature of condition and resource changes and use the stadial and interstadial terms as guidelines. The alternative is to restrict the understanding of past landscapes by using these rigid definitions, comprised of idealised variables and broadly apply these to 'Eurasia' in general. By doing so the stage on which early humans adapted, behaved and evolved, is oversimplified (e.g. interstadials resulted in 'semi-open' environments). This is exemplified in MIS 3 where the higher resolution data suggests oscillatory palaeoclimate prevailed in contrast to the more stable phases earlier in the IG-G cycle. Similar processes and events to those of MIS 3 may have occurred in earlier prehistory their significance obscured by the coarseness of the palaeoanthropological and archaeological record. Understandably perhaps, clearer windows into prehistory (such as MIS 3) will be seized as representative. When this occurs without a critical assessment of the supposed uniqueness of the phase, human behavioural responses, preferences and limitations are assessed from a false position. This brings us to the issue of how to interpret human responses to these supposed new challenges and whether such climate episodes can be identified or hypothesized earlier in the IG-G cycle.

Using mainly the isotopic variations of the Greenland ice cores some workers have surmised that climate changes exerted considerable effects on north, central and southern European landscapes and by implication perturbed the ecological relationships between fauna and flora across Eurasia during the Middle Pleniglacial (e.g. Stage Three Project 1993). Moreover, it is argued that Neanderthals experienced these oscillations for the *first time* during MIS 3 (ibid). At the same time it is a given that migrating Africans entered into Europe at a time of major environmental flux presumably without having experienced any analogous situations in Africa hence they presumably lacked a pre-adaptive edge. This is to say nothing of the fact that Europe had been home to Neanderthal populations for some 200 kyr, but it was now evidently 'there for the taking' in light of *H. sapiens sapiens* superior behavioural adaptations (Mellars 1999) and the inability of the resident Eurasians to adapt (Gioia 1990; Finlayson *et al.* 2000 a, b.). The *climate instability hypothesis* requires MIS 3 to have exerted major, new condition-resource configurations on European residents and the warrant for a shift in MP behaviours, the sum of over 200 ka of biologic and cultural evolution which took place during other major Pleistocene climatic and environmental changes. If this hypothesis is correct, we can tentatively predict that Neanderthal populations experienced:

1. More stable climate in pre-MIS 3 contexts.
2. Less dramatic or rapid climate change across IG-G, IS-S boundaries.

2.9 Hominin migration: a general perspective

That physical or environmental conditions may have been the most important selective pressures on biological and physiological changes of the genus *Homo* is of course an idea that is widely supported by many workers. In a recent review by King and Bailey (2006) a range of physical and environmental factors such as ecological diversity (broad range of fauna and accessible water supplies) and secure locations (to provide shelter from hazards and predators) were put forward as important contributing factors in the development of changes that include bipedalism, increased body size coupled with disproportionate increase in brain size, dietary diversification and early culture. King and Bailey (2006) also suggested that tectonic and volcanic processes may have been the single most important factor in creating the types of diverse environments (what they termed roughness) which facilitated early hominin dispersal out of Africa. This approach of course bypasses the limitation for migration carried by a pure climatic model in the sense that volcanic and tectonic processes, particularly in the African Rift, have been continuous throughout the Plio-Pleistocene. Thus one can infer that 'roughness' in this part of the world would have characterised all climatic regimes, notwithstanding the fact that its grain would have varied depending on the degree of activity and geomorphological processes which of course would have varied through the course of time.

Later human migrations such as RAO are of course largely accounted for by a combination of cultural and/or favourable climato-environmental factors. Cognitive and cultural developments are currently viewed as favourable factors in modern human exodus from Africa, while climatic and environmental factors are implicated in modern human arrival across much of Europe. One such event, the Hengelo interstadial (*ca.* 38-36 ka uncal BP) has been accorded major significance in this respect because it represents for some workers the probable period of time during which Aurignacian-equipped anatomically modern African populations began to colonize Europe (Mellars 1998). The Hengelo interstadial was marked by an extensive northward retreat of the permafrost zone into Holland (Ran *et al.* 1990) which presumably 'opened up' vast areas of Europe that had hitherto been frozen tundra and uninhabited by Neanderthal populations. Coleoptera and botanical data indicate MST of 9.5°C to 11.5°C in England and Holland, values somewhat similar to the preceding Hasselo stadial (Huijzer *et al.* 1998). Incipient periglacial conditions reoccurred in Belgium, Holland and northern Germany pointing to MAT between -1°C and -4°C, with MWT falling between -31° C and -16°C (Ibid.). Incipient phases of amelioration such as the Hengelo are recognised in the major pollen profiles as *Betula* and *Pinus* spikes, however strong seasonality differences, along with episodes of extreme cold still prevailed across the CP and parts of the SP and MP and would no doubt have represented a vastly different series of challenges to any equatorial-adapted modern humans to surmount. Whether the Hengelo resulted in any meaningful reforestation across the northern latitudes is unclear, as is the nature of the terrestrial environments in the time-phase post-Hengelo and pre-Denekamp – a period of some 4 kyr. I believe by this point these environments and ecologies were stable and witnessed no significant forest expansions during these late Middle Pleniglacial interstadials. However it is by no means certain that southern, Mediterranean and even central European regions were environmentally homogenous, nor stable. That central Europe saw significant tree refugia in areas north and west of the Alps (Willis *et al.* 2000; Müller *et al.* 2003) is interesting, for it demonstrates additional variable conditions and greater palaeoenvironmental variability in regions generally considered treeless and open during stadial phases of the post-Eemian oscillations.

This raises two issues that will be the subject of greater focus later in the thesis:

- Why did *H. sapiens sapiens* manage to populate the central European areas and not the comparable settings of south and Mediterranean Europe, which, based on the pollen and macrofossil evidence, seem to have been equally prone to environmental variability ?
- Did *H. sapiens neanderthalensis* retreat into the more forested lower-latitudes during the post-Eemian oscillations? If so, were they by implication well-suited to the closed, stable environments of the Mediterranean? Conversely, if Neanderthals retained a meaningful demographic presence in the higher latitudes during the post-Eemian why did they seemingly go extinct during the oscillations of MIS 3?

Mellars (1998) recognises the Hengelo interstadial as the 'temperate' window of opportunity that facilitated the movement of Africans into the northern Mediterranean and south west European regions. The real question is whether this phase was truly unique with respect to previous Middle Pleniglacial oscillations, and whether it provided Africans an unparalleled opportunity to enter western Eurasia and succeed in establishing a demographically significant presence, before displacing indigenous Neanderthals.

2.9.1 Environmentally mediated migration

In order to understand the significance of the Hengelo interstadial in terms of human migration and demographic change it is relevant to examine the palaeoclimatic context of earlier migrations. This section will begin with a brief review of hominin migration during the Lower and Middle Palaeolithic, addressing the question of whether or not European/African populations met specifically through the Levantine conduit and if this was a unidirectional process. It will examine the idea that migration was biogeographic and a result of palaeoenvironmental change. It will elaborate on the existing ideas behind the emergence of key socio-behavioural traits and how these may have emerged as a function of local adaptation to new ecological circumstances, rather than as the trigger which facilitated movements into new habitats on a global scale.

It is generally accepted that Africa was not only the birthplace of the earliest hominins, but also the earliest representatives of the genus *Homo*. The Out of Africa 1 hypothesis contends that *H. ergaster/erectus* migrated out of Africa somewhere between *ca.* 1.9-1.6

Myr and reached parts of Asia by *ca.* 1.8 Ma e.g. Mojokerto and Sanigran, (Java) (Swisher *et al.* 1994). A further specimen from Dmanisi (Georgia) dates to 1.77 Ma and has been described as *H. erectus* (Lordkipanidze 2005). This type of migration was probably mediated by the gross palaeoenvironmental similarities between Africa and Asia, both of which were characterised by extensive grasslands, a habitat that early *Homo* was apparently well-adapted to (Dennell and Roebroeks 2005). In this light it seems reasonable to suggest that hominins did not migrate further west and into the more seasonal higher latitudes because they lacked the required biologic and cultural adaptations. But it is by no means certain that Lower and Middle Pleistocene hominins migrated into Western Europe via the Levantine-Anatolian route. An equally plausible alternative link between Africa and Europe is provided by the Strait of Gibraltar. The Strait, under a modern interglacial sea-level is some 14 km wide at its narrowest point (fig 2.1), yet this would have been far lower during glacial periods, making for several short-water crossings of no more than 5 km (Straus 2001).

Figure 2.1 Satelite Map of Iberian/African coasts[7]

---

[7] http://www.ast.cam.ac.uk/public/planets/gif/ear/strait.gif

Certainly some more recent archaeological commonalities linking Iberia with North Africa include the abundance of cleaver flakes as well as "African-style" flake production techniques (known locally as the Kombewa or Janus Flake) observed in sites situated across the Maghreb, Spain and Portugal (Straus 2001). Perhaps the earliest Lower Palaeolithic fossil evidence pointing towards more permanent settlement across Iberia includes the *H. antecessor* remains from TD6 Gran Dolina, Atapuerca. These remains are thought to be older than 780 ka as they were recovered 1m below TD7 in which the Matuyama-Brunhes boundary is observed. This would place the TD6 find within:

> "…wet, temperate conditions [and that it] correlates to oxygen isotope stages 21 or 19".
>
> (Falguères et al. 1999:351)

For some workers, the deep roots of the Neanderthals and modern humans can probably be traced back to Early Pleistocene populations of *H. antecessor* or Middle Pleistocene *H. heidelbergensis* (Stringer 2001). Certainly by MIS 7 distinctive Neanderthal populations were now present across much broader areas of Eurasia, indeed they appear to have been the first hominins to have colonised the more northern and seasonal parts of Europe. This secondary Neanderthal dispersal is rarely granted the importance it merits. Some archaeologists seem pre-occupied with identifying the earliest inter-continental migrations even though it is probable that range expansions out of Africa (particularly with regard to early *Homo* and even with regard to the Levantine *Homo sapiens* of Skhül and Qafzeh) were mediated by gross biogeographical similarities between parts of Asia and Africa. Such a model cannot be envisaged for Neanderthal expansion into the climatologically and environmentally heterogeneous regions of western Europe where important behavioural innovations must surely have been required in order to settle in these seasonal, higher latitudes. Simmons and Smith (1991) reported that early Upper Pleistocene Iberian Neanderthals and North African populations may have intermittently crossed the Strait of Gibraltar. Fossils discovered from Jebel Irhoud (Morocco) are associated with a Mousterian industry dated by ESR to between 90 and 190 ka (Hublin 1993). It has been demonstrated by Simmons and Smith (1991) that Jebel Irhoud is characterised by well-developed occipital bunning, an anatomical feature absent from sub-Saharan African *H. sapiens*, yet common in Neanderthals. This observation leads Simmons and Smith to conclude that,

> "African and European populations were not reproductively isolated from each other during this time period".
>
> (Simmons and Smith 1991: 623)

This is an attractive idea. Certainly, glacial periods appear to have resulted in hominin abandonment of more central portions of the African continent because of increased aridity and desertification. Indeed, this pattern seems to have characterised several key sites in East Africa located in the Narok region of Kenya, where extensive breaks in archaeological sequences appear coeval with the early last glacial (*ca.* MIS 4). Similarly it could be argued that Jebel Irhoud reflects a situation where populations situated across Northern Africa were driven by palaeoenvironmental and demographic pressure into the Iberian Peninsula where they may have periodically interacted with resident Neanderthals during episodes of global cooling. Palaeoclimatic changes in this case led to a *environmentally mediated migration*, which was local and limited in its extent, resulting in limited assimilation between local African and European groups. The idea that the extreme south of Iberia was an attractive glacial refuge is supported by the findings of Finlayson *et al.* (2006) who have shown that Neanderthals persisted in the southernmost extreme of Gibraltar to at least 28 ka BP and even perhaps as late as 24 ka BP.

In East Africa, radioisotopic dating on the Herto cranium from the Middle Awash indicates that *sapiens* populations intermediate between older, archaic and later, fully modern humans were present by *ca.* 160 ka (White *et al.* 2003). Such fossils may be seen as candidates for precursors groups that had migrated into parts of Asia via the Levantine corridor (Qafzeh and Skhül) by around 100 ka. It has been argued that the Levantine specimens represent the early stage of a second migration out of Africa during the early Late Pleistocene (Vandermeersch 1989). Regional variants of *H. sapiens* (i.e. the Neanderthals) were also present in western Asia e.g. Tabun, Amud and Kebara. However we still lack the chronological resolution to infer that these populations ever met in the Levantine area, and can only speculate as to the nature of the social interactions (if any) that may have taken place.

Undoubtedly, the movement of humans into new habitats and over different time periods, e.g. Asian and European settlement by *H. ergaster/erectus* and *H. antecessor/ neanderthalensis/sapiens* respectively was based on a complex interplay between biological factors as well as demographic, social and cultural factors. Many successful movements, as well as less successful ones, must remain to be discovered in the archaeological record. Any evidence of demographic restructuring and dispersal into new palaeoenvironments must surely have required, but no doubt to a different degree, the same socio-behavioural breakthroughs which are viewed as inherent components of the 'Big 2' i.e. OOA I & RAO. Despite this, no theme of hominin migration has drawn as much attention, enflamed as much passion or been the focus of such intense scientific scrutiny and public interest as the RAO hypothesis. This is reflected in the apparent stand-off between the two major human evolutionary frameworks (RAO and MRT) both of which are concerned with establishing the 'where' of human evolution. These paradigms employ incompatible explanatory mechanisms in the search for the process of *Homo sapiens sapiens* evolution. This has led to broad divergences in interpretation as to 'how' and 'why' *Homo sapiens sapiens* emerged: as process or event. RAO argues that all archaic populations, some of which may have been demographically stable and well-adapted were simply replaced as opposed to a more gradual process of change involving gene flow and interbreeding. There is also an implicit theoretical expectation that earlier population movements never broke a regional equilibrium: no single human population or species managed to reach a level of demographic dominance. Yet it is argued that this long-term balance was overturned when a Late Pleistocene population of *H. sapiens* 'achieved' a socio-behavioural package that allowed them to impinge on and eventually replace adjacent human groups and populations globally (e.g. Gamble 1994, 1999; Klein 2000).

2.9.2 Non-environmentally mediated migration

Clive Gamble has examined the basis for what can be termed *non-environmentally mediated migration,* and has argued that changes in the social environment by-passed any intrinsic biological limitations in the colonisation of new habitats. These changes, in turn, led to the development of new behaviours suited to the exploitation of subsistence options in "*ecologically specialized environments*" (Gamble 1984:252). The 'Upper Palaeolithic Revolution' can be interpreted in this light as a suite of behaviours variously co-opted and utilised in specialized settings such as interglacial forests or high-latitude plains, that had hitherto only been sporadically exploited by Neanderthals via a "*going for broke*" strategy (Gamble 1984:252). The broad differences between Middle Palaeolithic (Neanderthal) and modern human adaptive strategies are summarised below.

	Going for Broke Strategy	*Modern Strategy*
Technological complexity?	n/a	Yes
Technological versatility?	n/a	Yes
Labour intensive?	No	Yes
Information sharing?	No	Yes
Prioritise abundant resources?	Yes	No
Planning?	No	Yes
Suited to environmental change?	No	Yes

Modern humans in this context are said to have been more co-operative; more flexible, the scale of their social life much greater. More novel forms of communication and information sharing generated in a sense a form of environmental resistance - an 'insurance policy'. Humans could rely on social bonds to minimise or circumvent occasions that were terminal to the Neanderthal populations, whose social systems, as complex as they may have been at the community level, did not reach the next-level of social organisation that would have facilitated the more permanent colonization and exploitation of more challenging palaeoenvironmental settings. In a sense their social systems were constrained by their own inertia, the Neanderthals were limited by their exposure to only a narrow range of condition-resources. Simply put, the Neanderthals apparently had no need for complex socio-behavioural innovations. The social revolution has been adopted as an explanatory framework by some archaeologists to account for the success of humans at the global scale, and as the explanatory basis for many of the classic features of the LSA/UP. Some of the most important of these features include: organic tools (Klein 2000); blade technology (Foley and Lahr 1997); logistical hunting (Soffer 1989), with a broader exploitation of taxa (Stewart 2004); a broad environmental and climatic adaptation (Gamble 1994) and symbolism (Mellars 1989b). Further traits and the timing of their appearance are summarized in table 6.2. However, many instances of 'modern' traits are associated to supposed non-modern humans. For example, the Neanderthals utilised UP stone tool technologies (Rigaud 2000); symbolism (Farizy 1994); a range of subsistence strategies such as the specialized and generalized hunting of a range of fauna (Burke 2004) the use of marine resources (Barton 2000) and plants (Gale and Carruthers 2000). This evidence suggests that Neanderthal social systems *were* changing, or that the 'modern behavioural standard' requires revision to exclude these traits. Rather than a repositioning of the modernity standard that the second position would require, it is more fruitful to accept that innovative behaviours emerged within late Middle and Early Pleistocene populations of *Homo* irrespective of their anatomical ranking. For instance McBrearty and Brooks (2000) have argued that features such as blade and microlith technology, bone tools, increased geographic range, specialised hunting, the use of aquatic resources, trade, art and decoration all appeared at sites widely separated by space and time across the African continent. The challenge is to step outside of the prevailing wisdom that modern socio-behavioural traits were restricted to *Homo sapiens sapiens*, and to develop an approach which acknowledges the apparent unsystematic emergence of these in space and time, across species or populations. The time is surely right to turn away from largely untestable explanations such as neurological changes that tie-in a package of 'key' behaviours locally in time with a particular species as advocated by Klein (2000).

Perhaps, then, the idea that hominin settlement, on a global scale, across the full-range of condition-resource variability did not mark the moment of 'becoming modern' but was instead the final-stage of a process that was initiated by *H. ergaster/erectus*. The mechanisms required to produce human colonization on a global scale are still very much the subject of debate. Certainly, hominins would have been required to adapt to new environments and climate zones which had remained terra incognita to their ancestors. The challenge is to determine if events such as the proto-expansions of *H. ergaster/erectus* into Asia and *H. antecessor* into Europe were the result of socio-behavioural changes (non-environmentally mediated), or whether demographic expansion occurred as biogeographical zones widened (environmentally mediated).

The preceding discussion has introduced the competing hypotheses of Neanderthal and modern human evolution and migration. Chapter three will expand on a further, related theme – Neanderthal extinction within a climatic and environmental context.

Ch apt er 3

Extinction Scenarios

3.1 Introduction

As we have seen, Neanderthals and modern humans share many similarities despite the uncertainty with regard to their relationship in biological terms (Wolpoff 1984; Stringer and Andrews 1998). These include a wide-range of shared cultural traits and to lesser-degree morphological similarities, especially between some of the latest European Neanderthals and modern human populations (*cf.* Clark and Lindley 1989; Smith *et al.* 1989 and edited volumes Nitecki and Nitecki 1994; Akazawa *et al.* 1998). One major departure however, is that Neanderthals, or to put it more accurately, the characteristic Neanderthal *form* seems to have disappeared from the archaeological record during late MIS 3 or early MIS 2 (*ca.* 30 ka). One of the more interesting and controversial explanations of recent years as to why this happened is that Neanderthal features were effectively drowned as waves of modern humans swept into Europe and inbred with the resident populations. Duarte *et al.* (1999) have argued that the Abrigo do Lagar Velho child is an example of this process. This claim has of course been met by scepticism by other workers (e.g. Tattersall and Schwartz 1999) who argue that if and when Neanderthal and modern human populations 'met' they would have readily perceived one another as anomalous. It is readily accepted but never demonstrated that an underlying social difference would have re-enforced a sense of 'us' and 'them', and this is presupposed irrespective of whichever process (excluding of course MRT) one invokes to account for Neanderthal 'extinction' and 'disappearance'. The Lagar Velho child clearly has an important role to play in the development of a 'third-way' of thinking with regard to Late Pleistocene European demographic changes, a field that remains as fertile for debate as ever despite recent interdisciplinary efforts to illuminate and clarify the nature of this process.

Whether Neanderthals were indeed swamped by modern human genes, or palaeoenvironmental disruptions reduced Neanderthal habitats below a critical supporting threshold, or inter-specific competition for ecological space and resources was won by the African immigrants the starting point is the same: using the *population* as the unit of measurement and contrasting this against Neanderthal groups, it is much easier to accept the underlying assumption, that modern humans equipped with key attributes (most likely socio-behavioural) were in all places and at all times equipped with a fundamental advantage that led to a demarcation between these people. But what is the basis for these models which use social mechanisms at the population level as explanations for Neanderthal disappearance? Could it not be that modern-day social and political disharmony has clouded and distorted our expectations and reconstructions of the nature and outcome of Palaeolithic social interfaces? Modern cultural interfaces illuminate both the imagination and depravity of the human condition. This is to say that during the Palaeolithic, meaning, or cultural difference as we interpret it hundereds of generations later may have been altogether vastly different. In view of this we simply cannot reconstruct but only infer the nature of such contacts, while 'hard' archaeology, such as recoverable artefacts will illustrate only part of what we seek to understand.

The following discussion will center on the theme of Neanderthal extinction and deal specifically with those models that view palaeoclimatic and palaeoenvironmental changes as a significant contributor or a sole factor in Neanderthal disappearance. It will also convey some of the issues introduced above, and determine if assumptions behind Neanderthal *groups* and modern human *populations* have facilitated the expectation that given the environmental circumstances of the Middle Pleniglacial, Neanderthal extinction was inevitable.

In chapter 2.0 the evolutionary relationship between the Neanderthals and modern humans was discussed. The emergence of modern humans was considered from two angles, firstly, those who support RAO theory and contend that the Neanderthals were a separate species (*H. neanderthalensis*). In this paradigm, interbreeding and gene flow with *H. sapiens sapiens* are deemed negligible contributory factors in the disappearance of the Neanderthals. The second position, advocated by workers such as Wolpoff and Caspari (2000) and Hawks *et al.* (2001) views the Neanderthals as regional variants of *H. sapiens*. This hypothesis envisages several linking processes such as inter-regional gene flow (sensu Braüer 1984) and hybridization. Clearly, much of the following discussion relating to the mechanisms of disappearance are variously employed by proponents of RAO and have little or no relevance to MRT based on the evolutionary premise behind that particular model. If Neanderthals were adversely affected by climate change they could then be used at least indirectly to support RAO as the more parsimonious evolutionary explanation for modern human emergence in Europe.

3.2 Ecological change

Clive Finlayson has recently authored or co-authored (Finlayson 2000, 2003, 2004; Finlayson and Pacheco 2000; Finlayson *et al.* 2000a,b; 2004, 2006) some important contributions to the Neanderthal debate, and these have provided some clear and refreshing departures from prevailing attitudes. One of these gains has been to consider both the Neanderthals and modern humans, and indeed all members of the Genus *Homo*, as a polytypic species. This is principally because of the fact that the biological species concept cannot be applied to fossils, thus there is no uncontroversial way to determine if Neanderthals and modern humans were a separate, single or a sub-species. This, they argue, has a further implication for proponents of competitive exclusion because there is no way to unequivocally demonstrate whether the competition was inter- or intra-specific. They have even suggested that if competition did occur, then Neanderthals would have held the advantage:

> "…in a situation of an expanding population (Moderns) and a stable one (the Neanderthals), the resident population would be expected to have the competitive edge over the pioneers because of their superior local knowledge of territory characteristics, available resources and optimal methods of resource collection".
>
> (Finlayson *et al.* 2004:1206)

Finlayson and co-workers have instead turned to the role of climate and environment as factors not only in Neanderthal extinction, but also as a major driver responsible for the geographical range dynamics of the genus *Homo* (Finlayson 2000, 2004, 2005). The thrust of the argument is that Neanderthal population decline and modern human population growth were independent, unrelated responses to climate change. It is claimed that the reason why modern humans succeeded was because their subsistence strategies such as long range hunting were better-suited to the more open, homogenous habitats of the late Middle Pleistocene, while the Neanderthals were specifically adapted to local exploitation of resources in mosaics habitats, an ecology which Finlayson *et al.* (2000a,b) claim diminished during the late Middle Pleniglacial. With regard to the Neanderthal problem, Finlayson (2003); Finlayson *et al.* (2004) discussed these 'unique' late MIS 3 environmental factors in more detail, and set out to show how these depressed the Neanderthals beyond recovery, but permitted at the same time the expansion of the Aurignacians, a term he uses interchangeably to mean modern humans. The main strand of their idea is that oscillatory climate became more frequent during the second half of MIS 3 and that this resulted in major habitat loss and wholesale ecological change. While the idea that climate became more oscillatory during the second half of MIS 3 may be true, its effects on terrestrial environments is less-certain, and it cannot be assumed that environmental shifts occurred as frequently as climatic shifts appear to have done in regional climate proxies such as the ice-core records. Finlayson (2004) made an important and far reaching claim that the second half of MIS 3 was perhaps the most unstable of the last climate cycle. This contention was derived from the inclusion of the isotopically heavy $\delta^{18}O$ values of the full glacial (MIS 2) and the isotopically light values of the deglaciation (MIS 1). Both MIS 2 and MIS 1 post date Neanderthal disappearance hence palaeoclimatic changes from these phases are irrelevant to the Neanderthal debate. In view of this it must be considered a mistake to have included these values into the MIS 3 analysis as it would have naturally distorted the actual trends which characterised late MIS 3 (d'Errico and Sánchez Goñi 2004). Therefore we can only conclude that Finlayson's claim, based on the manner in which the data were reported, is unsound.

Certainly one of the most important contributions of the 2003 and 2004 publications is the criticism of competitive exclusion as a cause of Neanderthal extinction. Finlayson and co-workers made a convincing case, based on the idea that unstable palaeoecological settings over wide areas of Europe would not in fact have promoted the development of stable (human) communities, a precondition for niche competition. Finlayson and co-workers go on to claim (and no doubt a consequence of their polytypic species concept) that competition should be discounted because of,

> "The apparent coexistence of distinct ecological populations in different parts of the world, including Neanderthals and Modern humans, over protracted periods in the Pleistocene without any indication of competitive exclusion of one population over another [population]".
>
> (Finlayson *et al.* 2004:1205)

While the ecological/climatological grounds for discounting competition is essentially sound, the contention of apparent co-existence is less so and this raises several issues. The first of which is Finlayson's claim of an '*apparent coexistence...over protracted periods*' is an assertion. There is no direct evidence for this, unless of course one argues that the Middle Eastern sites of Tabun and Skhül represent (i) Neanderthals and modern humans respectively and (ii) that they were contemporaneous. The first point is still open to debate and the second point seems unlikely based on current chronological evidence. Other claims for co-existence include the intercalated Châtelperronian and Aurignacian horizons from El Pendo, Roc de Combe and Le Piage. However, these claims have been strongly rebuffed on taphonomic and chronological grounds by Zilhão and d'Errico (1998) who argue that the dates on the earliest Aurignacian in north Spain are problematic, while the southern European sites of El Pendo, Roc de Combe and Le Piage are stratigraphically admixed and therefore unreliable. On a broader temporal and spatial level, we simply do not have the chronological evidence from which to confidently claim that *H. neanderthalensis* and *H. sapiens* coexisted at all. It is also worth noting Finlayson's use of the term *protracted*. Used in the context of co-existence its application is confusing and slightly contradictory as it is suggestive of competitive exclusion; an explanation he feels is eminently unsuitable. This having been said, competition as a factor in Neanderthal extinction at least on theoretical grounds was considered at length in Finlayson *et al.* (2000, 2004). It was concluded that competition is effective at structuring communities when they are at equilibrium. This is to say, when the environmental conditions facilitate stable populations to grow and where carrying capacity is fixed and stable. Quite reasonably, based on the climate proxies used to recreate palaeoenvironment it is argued that neither of these conditions was met during MIS 3 because climatic fluctuations continually disrupted ecological settings, remodelled habitats and carrying capacity. Competition could not have taken place under such circumstances. While this approach conforms to sound ecological theory, I feel that it fails to acknowledge the fact that both Neanderthals and modern humans were both socially and culturally advanced populations in their own right, and that there may have been other factors at play that render a strict ecological approach inappropriate. For example, there may well have been situations where conditions or resources remained constant in space and time (i.e. across stadial-interstadial cycles) these may have included symbolic or locally important landscape features, or functionally important resources such mining outcrops and water sources etc. Such features may have been the focus of attention and of primary importance to human populations despite the *flux* of fauna and flora (but two of many variables) which Finlayson quite reasonably argues would have prevented competition from taking place. In other words, competition may have occurred between resident and migrant groups for key resources against a backdrop of climatic and environmental heterogeneity and uncertainty. While I agree that there is real value in looking at human settlement as part of a biogeographic process, I feel that a strict rendering of this approach is unsound. It is for this reason that I would argue competition remains a plausible explanation at the regional-level for local extinction and cultural change.

Finlayson has largely followed Mellars and other archaeologists in favour of replacement scenarios by characterising modern human demographic structure as *populations* while Neanderthals are viewed as *groups* (e.g. Mellars 1998; Finlayson *et al.* 2004). This terminology implicitly creates the grounds for a clear distinction when discussing the subject of demographic changes, yet despite the methodological implication, it has not been satisfactorily demonstrated that the distinction is at all real and meaningful. Presumably the use of the term 'population' in this context is taken to represent large numbers, perhaps many thousands of people sharing a similar socio-behavioural package. *H. neanderthalensis* on the other hand is spoken of in terms of 'groups' and we could infer that these were characterised by less-systematic social and cultural traits. As these workers have yet to provide a more detailed rendition of the meanings behind these terms, this basic definition will have to suffice for the purposes of this discussion. Yet according to Finlayson *et al.* (2004) these Neanderthal groups somehow held advantages over the incoming moderns because they were the resident populations. Finlayson does not make it clear but we can perhaps expect that Neanderthals would have maintained their dominance had it not been for the "unique features" of late MIS 3, which he argues removed this starting advantage and depressed and fragmented the Neanderthal groups beyond recovery. Despite the focus on habitat loss as the prime factor in Neanderthal extinction, Finlayson *et al.* (2000) also argued that there were series of other factors linked in with the broad idea of palaeoclimatic deterioration such as disease, local competition, inbreeding and genetic swamping'. Despite asserting that only the 'broad-scale' processes of extinction can be understood, Finlayson *et al.* (2004:1206) have explicitly asserted a range of small-scale, regionally applicable processes which are unlikely, by themselves, to have resulted in instantaneous wholesale Neanderthal disappearance.

Finlayson (2004) does not agree with supporters of the notion that modern humans were more technologically and socially advanced than the Neanderthals. Yet he grants the former a raft of behavioural supplements such as fire, clothing, shelter, advanced society and advanced technology, traits the Neanderthals presumably found superfluous to their needs. In order to understand why these aspects were utilised more intensely by modern humans than the Neanderthals we must return to the issue of biology. Finlayson has proposed that the modern human gracile skeleton was perfectly adapted to the African savannah; hence it served as a pre-adaptation to the European Plain. This permitted modern humans in a sense to surf the ecological tide into the homogeneous landscapes (the unique features) which he believes proliferated across eastern and western Eurasia during the Middle Pleniglacial. But in order to successfully adapt to the colder settings of Europe, certain behavioural innovations were required. In contrast, he argues that the robust Neanderthal morphology placed severe restrictions on the range of palaeoenvironments that could be successfully exploited; specifically, Neanderthal morphology was congenial to mixed, heterogeneous palaeoenvironments where resources were closely packed, immediately exploitable (in contrast to the plains) and where close-quarter hunting was adopted. Finlayson argues that even these preferred Neanderthal palaeoenvironments situated principally in SP and MP eventually gave way to homogenous open palaeoenvironments, and it was the withering of these core habitats coupled with the Neanderthals inability to change morphologically and behaviourally that led to their extinction. The general theme of demographic change is aptly described in the following quotation:

> "As increasing climate variability created increasing spatial heterogeneity of habitats and landscapes in Africa, hominids became increasingly dependent on intermediate and open habitats and landscapes, evolving adaptations that permitted them to deal with the spatial uncertainties characteristic of such environments. Such adaptations, which may be summarized as adaptations that increased the scale of activity and improved environmental resistance, incidentally enabled hominids to expand their geographical range away from the tropics surmounting previous ecological barriers with increasing chances of success".
>
> (Finlayson 2004: 69-70)

Finlayson has clearly set out to argue that there were no major cognitive differences between Neanderthals and modern humans; instead, it was the gracile anatomical frame of modern humans which was simply more advantageous in the more open settings which eventually typified most of Europe during late MIS 3. In this context, habitat break-up can be viewed as the driving force behind the Neanderthal movement into the lower latitudes, which by implication were the most predictable and stable. Yet this cannot be true; the SP and MP do not appear to have been the regions best suited to the Neanderthal generalists because, as we will see in the next chapter, they witnessed the brunt of palaeoenvironmental deterioration during the Early and Middle Pleniglacial. In contrast, the NP and perhaps the CP were far more stable habitats but perhaps less ecologically diverse when compared with other lower latitude regions. So any Neanderthals retreating west and south over the course of the Weichselian in the sense Finlayson argues would have surely encountered far-greater challenges as they encountered rapidly fluctuating wooded-steppe, forest and steppe biomes in lower latitudes. This in an important point and a major criticism of the model outlined above.

A further point worthy of mention concerns the nature of cultural-environmental adaptation. If competition was not a factor as Finlayson believes, why did the Aurignacians fail to emulate their Mousterian counterparts and hasten an earlier appearance into the heterogeneous habitats of Iberia? If indeed, as Finlayson believes, the Aurignacian *sensu stricto* was an adaptive response to cold, open conditions, then surely some Aurignacian humans, particularly those occupying the transitional zones of northern Iberia would have begun to modify their technology and behaviour accordingly so as to facilitate an earlier entry into the heterogeneous zone of southern Iberia? If culture was adaptive as Finlayson advocates we can posit that Neanderthals in this region would also have modified their behaviour much in the same way as 'other' Neanderthals appear to have formulated the Uluzzian which is viewed as a response to the more homogenous environments adjacent to the Iberian zone. Why cultural change should be so directional in one way seems a difficult argument to uphold. In other cases for instance modern humans in Tasmania, long after the Neanderthal form disappeared were utilizing primitive stone tools (Cosgrove and Pike Tay 2004). These 'crude looking' tools were seemingly a discrete adaptive response to specific environmental conditions and to raw material limitations. The Tasmanian example illustrates the difficulties involved in trying to associate particular humans to particular cultures, and particular cultures to a specific environment. If as Finlayson believes technology was principally born from palaeoenvironmental requirements, it is reasonable to enquire as to why modern humans did not make this somewhat ironic technological leap *back* to the Mousterian.

Finlayson's (2004) publication provided a detailed elaboration of his Neanderthal extinction hypothesis. The Iberian Peninsula was chosen to illustrate the process at the regional scale. The spatial surface of the Iberian region was mapped into flat surface images using Universal Transverse Mercator (UTM) technology. These were combined with bioclimatic map data (Table 3.1) to divide MIS 3 into four palaeoclimatic categories: (a) *warm*, which lasted for 10.6% of MIS 3 (b) *moderately warm* which lasted for 22.7% (c) *moderately cold* which lasted 24.2% (d) *cold* which lasted 42.4%. Finlayson uses arbitrary 5 and 10 point units to reflect phases of population growth and decline over the post-Eemian-MIS 3 timeframe: (1) Neanderthals: 10 unit growth in *warm*, 5 unit growth in *moderately warm*, 10 unit decline in *cold*, and 5 unit decline in *moderately cold* (2) modern humans: 10 unit growth in *cold*, 5 unit growth in *moderately cold*, 10 unit decline in *warm*, and 5 unit decline in *moderately warm*.

Table 3.0.3 Modelled Meditteranean bioclimate. Shows progressive changes in MP bio-climate as a function of temperature during MIS 3. For comparison, temperatures in the SP during MIS 3 warm phases approached - 4 ˚C while cold values were around – 9 to - 11 ˚C.

	Bioclimate (Mediterranean)	**MAT (˚C)**	**MWT(˚C) (Min./Max.)**	**Upper T(˚C)**
1	Thermo	17-19	4-10, 14-18	-3
2	Meso	13-17	-1-4, 9-14	-7
3	Supra	8-13	-4-1, 2-9	-10
4	Euro	<3-10	-8 – 0, <0 - >8	

However it is by no means certain that high-magnitude DO and HE events resulted in more significant palaeoenvironmental change than low-magnitude DO across the Iberian Peninsula (Sánchez Goñi *et al.* 2002). Thus we must be cautious before accepting Finlayson's proposal that the cold value of 42.4% reflects a real departure, in palaeoenvironmental terms, from the moderately cold value of 24.2% in the absence of terrestrial environmental reconstructions to substantiate the claim. We must treat any claims regarding the preferential growth and decline of Neanderthal and modern human populations across these dubious bioclimate categories with cautious acceptance at best. Figure 3.1 illustrates Finlayson's Neanderthal population contraction/expansion pattern in the Iberian Peninsula.

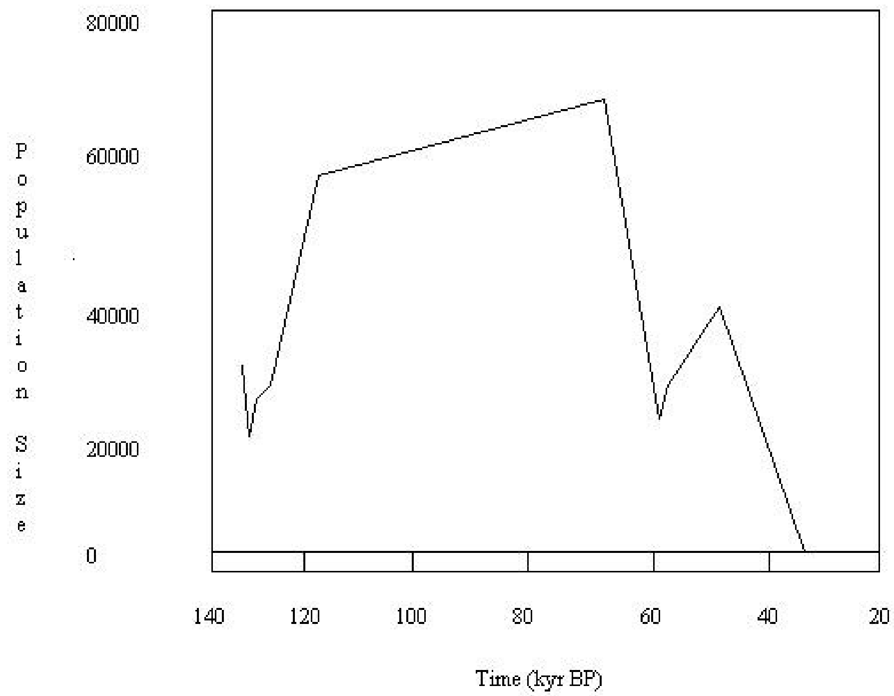


Figure 3.1 Neanderthal population decline in the Mediterranean Province

Fig. 3.1 shows that Neanderthal populations peaked during MIS 5a (*ca.* 84 ka to 72 ka) when Iberian environments were relatively closed. This is an important finding. Rather than demonstrating that the Iberian Neanderthal populations were at their optimum during semi-open-closed habitats, it clearly demonstrates that regional populations, in this case those of the MP, seemed to have a greater preference for more closed environments. This clearly has implications for those models which view the Neanderthals *en bloc* as poorly adapted to closed environments (e.g. Gamble 1999). We observe a clear decline in the 'population' with the onset of MIS 4, which did not improve considerably despite the MIS 3 ameliorations.

Finlayson strongly believes that the Iberian Neanderthals became extinct as a function of decreasing bioclimatic diversity over the Middle Pleniglacial. Despite his credible attempts to view the Neanderthals as part of a variable population of the genus *Homo*, he simplifies the process by creating an artificial and contradictory disjunction which categorises the Neanderthals as 'warm-adapted' humans. A final criticism is that he fixes the deck so to speak, by assuming that large numbers of incoming modern humans were present. This is necessary to avoid the unfortunate consequence of modern human populations, which he views as cold-adapted, going extinct during warm episodes.

3.3 Dual causal: competiton and climate

A further model, in this case combining various elements of competitive exclusion and palaeoclimatic change was recently outlined by d'Errico and Sánchez Goñi (2003). They adopted a similar approach to that of Finlayson by assessing the nature of Neanderthal extinction at the regional scale in the Mediterranean region. They collated 321 conventional ^{14}C and 118 accelerator mass spectrometer (AMS) determinations from archaeological sites located in Iberia and southern France. The archaeology was grouped into Mousterian, Châtelperronian and Aurignacian categories which were then measured in terms of frequency distribution by millennium over the MIS 3 phase. They highlighted a potential methodological caveat regarding the use and interpretation of the non-AMS ^{14}C determinations, which have a wider frequency distribution and a broader temporal range than AMS resulting in some Mousterian data post-dating the Aurignacian, a point unsupported by stratigraphic evidence. Hence it seems clear that non-AMS ^{14}C determinations are in many cases gross underestimates of real age. In light of this they reasonably argue that sites dated with the more accurate AMS method should be preferred in any assessments of the chronological nature of the MP-UP transition. d'Errico and Sánchez Goñi conclude that modern human population density in France was very high during Heinrich event 4 (H4) which they believe was a 1,000 kyr phase between 34-35 kyr BP. They state that the earliest securely attributed Aurignacian sites are no older than 35.3 kyr BP, and that the standard deviations of older dates may also place them within the H4 event. There are some AMS dates that would appear to indicate that modern human settlement occurred earlier in Iberia than France e.g. the 'archaic' Aurignacian at Castillo, (level 18C) dated by AMS to 44,732 ± 2826 kyr BP; Reclau Viver (level TIII) 43,638 ± 1856 kyr BP, while at L'Arbreda (level H) the Aurignacian has been dated to 41,528 ± 1151 kyr BP. However, Zilhão and d'Errico (1999) argue that these 'early Aurignacian' sites are unsound owing to uncertainties regarding the association between the dated materials and artefacts, and whether they have even been correctly attributed to the Aurignacian. Despite their reasoned criticisms they do not provide any grounds to reject other AMS dates such as the proto-Aurignacian from Mollet Cave (0.6-0.8m) at 40,942 ± 514 kyr BP; the Dufour Aurignacian from Valena (Level IV) and Labeko Cova (VII) dated to 40,891 ± 498 kyr BP (AMS) and 40,056 ± 1003 kyr BP (^{14}C) respectively.

They envisage a scenario where modern humans were not in fact present in any numbers across the Franco-Cantabrian region until 35 ka; moreover, they were prevented from settling in southern Iberia because of two main factors (i) resident Neanderthal groups and (ii) what can be interpreted as the 'challenging' H4 palaeoenvironmental contexts comprised of Mediterranean tree refugia and *Artemisia* (Zilhão 2000a; d'Errico and Sánchez Goñi 2003; d'Errico and Sánchez Goñi 2004).

> "Aurignacian moderns were probably not interested in colonizing these arid Mediterranean biotopes until after the H4 event".
>
> (d'Errico and Sánchez Goñi 2003:17)

This hypothesis rests on two key expectations (i) that H4 occurred between 34-35 kyr BP (ii) that distinct palaeoenvironmental settings characterised southern Iberia between the pre- and post H4 phase. The first of these expectations, the duration of H4, is problematic. It has been recently argued that H4 was a short 250 yr phase between 36.25 and 36 kyr BP and that it resulted in a modest sea-level change of 2m ± 1 (Roche *et al.* 2004). This is considerably less than a previous estimate of a 1,000-2,000 year duration with ~15m of sea-level rise (Bond 1993; Bond and Lotti 1995). Therefore we have an alternative interpretation of the data which no longer ties in a Franco-Cantabrian Aurignacian 'peak' between *ca.* 34-35 ka, while demonstrating that the quantitative effects of the Heinrich event (hence palaeoenvironmental impact) were less severe than previously thought. The second point emphasises that there were real palaeoenvironmental differences in Iberia, in the sense that southern Iberia is interpreted as a general "refugium zone" during H4 and that this was superseded by "improvement" after the H4 event (d'Errico and Sánchez Goñi 2003:784). Yet terms such as '*refugia*' and the '*subsequent post-H4 amelioration*' are poorly defined by the authors. Presumably, palaeoclimatic ameliorations led to an expansion of refugia over broader areas and not necessarily the introduction of new ecological resources within the starting refugia zones, hence there is some ambiguity regarding the relevance of these two terms which are essentially synonymous in meaning. In this light I believe that it is highly speculative and simplistic to extrapolate a 'general palaeoenvironment' from offshore marine records, as the authors did in this study, to a broad area like southern Iberia. It is an equally plausible scenario that parts of France, northern and southern Iberia were palaeoenvironmentally analogous, and that the very nature of these heterogeneous landscapes may have created ecological corridors both inter- and intra-regionally. Thus any suggestion that migration during a particular palaeoclimatic episode was mitigated by a more stable or homogenous palaeoenvironmental context is ignoring the underlying complexity of the region as Finlayson *et al.* (2004) have argued. While d'Errico and Sánchez Goñi concede that palaeoclimatic changes would have undoubtedly pressurised and fragmented the Neanderthals into disconnected groups, they dismiss this as the sole cause in extinction because Neanderthal populations survived previous cold events such as H6 and H5. This is a questionable assumption as both the demographic structure of ancestral Neanderthal populations, as well as the palaeoecological zones utilised by these populations may well have been quite different, hence it is inappropriate to assume, in a strict uniformitarian manner that climate events were essentially analogous across the MIS 3 timeframe (a point well made by Finlayson *et al.* 2004). This is an important consideration as HE and DO varied in relative magnitudes both in marine proxies and in terrestrial environments. For example H3 was marked by lower amounts of ice rafted debris (IRD) than H4, H5 and H6, which taken at face value may indicate a weaker ice discharge or less IRD in the ice load, however H3 coincided with a period of insolation minima which resulted in extremely cold conditions at *ca.* 30 ka (Sánchez Goñi *et al.* 2003) suggesting that this was a major climate deterioration after all. After assessing the archaeological patterning d'Errico and Sánchez Goñi conclude that intra-specific competition was the dominant cause of Neanderthal extinction:

> "How can one reasonably conceive an independent demographic implosion of a well-adapted human population [Neanderthals], while accepting that another population was occupying neighbouring territories, but refuse to establish any causal link between these two events?"
>
> (d'Errico and Sánchez Goñi 2004: 1205)

The theme of competition is implicit, as is the premise that both Africans and Eurasians were discrete, contemporary populations that interacted in different ways. A competitive exclusion scenario such as this fails to consider that Neanderthals themselves may well have been drawn into competition for the diminishing resources and habitable areas of the Iberian Peninsula long before and independent of the 'added pressures' of modern humans. As Finlayson and co-workers have pointed out, the circumstances for competition to have arisen may never have occurred, or if they did, they may have been too short-lived to have resulted in competitive exclusion. Alternatively competition may have centered on more resilient variables or resources during episodes of ecological instability. A final point is that even if ecological circumstances were amenable to competition, it cannot be claimed with any certainty that Neanderthals and modern humans were ever in proximity to such a degree for a sustained episode of demographically meaningful competition to have taken place.

3.4 Discrete climate stress

As part of the Stage 3 Project (2003) Stringer *et al.* (2003) developed a hypothesis that interwove the two themes of inter-specific competition and palaeoclimatic stress into a multi-causal hypothesis of Neanderthal extinction. They did this by examining the Lago Grande di Monticchio pollen profile and the GISP2 ice-core and asked in what way (i) absolute local temperature, and (ii) the rate of temperature change influenced Neanderthal populations over the Middle Pleniglacial. These parameters are viewed as primary controls over key human resources e.g. flora and fauna and also constrained the way in which new adaptations emerged to meet the changing biotic environment – which was a function of the 'new' absolute temperature state. They translated the GISP2 $\delta^{18}O$ data into absolute temperature values and these were analysed to see if they were representative of trans-European temperatures in general. One interesting and no less startling finding was that the reconstructed temperature variations from Lago Grande di Monticchio were only 1/3rd of the amplitude of the GISP2 temperature fluctuations. However the GISP2 data was preferred because according to the authors it is, "*a useful indicator for the basic temperature conditions across Europe*" (Stringer *et al.* (2003:236).

Using the reconstructed temperature values from the GISP2 and episodes of woody taxa development identified in the Lago Grande di Monticchio profile two major stress-periods were identified: the first one at *ca.* 30 ka (*ca.* Heinrich event 3) and the second at *ca.* 65 ka, with stress minima at *ca.* 50 ka and *ca.* 80 ka. Stringer *et al.* (2003) believe that *H. neanderthalensis* survived in 'stress refugia' at *ca.* 65 ka but at *ca.* 30 ka, the added 'circumstantial' pressures of inter-specific competition contributed to Neanderthal extinction. The model is quite explicit in its use of the 30 ka date as the onset of the major stress peak, but it does not indicate if this was phased-in over the preceding several millennia, nor does it indicate how long the episode lasted. This is a concern as many workers agree that *H. neanderthalensis* seems to have been under some form of pressure and lessening their grip on western Europe over the previous several kyr (Pettitt 1999) therefore this 'acute' episode at 30 ka may be nothing more than a correlate with the H3 event.

By Stringer *et al's* own admission there are some considerable differences in terms of reconstructed palaeotemperature values between GISP2 (situated near central Greenland) and LGdM (situated near Naples). Indeed this is to be expected as both proxies are separated by some 4,200 kilometres. This fact alone must caution against directly extrapolating palaeoclimatic values across broad regions especially in any region as topographically complex and climatically heterogeneous as Eurasia. In this light we must conclude that claims of, "*drops of up to 10 degrees C in a human lifetime*" (Mellars 1998) based upon GISP2 palaeotemperature reconstructions were, in a lot of cases probably substantially less, and that some of the weaker GISP2 oscillations actually resulted in negligible terrestrial disruption.

The climate stress model is built on the idea that strongly expressed interstadial events (woody taxa) in the Lago Grande di Monticchio profile become less-frequent over the 110 to 10 ka BP phase and that,

> "periods of rapid change can also destabilize local ecologies, reducing the carrying capacity of the environment until stability is re-established".
>
> (Stringer *et al.* 2003:235)

The second key concept behind the climate-stress model is that the levels of stress on Neanderthal populations increased because,

> "…less productive glacial/stadial environments will be less able to support specialized organisms at the top of the food chain".
>
> (ibid)

The first of these concepts, which is to an extent accurate, does however brush over an underlying complexity. While there is no doubt that periods of environmental change saw an influx of new variables coupled with a decrease or a disappearance altogether of pre-existing variables, one cannot simply claim, as Stringer *et al.* have done, that ecological change *a priori* results in a reduction in carrying capacity. Rather it would be more accurate to acknowledge that such changes would have resulted in some net loss of carrying capacity (as existing fauna and/or flora migrated or died-off) which was subsequently replaced by new resources. Therefore the real challenge was probably not so much a gross loss in carrying capacity, as much as one of adapting to net changes in existing or introduced variables and whether the behavioural potential of the population in question could meet the new circumstances. With regard to the second concept their analysis appears to have discounted a series of subtle forest expansions. For instance, the period between 73 ka and 50 ka BP witnessed four episodes of *Quercus, Betula* and *Fagus* woodlands corresponding to some 9,600 years of interstadial conditions (*cf.* Allen and Huntley 2000b). Similarly, the 12.9 kyr phase between 42.3 ka to 29.4 ka BP witnessed some 6,400 years of *Betula/Quercus* woodland (ibid). Palaeoenvironmental stress may have been expressed as *two* forms; this is to say both during the cooling trend as well as during the abrupt return to interstadial conditions. Moreover palaeoenvironmental disruption may have been more pronounced during the rapid-warming as indicated by the sharp angle of the upward-limb of the DO cycles, and less acute during cooling, which appears to have been marked by a gradual down stepping saw-tooth pattern of the ice records. Hence 'stress', in terms of palaeoenvironmental disruption, was probably greater during the onset of rapid warming on the upward-limb of DO cycles as human populations, fauna and flora, had less time to adjust to the change in palaeoenvironmental trend. Indeed, phases of rapid warming would have caused relatively rapid forest expansion outward from refugia zones at rates between 0.2 and 2 km/year. Even during short 300 yr interstadials, this could have created disruption zones between 60km and 600km wide propagating from the refugia centers. This is an important implication for the climate stress hypothesis because Lago Grande di Monticchio between 110 ka to 10 ka witnessed many lower-order reversions to forest conditions which do not appear to have been factored into the climate-stress hypothesis. Stringer *et al's* model seemingly imbues equal stress values to both the warming and cooling, however I believe that this model has artificially exacerbated the stress, by considering the larger forest expansions and placing less-emphasis on the episodes of lower magnitude expansions. If these more subtle expansions are considered, they may smooth the apparent stress peaks at 60 ka and 30 ka, and support the idea that the MP was highly irregular and heterogeneous region for much of the Middle Pleniglacial.

3.5 Socio-behavioural advantages

Paul Mellars is perhaps the most vocal of the European archaeologists in support of the RAO theory. He has used his extensive knowledge of the French archaeological record to support this hypothesis by arguing that a dramatic transformation in almost all aspects of human behaviour occurred during MIS 3 (Mellars 1989a,b; 1996). He has argued that the Upper Palaeolithic represents a clear departure in almost all aspects of the visual archaeological record, in terms of stone and bone technology, art and ornamentation, social organisation, demography, communication and subsistence patterns from the earlier European Middle Palaeolithic (Mellars 1998). Moreover he argues that the chronological emergence of these distinctive 'cognitively modern' traits in the European archaeological record can be can be tracked, occurring initially with the first pulse of modern humans at *ca.* 43 ka in SE Europe, before propogating into other parts of Europe via a so-called 'bow-wave' effect, eventually reaching NW Europe at *ca.* 35 ka. Mellars believes that the staggered appearance in space and time of these modern traits can be used as a proxy to infer the expansion of anatomically modern human populations and that the progenitors for these first modern Europeans lay somewhere to the east, either in the Mediterranean or southwest Asia (Mellars 1998). He argues that a large-scale migration from these temperate regions would have required a major phase of amelioration in periglacial Europe and that this happened during the Hengelo interstadial at *ca.* 38-41 ka. Mellars states that this amelioration,

> "[I]mmediately follows the sharp glacial episode known as Heinrich Event 3".
>
> (Mellars 1998:497)

However the H3 event is generally accepted to have occurred between *ca.* 29-31 ka (Bond *et al.* 1992; Hemming 2004) so presumably Mellars means the H4 event which occurred between *ca.* 38-37 ka (Bond *et al.* 1992; Hemming 2004), with the Hengelo interstadial sometime between *ca.* 41-37 ka (Van Huissteden *et al.* 2003). Leaving Chronological uncertainties to one side, the amelioration is said to have resulted in the expansion of mixed deciduous-coniferous woodland across much of the Mediterranean (van Andel and Tzedakis 1997). These palaeoenvironments are said to provided modern humans the opportunity to 'surf the ecological tide' into eastern, central and western

European regions with minimal adaptation on their part. Mellars believes that the Neanderthals were far-less suited to mixed deciduous-coniferous woodland than modern humans so they would have abandoned vast areas of the Mediterranean leaving essentially competition-free habitats for modern humans to exploit. This is perhaps an oversimplification as it seems probable that from the late Eemian at *ca.* 107 ka, and for periods thereafter vast areas of Europe was structurally similar to the Mediterranean during the Middle Pleniglacial with significant forest and woodland stands which appear to have supported Neanderthals at one time or another (chapter five). Therefore we cannot discount the idea that *all* Neanderthal populations were generally unsuited to woodland or semi-closed habitats. Mellars argues that once modern humans had gained a significant demographic presence a period of co-existence ensued which resulted in the Neanderthals adopting some distinctive UP traits via acculturation (Mellars 1998, 1999). However two main factors led to their extinction. Firstly, the gradual and steady increase in the more behaviourally advanced modern human populations and the inter-specific competition that ensued for the exploitation rights of specific territories. Implicit in this idea is the notion that Neanderthals were destined to lose any instances of direct competition. Let us consider this first point in more detail.

Mellars (1998:502 underscore my emphasis) stated,

> “If there is any truth in the assumption that the anatomically modern human populations possessed not only more complex and economically efficient technology than Neanderthal groups but probably also more highly-structured patterns of social organization and probably more complex and efficient systems of inter-group communication then it seems almost inevitable that in any situation of direct competition of this kind the anatomically modern human populations would be most likely to outcompete the Neanderthals. The result would be a gradual contraction of overall territories and economic ranges and almost inevitably some fragmentation of the Neanderthal groups into smaller and more demographically isolated social units”.

This seductive quotation summaries very neatly the rationale behind replacement and extinction however it requires a significant degree of faith in order to accept it as true: qualifiers such as ‘*almos*t’, ‘*some*’ and ‘*probably*’ combine to result in a very ambiguous scenario. Mellars meaning behind African populations is vague but still implies a more structurally ordered or advanced phenomenon compared to the Neanderthal groups.

Without considering the underlying *sine qua non* population replacement would demand, replacement is accommodated from the theoretically unsound position of *populations replacing groups*. A self-reinforcing outcome based on a dubious starting premise.

The second factor views palaeoclimatic changes, specifically the, "*HE 4* [*sic*] *event which probably centers on about 33-34 ka*" (Mellars 1998:515) as having necessitated major behavioural changes in order to cope with changing subsistence options. In order to illustrate this point, Mellars has argued that the palaeotemperature variations from the GISP2/GRIP ice-core (i.e. changes of 8° C or more in well under a human lifetime) led to considerable palaeoenvironmental disruption and this is reflected in the frequency changes of various fauna from La Ferrassie 'across MIS 3' (Mellars 1985). On closer inspection it appears that the main faunal changes post-date the horizons relevant to the Neanderthal disappearance i.e. they are older than 30 ka. Only layers MIb-L1b (Châtelperronian and Aurignacian 0) and K4-L1 (Aurignacian 1 and 2) are pertinent (perhaps K4-L1 are even too late?). These horizons show only moderate reindeer increase, low horse values (a similar trend for later levels) and reduced frequencies of red deer (*cf.* Mellars 1989:494 fig. 1).

Mellars argument also rests on the idea that the Mediterranean region provided humans viable ecological settings and opportunities in relation the rest of Europe, a position which is probably unsound. As we will see in chapter four, the Mediterranean region experienced some of the greatest ecological upheavals of the Middle Pleniglacial. These would have failed to offer *H. sapiens sapiens* easy surfing into the European backwaters by any means and surely would have required more than the '*limited adaptation*' Mellars (1998:496) speaks of. As an aside to viewing the appearance of Africans in Eurasia as a large-scale demographic event during a narrow time frame, Mellar's qualifies this with a caveat that the process would have varied in response to local ecological conditions (yet these ecological nuances are unspecified). This is tautological. In breaking down the large-scale process into ecologically dependent, temporally unrelated colonisations, the process is not one of seizing the Hengelo window of opportunity but rather a protracted pushing-and-shoving unrelated to any single palaeoclimatic regime. Did the Hengelo really afford sufficient time for populations to form together in the extra-European areas, migrate, adapt and replace, to say nothing of becoming established in these supposed temperate Mediterranean regions? Moreover, can a clear concentration of statistically meaningful, securely dated and representative Aurignacian sites really be securely attributed within the Hengelo Interstadial, to support the argument of a major human migration event? Based on the limited chronological resolution of (i) the archaeology in question and (ii) the Hengelo interstadial (iii) the authors of the early Aurignacian, it is extremely difficult to uphold this contention.

3.6 Biogeographical factors

Stewart *et al's* (2003) paper represents an interesting and important contribution to the Neanderthal debate as much for its critique of the competition-extinction scenario as for the alternative hypothesis it sets forth. In support of the argument made my Finlayson *et al.* (2000a,b) they emphasise that the growth and decline of modern human and Neanderthal populations respectively were independent responses to climate change. They implicitly accept Finlayson *et al's* (2000a, b) argument that Neanderthal resource acquisition strategy was ill-equipped to exploit mobile herd ungulates in increasingly more open ecologies during MIS 3. Stewart *et al.* (2003) also remind us that a long period of apparent co-existence lasting perhaps 10kyr is also grounds to reject modern human involvement in Neanderthal extinction. Stewart (2004, 2005) and Stewart *et al.* (2003) argued that the extinction of the Neanderthals should be considered within the context of the broader ecological community and specifically viewed alongside the disappearance of other large mammalian fauna some of which went extinct during the later Middle Pleniglacial. In the 2003 treatment Stewart *et al.* analyzed the *Stage 3 Project Mammalian Database* to test for synchrony between the demise of Neanderthals and other mammalian fauna. They reconstructed the biogeography of 41 extinct and extant faunas (including Neanderthals and modern humans) into three main categories i) taxa whose Late Pleistocene/Holocene distribution remained the same ii) taxa whose distribution shifted north during the Holocene iii) taxa whose distribution shifted into SE Asia after the Pleistocene. They also recognised two further categories: iv) taxa that went extinct near the Pleistocene/Holocene boundary and v) taxa that went extinct at the LGM. Despite the chronological uncertainties of the dated faunas, coupled with the problem of associating these with particular climate episodes Stewart *et al.* claimed that they were able to assess the frequency and spatial distribution of mammalian fauna within three temporal phases that were chosen on the basis of climatic and chronological concerns. The first of which was an 'early' 13 kyr phase between 60-47 Ka; the second was a 'middle' phase lasting 9kyr between 37-28 Kyr and the third was a 'late' phase lasting 8kyr between 28-20 Kyr.

Three main temporal patterns were identified:

1. Mammals that do not change frequency of occurrence through time. These include some extant taxa, those that retreated north and some that became extinct at the end of the Pleistocene (e.g. *Rangifer tarandus, Equus ferus, Mammuthus primigenius*).
2. Mammals whose presence decreased significantly over MIS 3. These include the '1st phase' of the megaufaunal extinctions e.g. *Panthera pardus* and the 'IG survivors' *Stephanorhinus kirchbergensis*, *Elephas* (*Palaeoloxodon*) *antiquus* and the Neanderthal (*Homo neanderthalensis*). All carnivores went extinct while the Neanderthals and herbivores disappeared from Europe.

3. Mammals that increase. These include the musk ox (*Ovibos moschatus*) and modern humans (*Homo sapiens*).

In terms of the spatial distribution of the Neanderthals it is argued that they were more closely related with the interglacial survivors (the straight-tusked elephant and the Merk's rhino) and were part of a biogeographic re-organisation which saw all three species retreat south and to the west by the end of MIS 3. Out of these three interglacial survivors, only the Neanderthals made it into the 'late' phase. Stewart *et al.* (2003) concluded it was the extreme cold, along with a reduction in carrying capacity that led directly to their extinction.

Stewart’s inclusion of the Neanderthals into a faunal suite termed the ‘interglacial survivors’ represents an explicit rejection of the notion that the Neanderthals were Arctic or hyperarctic adapted. Stewart prefers instead to view the post-cranial ‘robustness’ of the Neanderthals as a response to the heterogeneous, physically demanding nature of the landscapes inhabited (*cf.* also Finlayson 2004). It is worth discussing the term ‘interglacial survivors’ in more detail. In this context, the Neanderthals represent a Weichselian evolutionary accident stranded in the palaeoecologically unstable regions of the European peninsula. While Stewart’s holistic biogeographical approach to this problem is attractive, it seems unusual that Neanderthals would contradict basic ecological theory and fail to track favourable habitats, even to the extent of moving ‘out of Eurasia’. Moreover, it is too simplistic to portray the Neanderthals as a ‘temperate/interglacial adapted species’. The Neanderthals seem to have emerged as a result of a long evolutionary process over very broad geographic areas that witnessed vastly different palaeoenvironmental contexts. It is inaccurate to simply reduce them to a specialized fauna, and claim implicitly that they were suited to a specific or narrow range of climatic and environmental circumstances. The Neanderthal evolutionary story may have begun as far back as MIS 12 (425-480 ky BP; Condemi 2000) with warm episodes such as MIS

5e contributing to demographic expansions (Hublin 1988). Moreover, as Stewart (2004) has pointed out, there is considerable evidence that species such as the cave bear (*Ursus spelaeus*) and the giant deer (*M. giganteus*) which were well represented in northern Europe during the Eemian persisted well after the LGM in Europe. The implication is that if other 'interglacial' species persisted, the rationale for the 'interglacial survivors' becomes less tenable.

Stewart's hypothesis, as with the models discussed previously, accepts the premise that the palaeotemperature changes recorded in the GISP2/GRIP ice-cores also reflect major palaeoenvironmental changes across the Neanderthal range. All of these models make the claim, but fail to satisfactorily demonstrate that populations were affected by these oscillations at the regional-scale. As I see it there are two pre-requisite points that must be met before this argument can be accepted: (i) that clear correlations can be made between GRIP/GISP2 oscillations at the macro-scale i.e. inter-regional terrestrial environmental change (ii) that the archaeological data in some way reflects palaeoenvironmental change by demonstrating a clear correlation between palaeoenvironmental turnover and demographic and/or cultural change. Stewart attempts to meet the second condition by arguing that the Neanderthals went extinct owing to the extreme climate conditions of the LGM. This is an unusual statement as the LGM post-dated Neanderthal disappearance by several millennia. I view this contention as a form of extreme deduction or a 'common-sense' interpretation, where the LGM *must* explain the extinction because of the extreme cold. Stewart (2005) argues that climatic instability was instrumental in supporting the *mammoth-steppe*, a biome that both the megafauna and the Neanderthals were dependent upon (without specifying which regions and at what time). However the approach to the LGM saw a decline in oscillatory palaeoclimate (hence mammoth-steppe) leading to a shift in Neanderthal distribution into more southern and Mediterranean regions as they sought relief from the LGM cold. Again, this claim fails to fully appreciate the oscillatory nature of SP and the MP palaeoenvironments. The Mediterranean regions witnessed major phases of instability from *ca.* 75 ka to *ca.* 20 ka and this is reflected in marine core evidence (Sánchez Goñi 2003) and pollen profiles (Allen *et al.* 1999; Allen and Huntley 2000).

3.7 Survival of the quickest

Those hypotheses reliant on a single-cause factor in the extinction of Neanderthal populations in contrast to the survival of modern human populations in Europe during MIS 3 must convey to the latter some fundamental advantage(s) over the former. In whatever forms these differences were expressed, whether biological or cultural, they could have distinguished these populations at the species level. If Africans were equipped with such advantages, it is of critical importance to identify instances of such in the archaeological record considering the lengthy period of apparent co-existence between Neanderthals and modern over the *ca.* 40 to 30 ka phase. So far, no satisfactory argument has been offered explaining why, if modern humans were equipped with greater cognitive and behavioural advantages, (e.g. Klein 2000) why it would take well over 10,000 years for such advantages to facilitate a 'rapid replacement process'. Langbroek's (2001) publication in a sense conveyed the author's scepticism of a replacement scenario based on a cognitive or behavioural edge alone, and outlined a more holistic, ecologically grounded hypothesis of why modern humans succeeded where Neanderthals failed. Langbroek (2001) in keeping with Mellars (1998) identified the Hengelo interstadial (39-36 kyr BP) as key period during which modern humans first entered parts of Europe. However Langbroek (2001) stressed modern humans did not in any way compete with resident Neanderthal populations for space and territory. On the contrary, the Neanderthals lifestyle and demographic structure was such that Africans were initially marginalized and,

> "…condemned to exist at the fringe of a well-established Neanderthal society" [in a] "restricted and empty [presumably unfavourable to the Eurasian populations] part of Europe", [which Langbroek then perplexingly described as], "a riparian finger in the centre of Europe".
>
> (Langbroek 2001:130/131)

Implicit in Langbroek's hypothesis is the notion that the Hengelo interstadial was climatically stable at least in comparison with earlier and later phases of the Middle Pleniglacial. With the end of the Hengelo came a new phase of climatic and environmental disruption which Langbroek argues resulted in a pivotal episode of demographic restructuring which saw both Neanderthal and modern human populations retreat either toward the Middle East or the Mediterranean where more 'favourable' ecological settings were to be found. It is claimed that this post-Hengelo exodus left vast swathes of Europe unoccupied. In order to successfully re-populate these regions which were now more frequently subject to ecological disruption a more flexible behavioural package was required to that which sufficed during the Hengelo. Langbroek argues that modern human behaviour in terms of logistics, mobility and permanent settlement was much better suited to these new circumstances than the Neanderthals, who were burdened by low-mobility, dependence on familiar resources and intimacy with their surroundings. Neanderthals were essentially foragers, not logistic procurers. The overall Neanderthal strategy was totally unsuited to the ecological fluctuations of middle to late MIS 3. The two main implications of this model are: (i) that as ever increasing areas of Europe became more ecologically unstable, the Neanderthal niche diminished, while the scope for modern human settlement increased. Langbroek's hypothesis is similar to that suggested by Finlayson *et al.* (2004) in the sense that the major demographic population turnover, from indigenous Neanderthal to migrant modern humans was forced by climate change. In Langbroek's words Africans (on a population scale) were better suited to the,

> "contingent particularities of the historical process that led to Neanderthal extinction in Europe".
>
> (Langbroek 2001:125)

(ii) There was a significant difference in terms of cognition and/or behaviour between the populations because any instances of 'modern' Neanderthal behaviour were nothing more than minor behavioural deviations from an otherwise socially uncomplicated lifestyle. Langbroek (2001) explains-away 'modern' subsistence approaches such as the evidence for specialized hunting of prime-aged animals at Salzgitter-Lebenstedt and Mauran as idiosyncratic attempts to break out of this inertia. Instances of behavioural similarities between Neanderthals and Africans are essentially unimportant; they are of less importance than the real issue of how their land use separated them into the 'behaviourally Neanderthal' and 'behaviourally modern'. He views the Neanderthals as,

> "highly idiosyncratic in some fundamental aspects of behaviour".
>
> (Langbroek 2001:124)

Although this position exchanges terminology such as 'archaic' for some semblance of modernity it still *a priori* excludes Neanderthal populations from adopting a specific behavioural trait, in this case, the adoption of a 'fundamentally' different land-use strategy. Hence Langbroek's (2001) argument represents another derivative of the strand of the theme which contends that modern humans and Neanderthals were fundamentally different at the cognitive and behavioural level and is akin to the reasoning of Mellars (1998).

Langbroek's (2001) states that the first modern humans to enter Europe were 'confined' in a peripheral area of western Europe and unable to stake a broader foothold because of a well-established Neanderthal society. He provides no data, however to support this idea, nor were any case studies of early modern human sites provided which could have supported at least one strand of the hypothesis, the claim that modern human land-use methods were significantly different from those of the Neanderthals. Notwithstanding the uncertainty relating to the authors of the early European Aurignacian industry (which Langbroek associates with modern humans only) is the fact that Aurignacian sites appear to have declined in number across Germany between 36-33 kyr BP. If indeed, as Langbroek claims, the Aurignacian moderns were better-suited to post-Hengelo environments in central Europe then it is perhaps unusual to see population numbers diminishing during a phase of time when they ought to have been re-populating regions recently abandoned by the Neanderthals. A further problem with this hypothesis is the underlying claim that Neanderthals were best-suited to locally available resources in heterogeneous habitats that were exploitable with minimal planning alongside a low-mobility strategy. Presumably, if this was the case, Neanderthal groups would have controlled far-smaller territories in topographically and ecotonally diverse areas. Such a specialized strategy would have been unlikely to have supported large and stable populations to the degree that Langbroek implies was large enough to exclude modern humans from Europe until climate instability disrupted even these settings. This results in a potentially absurd scenario where Neanderthal *groups* prevented modern human *populations* from colonizing Europe.

Langbroek believes his model does not employ the flawed paradigm of a strong cognitive dichotomy between Neanderthals and modern humans. But it does: indeed this is the only conclusion that we can reach when it is claimed the coping strategies between modern human and Neanderthal populations to ecological disturbance were so vast, that it resulted in two distinct demographic responses over a *ca.* 13 kyr period.

3.8 Neanderthal land use and subsistence during the Middle Pleniglacial

Before complex mechanisms such as palaeoenvironmental disruption or inter-specific competition can be seriously considered as causatory factors in Neanderthal extinction one must first ascertain as accurately as possible the underlying capacities and behaviours of both Neanderthals and modern humans. Only by understanding how the environment may have shaped behavioural variation in the archaeological record can one then begin to make judgements regarding behavioural potential, and by doing so understand why certain behaviours may have been more advantageous than others in a given situation, and from that speculate in what ways such differences may have helped or hindered human populations. If behavioural differences, for instance, in terms of subsistence, technology and land-use can be identified in close chronological proximity and exclusive to another culture or species, we may then proceed to infer in what ways these behavioural differences would have facilitated expansion (geographic and demographic), or promoted the preferential stability of one bio-cultural group over another. Of course, in order to understand more closely the advantages provided by archaeological signatures it is necessary to reconstruct as best as possible the ecological context in which they were used. Such fine-grained resolution is of course practically impossible to reconstruct on anything more than the site level in most cases predominantly because of the fragmentary or biased nature of most records. It will never be possible to observe in anything but the minds-eye the vistas and landscapes of the Neanderthal world and understand why certain behaviours were chosen over others, nor understand the pressure exerted on behaviour by changing conditions and resources through time. Nevertheless it is safe to claim that a degree of plasticity in behaviour did exist and that it was co-opted and modified to suit the contingent needs of new circumstances. Such is the difficulty then in accepting the prevailing view, the *a priori* assumption that in all cases, across all groups and populations, during encounter or co-existence Neanderthals and modern humans would have viewed each other as something fundamentally different based on purported cognitive or perceived morphological differences. This is a methodological buttress necessary to support arguments such as replacement and extinction, yet it restricts any attempt to decouple the terminological distinctions (moderns and archaics - the 'us' and 'them') from particular behavioural or social traits, and by implication, adds to the perception that they *must* have understood one another as different entities.

This section will investigate the foundations for this buttress which separates the Neanderthals and modern humans into distinct human categories by examining some important elements of the Late Middle and early Upper Palaeolithic record of Europe. Hunting, landscape use, social interactions and demographic responses to palaeoclimate as gauged from archaeological proxies provide a means to illuminate this issue. If this buttress exists at all, we should observe meaningful variation in the archaeological record which facilitates an unambiguous division of behaviour into broad Neanderthal and early modern socio-behavioural packages. If, by contrast we do not see such patterns then the buttress can be seen as unnecessary; a needless partition resulting in a false interpretation, an artificial difference.

The Neanderthals are generally characterised by a lack of socio-territorial organisation, while their methods of lithic raw material and animal resource procurement, as well as their hunting technology are generally interpreted as less-complex than those of modern humans (Trinkhaus 1986). Conversely, modern human land-use and faunal exploitation was logistically organized. This is to say that modern humans were far better at pre-empting animal movements and migrations, anticipating future events, exploiting seasonal territories and extending the home range over wider territories (or regions). Such organization is generally thought to have been lacking in Neanderthal societies, or only rarely practised (e.g. Gamble 1986, 1999; Soffer 1989). One of the most important strands of archaeological research, from which behavioural reconstructions can be reliably made, concerns the way in which humans extracted energy from the landscape. The range of faunas present in archaeological assemblages, the frequency in which they are present and relative age structures can be used to glean important information relating to the social organization of past human populations. In terms of subsistence strategy, Burke (2000) has summarised the methods adopted by which Palaeolithic people acquired prey and these can be divided into four categories. These are:

a) *opportunism* - non-selective kills made on encounter with the prey-type
b) *selective* – hunting to acquire a specific attribute e.g. pelt that can be obtained from several taxa
c) *specialized* – a method of hunting that involves specific focus on single taxa
d) *mixed* – this strategy involves a combination of strategies (a) to (c).

Clearly, the ecological niches exploited by any human group would largely dictate the employment and relative practice of a specific strategy. This is equally applicable to the Neanderthals as it is to any other species. Specialized hunting can be defined as the combined effort of a group of hunters who worked in concert to pre-empt and focus on the capture of a specific prey type, which was but one of many subsistence options available. Specialized hunting is a strategy which is synonymous with the Upper Palaeolithic. High incidences of particular fauna occurring time after time in archaeological assemblages such as reindeer is interpreted as a testimony to this strategy despite the fact that the commonality of reindeer for example in many archaeological sites probably owes as much to environmental factors as to any revolution in hunting strategy.

The evidence for specialized hunting does not appear to be a purely Upper Palaeolithic phenomenon however. In a recent publication, Costamagno *et al.* (2006) have argued that the site of Les Pradelles provides evidence that Neanderthals focussed on the exploitation of reindeer during the fall, an optimum time for communal hunting since reindeer aggregate in large herds at that time of the year. They point out that carcasses were subjected to logistical treatment, with only the nutritionally rich elements being taken back to the site. That the exploitation of these herds and subsequent processing at Les Pradelles was repeated supports the idea that the Neanderthals in this region probably planned well ahead to anticipate the herd aggregations. Similar evidence supporting the idea that the Neanderthals practised specialized hunting comes from Salzgitter Lebenstedt (Germany) where the, long-term selective exploitation of reindeer is well-documented alongside evidence for systematic meat and marrow processing (Gaudzinski 2000). Lazaret Cave has also produced evidence for the selective hunting of red deer and ibex (Valensi 2000) while in the Rhineland, Conard and Prindiville (2000) have shown that long-term prey selection of equids and bovids was more commonly practised by the Middle Palaeolithic Neanderthals than by the later UP inhabitants of the region. Data from 323 sites spanning from MIS 8 to MIS 3 located within the NP and CP indicate that both selective and specialized hunting of particular species was practised by Neanderthals (Patou-Mathis 2000). These strategies were adopted during both warm and cold palaeoclimatic contexts and demonstrate that the Neanderthals were taking a wide range of fauna and adapting to new palaeoenvironmental situations by modifying their behaviours accordingly. This is summarised as follows,

> "…this degree of hunting specialization seems more frequent during temperate phases or maximum cold phases. Animals are often selectively killed according to their age, sex, size and ethology. This is a testament to the

> hunting skills of Neanderthals. Species rare in the environment, smaller and less 'profitable' species, or those difficult to hunt are sometimes preferred. This may indicate that cultural traditions also influenced the choice of prey".
>
> (Patou-Mathis 2000:393)

It appears that the Neanderthal populations inhabiting the NP and CP practised more sophisticated subsistence strategies and modified their behaviour to suit the resultant environments of fluctuating stadial and interstadial climate regimes.

Burke (2004) has reported that Neanderthals practised a mixed strategy of opportunistic (encounter) hunting with seasonal hunting of equid herds at Starosele (Crimea) adding further support to the idea behavioural strategies, at least in terms of subsistence, were plastic during the later Middle Palaeolithic and could meet the requirements of new environmental circumstances. More recent work at the Crimean site of Karabi Tamchin (level H) also indicates that Neanderthals focussed on the acquisition of prime-aged adults, and that foetal equid remains shows they were occupying highland regions during late fall or winter (Burke 2006). Neanderthal populations situated in more coastal regions such as the inhabitants on the southern Iberian coast appear to have broadened their exploitation strategy to include a wider array of nutritious resources. Barton (2000) reported that between 49-45 ka the Neanderthals of Gorham's and Vanguard Cave regularly included mussels, cockles and limpets in their diet. In the same publication it was shown that Neanderthals were selectively harvesting large mussels and processing these with task-specific shucking knives and baking the shellfish on hearths which were used repeatedly. Gale and Caruthers (2000) also reported that the Neanderthal inhabitants of Vanguard Cave and Gorham's Cave were processing labour intensive pine nuts, possibly for storage between 50 ka and 40 ka. Neanderthals were by no means choosy gatherers however. Richards *et al.* (2000, 2001) analysed stable isotopes $\delta^{13}C$ and $\delta^{15}N$ from two of the Vindija Cave (Croatia) Neanderthals and found that they were top-level carnivores having obtained almost all of their dietary protein from animal sources. Other studies have emphasised the broad parallels in hunting strategy between Middle and Upper Palaeolithic hunters. For example, Drucker and Bocherens (2004) demonstrated that large-bodied herbivores were fundamental components of both modern human and Neanderthal diet. This contrasts slightly with the findings of Stewart (2004) who claims that Africans exploited greater numbers of small-bodied prey relative to the Neanderthals. However Estévez (2004) counters this by arguing that even the Neanderthals expanded their subsistence base during the Middle Pleniglacial and this could have resulted in the extinction of several species of carnivore in the Iberian Peninsula. What these studies highlight is that subsistence strategy appears to have been flexible and largely dependent on the prevailing ecological circumstances.

There are clearly some parallels in terms of subsistence strategy between Neanderthals and modern humans over the time phase in question, and no single behavioural trait or signature can be used to unequivocally uphold the notion that Neanderthals and modern humans were anything other than part of a single population striving for the same ecological resources. If the appearance of modern humans in Eurasia at *ca.* 38 ka constituted nothing more than a larger *Eurasian population* in general (e.g. Davies 2001) who has argued that from 45-38 ka moderns were present only in low population densities) this may well have resulted in some inter-population competition for resources at a variety of scales, both between Neanderthals and within Neanderthals and modern human groups. The nature of intra-specific competition would have varied from region to region depending on the nature of the local ecological and cultural factors. Certainly, competition cannot be viewed as an inevitable outcome, consistently taking the same form, at all times, and leading to the same outcomes. Just as direct subsistence strategies appear to have been flexible, other elements of behaviour such as socio-territorial organisation would have varied between populations, the tempo of which also varying over time as humans adopted perhaps more sophisticated means of consolidating their ownership of key locales at the sub-regional level, defending these territories not only from other Neanderthals but also from modern humans. Perhaps Burke's (2004a) observations are salient in this sense because they appear to indicate that it was modern humans who increased their dietary breadth to include smaller fauna such as rabbits (because they were excluded from more attractive resources by the Neanderthals). To suggest that it was modern humans who were excluded from the prime resources by Neanderthals who as we have seen, were clearly capable of hunting prime fauna is a refreshing alternative to traditional expectations which are still widely adopted in the current literature. For example Finlayson (2004) argued that the Neanderthals were generalized hunters while modern humans were more specialised. Finlayson's reasoning behind why Neanderthal and modern humans land use and food procurement strategy was so different stems from his own investigation into habitats at the extreme south of the Neanderthal range in Europe i.e. Gibraltar and 'other areas'. This Neanderthal

Utopia was said to have been a mix of shrub and light tree cover which was never fully closed (ibid.). These intermediate environments, he argues, were supposedly buffered from the MIS 3 climate oscillations and maintained a degree of ecological stability and resource predictability in contrast to other areas during the Middle Pleniglacial. As we shall see in the next chapter, this view is probably wrong. These intermediate environments were not buffered from oscillatory climate; they were a function of these changes. They were especially pronounced in the Mediterranean regions (e.g. Italy and Iberia) where steppe episodes were rapidly replaced by woodland during phases of amelioration. A second concern is with the idea that heterogeneous habitats provided Neanderthals a more permissive and somewhat easier environmental context from which to acquire food than the harsher, more homogeneous environments inhabited by their modern human counterparts. This position is ambiguous because it appears that much of central and northern Europe at this time was non-analogue and did not simply fall within the broadly defined open or semi-closed environmental bracket. Added to these problems is the fact that it cannot be simply assumed that ecological variables were sufficiently optimum to promote exploitation by Neanderthals for a wide variety of reasons e.g. lag-times before a particular ecological context (e.g. marine, river resources) reached an adequate level to exploit. Thus the Mediterranean Neanderthals, especially those close to ecologically sensitive, climatically sensitive zones would have witnessed frequent landscape remodelling. This pattern probably characterised parts of central and Western Europe, although to a lesser degree, as they too maintained significant refugia tree populations and mixed ecotones - the quintessential Neanderthal ecology (see Willis 1996, 2001 for a discussion of these environments) but which Finlayson (2004) argues were more homogenous and stable at this time.

The previous discussion has shown that both Neanderthal and modern human hunting strategies in pleniglacial settings were comparable. However it is important to assess the Neanderthal behavioural strategy in what have been termed the difficult or hard habitats such as more fully open contexts e.g. steppe, steppe-tundra or fully forested palaeoenvironments as well as in terms of the acquisition of larger taxa. Gaudzinski (2004) has shown that Neanderthals were capable hunters of *Stephanorhinus kirchbergensis* and *Palaeoloxodon antiquus*, contra Stewart (2004) and that the apparent absence of macro-fauna in pre-UP contexts owed as much to the fact that bone was only rarely utilised for functional purposes during the MP than to any novel hunting strategy (Munzell and Conard 2004). Thus it is equally possible that higher incidences of mammoth bone in

Upper Palaeolithic archaeological sites could be artefacts, that is to say, the product of scavenging rather than the product of direct hunting made possible by some technological breakthrough or innovative hunting method.

At the site of Raj cave (Poland) the archaeological and palynological evidence shows that there was almost continuous occupation across the MIS 3 stadial and interstadial climate fluctuations. The Neanderthals who occupied this setting appear to have coped with fluctuating palaeoenvironments by adopting a flexible subsistence strategy that involved the scavenging and hunting of horse, reindeer and bovids as well as specialized hunting of females and the young during the summer seasons (Patou-Mathis 2004). In the Western Crimea (Burke 2000) and in the north-western Caucasus (Hoffecker and Cleghorn 2000) a similar behavioural pattern of seasonal and selective hunting is observed, while Valensi and Psathi (2004) and Fiore *et al.* (2004) have shown Neanderthals present in southeast France and northern Italy practised selective and specialized faunal exploitation throughout MIS 6 to MIS 3. These studies support the idea that Neanderthals were practising advanced behavioural techniques to secure high quality resources from uncertain habitats which apparently required social organisation hitherto deemed beyond the scope of Neanderthal potential (e.g. Gamble 1999; Finlayson 2004). In line with this thinking it is generally accepted that Neanderthals only ventured into the European plain during favourable palaeoclimatic regimes, and that this setting was not fully exploited until modern humans appeared (Gamble 1999). However some recent findings have complicated this hypothesis. Artefacts from Elniki II (Upper Kama) and Zaozer'e are associated with loess which pre-dates the last interglacial soil, while an eastern Micoquian-type industry pre-dating 60 ka was excavated at Garchi 1 (Pavlov *et al.* 2004). These represent the earliest traces of human activity this far north (59°N). Other evidence indicates that some groups had reached the Arctic (Mamontovaya Kurya, 66°N) by 35 to 40 ka (Pavlov *et al.* 2001). There are no hominin remains at Mamontovaya Kurya, however Neanderthal authorship is possible, particularly as some of the earliest modern humans in Europe vastly post-date this archaeology at *ca.* 34-36 ka (Trinkaus *et al.* 2003). Pavlov *et al.* (2004) have documented human occupation at Zaozer'e (58°N) between *ca.* 31 ka and 33.5 ka. This site has produced bone and antler tools, pendants, polished mammoth tusk and ochre pieces. Faunal remains are mainly equid (*Equus cf. latipes*). Cold flora including mixed herb (e.g. *Artemisia*) comprised 33% of the occupation phase while forest (e.g. *B. alba, humilius, nana; Picea abies*) and spores (e.g. *Pteridium aquilinum*) comprised the remaining 40% and

27% respectively. Archaeology includes Eastern Micoquian knives which resemble late MP Neanderthal assemblages from western, central and south-eastern Europe. Other tools include Châtelperronian-like backed knives and burins. These MP traits, so redolent of Neanderthal archaeology are seductive. Whether they were introduced from Neanderthal populations in Europe is a possibility not to be quickly discounted because Pavlov *et al.* (2004) do not consider these as 'transitional industries' and prefer to see the original source for the transition somewhere to the south or west. Definitive evidence for plains adaptation does not occur coeval with the appearance of modern humans in Europe, and it is not until the middle UP at e.g. Sungir and Garchi (Roebroeks *et al.* 2000) that such arguments can be made. However, Pavlov *et al.* (2004) believe there is vast amounts of early UP (non-Aurignacian) archaeology yet to be discovered under the aeolian and fluvial sequences of the northeastern plain (Kama Basin) and even Arctic Europe. These data suggest that Neanderthal behaviour, distribution and palaeoenvironmental tolerances may well be far more complex than hitherto appreciated.

3.9 Summary

This discussion has reviewed the grounds for the claim that Neanderthals were cognitively or behaviourally less-advanced than modern humans. If this was the case it does not appear to have restricted the Neanderthals from adopting a range of hunting strategies analogous to those of fully-modern humans across a variety of palaeoclimatic and palaeoenvironmental circumstances. More recent evidence also points to the Neanderthals as having more sophisticated socio-behavioural adaptations as they appear to have intermittently colonised far higher latitudes during much colder phases of climate than hitherto acknowledged. This evidence certainly complicates the hypothesis that 'Neanderthals in general' preferred the 'warmer and closed habitats' of the southern latitudes over anywhere else. We have also seen that many models of Neanderthal extinction (e.g. Mellars 1998; Stage 3 Project 2003; Stewart *et al.* 2003, Stewart 2004) propose that the SP and MP were palaeoenvironmentally more stable than the higher latitudes during the Middle Pleniglacial and it was contraction of these 'warmer and closed habitats' at the end of MIS 3 which led to ecological crisis and Neanderthal extinction. Essentially the Neanderthals became disarticulated isolates seeking out ever diminishing stable or mosaic biotopes. It is this theme, the palaeoclimatic and palaeoenvironmental backdrop of the European study provinces, and the foundation it provides for climatically and environmentally-focussed models of Neanderthal extinction, which will be explored in more detail in the next chapter.

Chapter 4

The Last Interglacial-Glacial Cycle

4.1 Introduction

When the archaeological record reveals the emergence of new behaviour it is necessary to constrain the palaeoenvironmental backdrop before, during and after the identification of behavioural change in order to elucidate the causes more accurately. It is not sufficient to propose that Late Pleistocene socio-behavioural changes were simply a reflection of 'modernity' or 'mutations' as some have proposed (e.g. Klein 2000). Similarly, the differences in the nature and patterning of archaeological residues cannot be explained away by our inferences of the social or cognitive limitations of the hominins themselves. While cognitive change no doubt played an important role in the cultural evolution of *Homo*, variation in the Palaeolithic archaeological record must also have been influenced by the meshed effects of palaeoclimate and palaeoenvironment which varied considerably over time, and which were ultimately responsible the behavioural landscape. This was understood by Gamble (1984) in his effort to reveal how archaeological variability occurred as a function of ecological variation on a regional scale. This chapter will review the palaeoclimatic and palaeoenvironmental nature of the last IG-G cycle using a similar regional approach, the scope of which is shown in fig. 1.1.

1. *The Northern Province* (south east England, France, north and east Germany, and Belgium) from approximately -5°W and 10°E meridians and approximately 50°N and 55°N parallels.
2. *The Central Province* (East Germany, Poland, Czechoslovakia and Hungary) 10°E and 20°E meridians and 50°N and 55°N parallels.
3. *The Southern Province* (South West France and east Italy) 10°E and 20°E meridians and 44°N and 49°N parallels.
4. *The Mediterranean Province* (Italy, Portugal and Spain) 10°E and 20°E meridians and 36°N and 43°N parallels.

The three main objectives of this chapter are:

•To refine our understanding of palaeoclimatic phases particularly the environmental components of stadials and interstadials.
•To gain insights into how palaeoenvironments differed across the four study provinces.
•To determine the nature of the synchrony between palaeoclimatic and palaeoenvironmental change, and how this was variously expressed across the study provinces.

This approach is somewhat different to that of Gamble (1984) who used firmer points of reference in order to examine archaeological variation (e.g. major drainage basins associated to regional populations of hunter-gatherers). In this research the study province approach is satisfactory as it will at the very least provide qualitative insights into how palaeoclimatic change was expressed in space. A range of marine, ice and terrestrial palaeoenvironmental proxies were used to furnish an understanding of the last IG-G. These are discussed here and elsewhere in the thesis. The locations are shown at fig. 4.1.

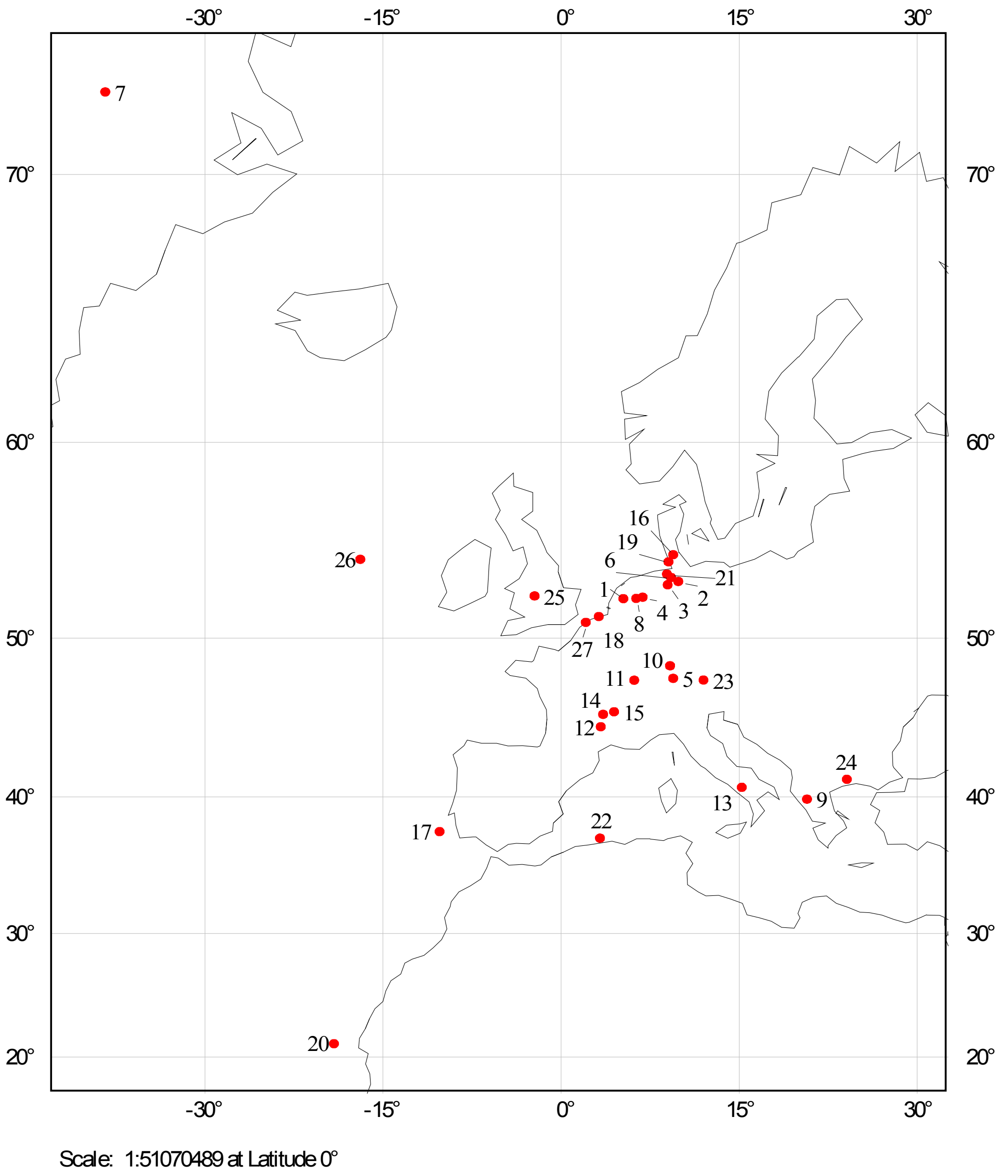


Figure 4.1 List of palynological, ice and marine proxies discussed in text

1, Amersfoort; 2, Bispingen; 3, Brörup; 4, Denekamp; 5, Füramoos; 6, Glinde; 7, GRIP/GISP2; 8, Hengelo; 9, Ioannina; 10, Jammertal; 11, La Grande Pile; 12, Lac du Bouchet; 13, Lago Grande di Monticchio; 14, Le Velay; 15, Les Echets; 16, Loopstedt; 17, MD95-2042; 18, Moershoofd; 19, Odderade; 20, ODP 658; 21, Oerel; 22, Padul; 23, Samerberg; 24, Tenaghi Philippon; 25, Upton Warren; 26, V29-191; 27, Watten.

4.2 Historical perspective

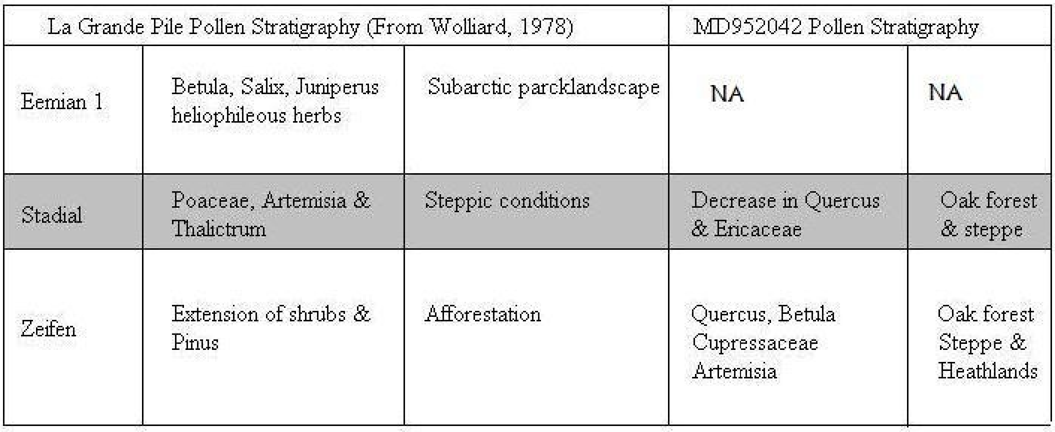
Penck and Brückner's 1909 Alpine model marked an important breakthrough in geological research insofar as it represented the first formal scheme to recognise climate cyclicity based on observations from the fluvial-glacial outwash terraces of the north Alpine foreland. Four major glacial episodes were recognised and these were named after the Bavarian river valleys: Günz, Mindel, Riss and Würm. This scheme was subsequently adopted as the first Pleistocene climatic framework. The next major advancement came in 1947 when H. C. Urey discovered that isotopes O^{18} and O^{16} fractionated from water at different rates as a function of temperature and that carbonate secreting organisms such as molluscs recorded the relative isotope values (hence prevailing temperature) during their lifetime. Emiliani (1955) applied the same methods to marine foraminifera which are abundant in long, continuous sedimentary sequences and from the reconstructed temperature values he recognised many more Pleistocene IG-G cycles than the four reported by Penck and Brückner in 1909. Further work by Shackleton (1969) developed this scheme into a stratigraphic framework which is now referred to as the Marine Isotope Stage (MIS) or Oxygen Isotope Stage (OIS) record. The low and high resolution SPECMAP series of Imbrie *et al.* (1984) and Martinson *et al.* (1987) respectively are based on stacked $\delta^{18}O$ records. $\delta^{18}O$ fluctuates according to change in global ice-volume and eustatic sea-level which are in turn principally controlled by orbital factors largely accounted for by Milankovitch theory, which predicts that solar radiation exerts the major control on global climate including the growth and decay of ice sheets during periods of reduced and increased insolation respectively (Imbrie *et al.* 1984).

Shackleton (1969) used MIS data to clarify that the Eemian interglacial phase correlated to the first *ca.*12 kyr of MIS 5 (i.e. *ca.* 122 to 100 ka and not the whole stage). This was a major breakthrough provided archaeologists opportunities to contextualize human demography within a broad climato-chronostratigraphic framework. While the MIS framework undoubtedly offers useful albeit general insights into palaeoclimate change, the exclusive use of marine-based chronologies for palaeoenvironmental reconstruction is problematic. The issues are threefold: firstly, MIS frameworks rarely provide the necessary detail to investigate millennial and centennial scale climate events, such as the millennial scale changes recorded in ice-core catalogues (Dansgaard *et al.* 1993). Secondly, marine $\delta^{18}O$ reconstructions are derived from benthic foraminifera which record ocean cooling as well as ice growth. Lastly, there is further uncertainty over the response times of vegetation to both gradual and rapid $\delta^{18}O$ variation and whether an in-phase relationship is demonstrable, as well as how this was manifested across Europe (Huntley 1991). Hence, our understanding of human environmental tolerances based on SPECMAP derived climatic and environmental reconstructions will never be a fully informed one.

The following discussion will center on the character of the climate labels: glacial, interglacial, stadial and interstadial. The aim is to identify which conditions and resources were distinctive in specific climate phases and identify conditions and resources that transcended different climate states and assess their relative prevalence and importance to the climate phase in question. I will begin with a brief review of the transition into the last interglacial period. For the purposes of this review the Saalian-Eemian transition (MIS 6/5e) will mark the beginning of the last IG-G proper. Several lines of evidence and current models will be assessed and a reconstruction of the Eemian across northern and southern Europe will be presented.

4.3 The Saale-Eemian transition

Prior to the transition at *ca.* 140 ka cold-steppe or tundra appear to have been the dominant biomes across much of the NP and SP. The Saale/Eemian transition is well-marked in the southern province (SP) at La Grande Pile, Les Echets, Lac du Bouchet/Ribains and Praclaux Crater (Reille and Beaulieu 1995, 2001; Cheddadi *et al.* 1998) as a boreal forest episode which was interrupted by a short (100 year) phase of highly seasonal environments with mean temperature of the coldest month (MTCM) comparable to modern day central Russia (Field *et al.* 1994). Mean summer temperature (MST) was no more than 10˚C, a value in accordance with late Saalian temperatures (Zagwijn 1996). Fauquette *et al.* (1999) have shown that the SP was characterised by MAT of between -10˚C and -5˚C (La Grande Pile) and -2˚C to 2˚C (Les Echets). Low precipitation (100mm-650mm) would have restricted the development of any significant forest canopy. These data suggest that a steppe biome prevailed in the SP, with tundra in the more northern regions of France. These terrestrial data are complemented by palynological analysis from marine core MD-952142 which shows the transition in southern France and parts of the MP were analogous with the Younger Dryas event (Sánchez Goñi *et al.* 1999). Fig. 4.2 shows the transition as a short-lived steppe biome sandwiched by another boreal episode followed by the Eemian-proper (MD42-3). This early Eemian interruption dates to *ca*. 127 ka and may coincide with Heinrich event 11 (H11) (Shackleton *et al.* 2002). HE are distinguishable in some North Atlantic sediment cores as horizons of ice rafted debris (IRD) derived mainly from the bedrock of the Laurentide and Fennoscandian ice sheets, and subsequently transported into the North Atlantic during phases of large-scale iceberg discharge (Heinrich 1998; Bond *et al.* 1992). A consequence of iceberg influx was a concomitant release of freshwater into the North Atlantic Ocean, resulting in thermohaline circulation (THC) collapse leading to widespread palaeoclimatic changes over the North Atlantic region (Roche *et al.* 2004). Core MD-952142 shows that the emergence of interglacial taxa at *ca*. 126 kyr BP (Zone MD42-3) post-date H11 thus supporting the idea that climate amelioration resulted in significant and widespread environmental change across western Europe. The Mediterranean marine core V29-202 also records the MIS 6/5e transition coincident with H11 which Oppo *et al.* (1997) incidentally reported was, at least in terms of temperature a higher magnitude shift than the Holocene (MIS 2/1) transition. This short lived phase of seasonal climate gave way, very rapidly, to warm temperatures and a balanced seasonal temperature and precipitation regime. Indeed Field *et al.* (1994) suggest temperature increased from -18˚C to 5˚C in 700 years. One may expect that temperate forests diffused outward from southern refugia into northern regions. It follows that if the onset of Mediterranean forest at *ca*. 126 kyr was not inhibited by regional factors, then the evidence for substantial forest development in the NP should post-date *ca*. 126 kyr BP. It is for this reason that this date is taken to mark the onset of the Eemian in the SP and Mediterranean province (MP).



La Grande Pile Pollen Stratigraphy (From Wolliard, 1978)			MD952042 Pollen Stratigraphy	
Eemian 1	Betula, Salix, Juniperus heliophileous herbs	Subarctic parcklandscape	NA	NA
Stadial	Poaceae, Artemisia & Thalictrum	Steppic conditions	Decrease in Quercus & Ericaceae	Oak forest & steppe
Zeifen	Extension of shrubs & Pinus	Afforestation	Quercus, Betula Cupressaceae Artemisia	Oak forest Steppe & Heathlands

Figure 2.2 The Saale-Eemian transition

Example of a rapid climatic and ecological change at ca. 128-126 kyr across northern and southern Europe. This represents perhaps the earliest severe environmental disruption of the IG-G cycle (data from Wolliard 1979; Sánchez Goñi *et al.* 1999).

4.4 The Northern and Southern provinces during the Eemian

Essentially, interglacial phases resulted in the broad expansion of coniferous/deciduous forests across areas of Europe which were characterised by open steppe or steppe-tundra environments during glacial climates. Forest expression is influenced by various factors e.g. local rainfall, altitude, soil drainage, disease and competition, any or all of which can result in considerable local or regional differences (Huntley 1991). Palaeoclimate and environment can be reconstructed from pollen records, as can much finer-grained parameters such as mean summer temperature (MST) and mean winter temperature (MWT), evapotranspiration rates, growing days above 0°C and 5°C (Fauquette *et al.* 1999). These thresholds group pollen taxa into plant functional types which comprise biomes - broad-scale vegetation units from which inferences and models of palaeoenvironment can be made (ibid.).

The last interglacial period is referred to under various nomenclatures across different parts of Europe. For instance in Britain it is referred to as the Ipswichian, in northern Europe the Eemian and in France the Riss-Würm. For the purposes of this discussion I will refer to it as the Eemian which appears to be the most frequently used term in the literature. The Eemian in terms of structure, duration and temperature is summarised in fig 4.4. Pollen diagrams from the NP, SP and the CP all reveal a comparable structure facilitating the recognition of the Eemian as a viable biostratigraphic unit (Zagwijn 1996). The question of whether the Eemian represents the same chronostratigraphic unit is less certain, particularly on an inter-regional scale, and this will be examined below.

The annual laminations from the Bispingen sequence suggest that the Eemian lasted 9.6 kyr in the NP (Caspers *et al.* 2002).

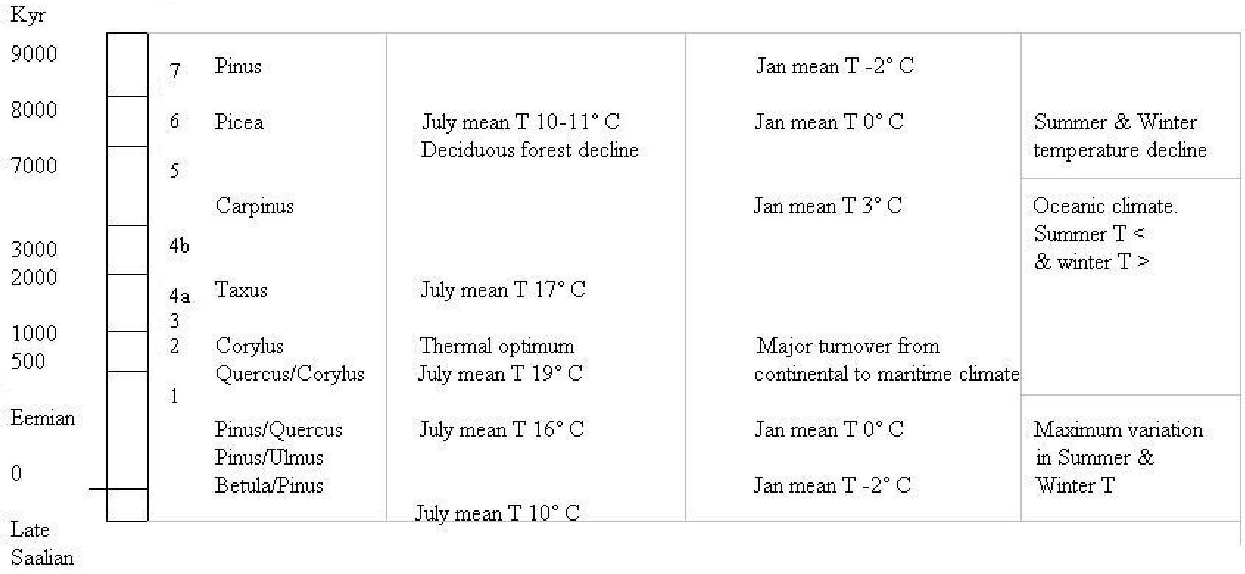


Figure 4.3 The Eemian vegetation structure over northern Europe: Modified after Müller (1974) and Zagwijn (1996)

However this is probably a minimum value, as the late Eemian section may be unconformable due to the onset of climate deterioration that caused the demise of boreal woodland in favour of nonarboreal environments. This downturn has been recognised as a stadial event in several European pollen sequences, notably the Melisey I in La Grande Pile and as the Herning stade in northwest Germany. Similarly, the oscillatory nature of the transition at *ca.* 127 ka may have eroded evidence of earlier forest developments. Bispingen then may not reflect the actual duration of the Eemian in northern Europe. In a comprehensive study Aalbersberg *et al.* (1998) collated palaeobotanical, coleopteran and periglacial data from 106 sites on a west to east transect (50°-60°N latitude). They identified three distinct vegetation phases corresponding to the Eemian section of the profile: firstly, an early *Pinus-Quercetum/Corylus* phase (zones (1) to (3) fig. 4.3; Cheddadi *et al.* 1998). At this time the NP was fully temperate with a sub-continental climate. MST of

20˚C prevailed in England while MWT in northern Europe was similar to that of the present day; however, MST appears to have been lower in Eastern Europe at *ca.* 18˚C. Zagwijn (1996) concluded that the early Eemian witnessed lower temperatures and that the early Eemian *Betula* development was diachronous across parts of northern Europe; moreover herb pollen counts also comprised intermittent episodes during the early phase. This suggests that short-lived periodic reversions back to semi-open biomes were characteristic of the early Eemian landscape. Phase 2 saw full oceanic conditions with increased precipitation over the next 2 kyr; lower MST was balanced by higher MWT resulting in consistent mean annual temperature (MAT). The Eemian thermal optimum was characterised by oceanic climate and a *Carpinus-Picea* phase. Slight decreases in MST (~18˚C) were recorded across the NP; however seasonality differences were negligible due to MWT increase. Zagwin (1996) reported *ca.* 3 kyr of gradual decline in both the MST and MWT, however conditions remained maritime. This temperature decline corresponds to late (4) to early (5) in fig. 4.3. Temperature appears to have declined by as much as low as 4˚C or 5˚C, enough to force the retreat of mixed thermophilous forests into refugia situated in Germany and Poland. This heralded in the onset of the third stage, the *Picea-Abies* phase (Aalbersberg *et al.* 1998) and may correspond to reduced summer insolation values at *ca.* 120 ka (Tzedakis 2003). This phase corresponds to 5 in fig. 4.3 (Cheddadi *et al.* 1998). These reconstructions suggest that by *ca.* 116 ka the fully-closed Eemian environments were beginning to dissipate in the NP. In contrast, the Eemian, in terms of its onset, duration and deterioration appears to have been of rather different character to that of northern Europe in the lower latitudes e.g. the Mediterranean. Kukla *et al.* (1997, 2002) used marine core V29-191 and pollen data from La Grande Pile and Ribains to fix the MIS 6/5 boundary to between 130 ka-126 ka and the MIS 5e/d boundary to 107 ka giving a total duration of between 23 and 19 kyr. They reported that by 115 ka non-arboreal pollen had increased and by 113 ka deciduous elements were completely replaced by coniferous elements. One important finding to emerge from Kukla *et al's* (1997, 2002) studies is that much of the MP supported deciduous or boreal forests well into MIS 5d, which according to the MIS data was a cold stadial phase. Palaeoenvironmental data show instead that a coniferous phase persisted in the SP until 107 ka, long after full forest had disappeared in the NP and CP. Although the nature of the transition between the Eemian/Melisey I was no doubt different to that of the Saalian-Eemian (because rapid warming resulted in quicker ecological changes, while cooling was a slower process resulting in more gradual in-situ ecological deterioration) it is clear that the late Eemian downturn resulted in some major palaeoenvironmental changes on a range of spatial scales as deciduous forests gave way to boreal woodland which in turn was replaced by semi-open parkland. For example, it appears that within a few centuries either side of 111 ka the post-temperate *Picea-Abies-Carpinus* forests gave way to a 4kyr phase of boreal taiga. This major environmental oscillation, preceding the termination of the Eemian in La Grande Pile by 4 kyr ushered in some 4 kyr of further environmental oscillation between coniferous forest and taiga until 107 ka. Its impact on human populations will be assessed in greater detail later. The major implication of the Eemian-Melisey I transition is that it clearly provides a strong caution against accepting reconstructions based on what appear to be unambiguous climatic phases observed in marine isotope data.

4.5 Northern and southern/Mediterranean palaeoenvironmental variation

Table 4.1 shows some recent estimates relating to the onset, duration and termination of the Eemian interglacial.

Table 4.4 The Eemian

Site	**Kyr**	**Duration**	**Reference**
SPECMAP/Bispingen	128-116	12	Imbrie *et al.* (1984)
V29-191/LGP	126-107	19	Kukla *et al.* (2002)
Ioannina	127-111	16	Tzedakis *et al.* (2002)
MD95-2042	127-111	16	Shackelton *et al.* (2003)

It is important to establish a) the duration of the Eemian and b) and how Eemian environments varied geographically in order to constrain as best as possible the nature of the habitats that may have supported Neanderthal presence. This will also allow one to assess the merits of the notion that interglacial palaeoenvironments were 'hard habitats which required more advanced social systems (e.g. Gamble 1999) in order to permit permanent habitation. Tzedakis *et al.* (1997) reported that the Eemian lasted well into MIS 5d (table 4.1). Further work by Tzedakis *et al.* (2002) corroborated this view and indicated a similar duration of 16 kyr from 127 ka to 111 ka, while Shackelton *et al.*

(2003) showed that the Eemian forests were well established in the Mediterranean from 127 ka to 111 ka (Sánchez Goñi *et al.* 1999; Shackleton *et al.* 2003). The pollen rich marine core MD95-2042 provides the opportunity to examine how different proxies (pollen and isotope) from a single core responded to climate change. Pollen data confirms that thermal optimum forests only became fully established after the MIS 5e peak, but persisted long after the δ^{18}O ratio fell to stadial (MIS 5d) values. Clearly then, an asynchronicity exists between different proxies in this case isotope and pollen data, and that the deciduous optimum did not coincide with the MIS 5e peak in southern European areas (Shackleton *et al.* 2003). Similarly, deciduous forests (*Carpinus/Abies*) were only really present across broad areas of southern *and* northern Europe during the thermal optimum. In contrast, full deciduous forests persisted much later in parts of the extreme south of the SP and MP, well into MIS 5d (Sánchez Goñi *et al.* 1999). By the late Eemian, more northern regions of Europe were comprised of coniferous forests e.g. spruce, fir, and pine akin to the pioneer phase of the early Eemian.

To conclude this section it would appear that the NP saw steppe environments by 115 ka, while the MP and parts of the SP remained forested habitats until 107 kyr (Kukla *et al.* 1997). That open habitats, e.g. Bispingen at 115 ka were juxtaposed against extensive forests e.g. La Grande Pile only 600km to the south suggests quite marked environmental heterogeneity prevailed at the regional scale. If the late-Eemian in Bispingen is unconformable perhaps this situation was not as extreme as it appears, though Zagwijn (1994) has shown vegetation belts were diachronic across much of northern Europe in post-Eemian contexts, so this heterogeneic structure may have been real. The reality is that some areas of Europe e.g. north and central France between 115-107 ka were characterized by complex environmental structures somewhat atypical to that which is traditionally associated with interglacial climate. Acknowledging that reconstructions of Eemian palaeoenvironments derived from coarse records such as MIS or incomplete records such as Bispingen will provide only a limited insight into the period between 125 ka to 115 ka will necessarily carry implications relating to how Neanderthal socio-behavioural variability is interpreted against the backdrop of this so-called hard habitat of the interglacial forest.

MIS 5e: an unstable phase?

We have seen that it is perhaps too-simplistic to infer palaeoenvironmental changes from MIS records or to argue that a consistent cause and effect relationship operates in close synchrony between climate and environment. In this light it is of value to explore finer grain or more sensitive regional proxies and to examine whether the Eemian, a period normally assumed to have been stable, experienced environmental disruption and over what scale. Fig. 4.5 shows the SPECMAP $\delta^{18}O$ curve for the last 200 kyr.

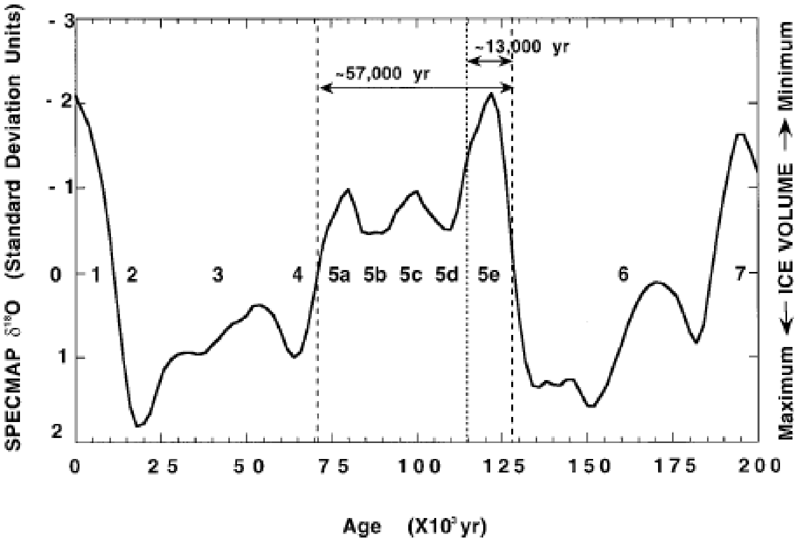


Figure 4.4 **SPECMAP time series (after Imbrie et al. 1984)**

Fig. 4.4 shows that in general terms high-magnitude low-frequency oscillations were the norm. The curve between 135 ka to 120 ka is shown as a strong upward warming trend with no reversions to colder values. From 120 ka to 115 ka there is a steady cooling trend. No sudden or frequent oscillations can be observed at this scale for MIS 5e. In contrast, Johnsen *et al.* (1992, 1995, 1997, 2001) reported that the Eemian equivalent of the GRIP ice core (125 to 115 kyr) was marked by five isotope fluctuations: at peak values 5e1, e3 and e5 show temperature in keeping with interglacial values; while 5e2 and 5e4 indicate that temperature dropped to mid-glacial values. In terms of maximum $\delta^{18}O$ amplitude contrast MIS 5e1 was interpreted as a "*catastrophic*" event (GRIP 1993:206) lasting *ca.* 70 years which saw temperature values (based on isotope estimates) drop from interglacial to mid-glacial levels. MIS 5e2 and MIS 5e4 (lasting *ca.* 2 kyr and *ca.* 6 kyr respectively) both indicate similar temperature drops. These values suggest that temperature changes of up to 10°C may have occurred within a human lifetime during a phase traditionally viewed as climatically stable. Such climate shifts from interglacial to glacial temperature may have significantly altered human habitats *if* these temperature changes were translated into European terrestrial environments. Unfortunately, it is difficult to establish if 5e2 and 5e4 had discernible effects on human environments owing to the discontinuous nature of many terrestrial proxies. Moreover, the MIS 5e fluctuations are not observed in the adjacent GISP2 ice core or other North Atlantic marine records. Therefore these fluctuations, rather than examples of rapid climate change over Eurasia, may instead reflect regional climate change over Greenland (Taylor *et al.* 1993).

The GRIP oscillations raise a fundamental question: what scale of $\delta^{18}O$ variation reflects meaningful terrestrial environmental change on a broad European scale? It cannot be simply assumed that quantitative contrasts in isotopic variation represents meaningful climate change and deduce in a normative manner that human environments were disrupted. It is acknowledged that benthic foraminiferal $\delta^{18}O$ values of 2.5‰ and 4.5‰ represent interglacials and glacials respectively (McManus *et al.* 1999). A rise in $\delta^{18}O$ from 2.5‰ to 3.5‰ embodies half of an IG-G cycle yet in physical terms little ice growth or sea-level fall occurs because the principal $\delta^{18}O$ change is caused by deep-ocean cooling. A 3.5‰ value produces approximately 30m of sea-level regression (only 25% of the total 120m sea-level drop at the last glacial maximum) so in real terms, it can be seen that relatively large movements in the isotope signature (in this case ½ of the IG-G cycle!) do not represent significant ice build-up, *nor periods of inherent climate instability*. Furthermore, it appears that 'end-member' palaeoclimatic phases such as G or IG were essentially stable (i.e. $\delta^{18}O$ values of ~2.5 and ~4.5‰) (McManus *et al.* 1999). The picture changes when $\delta^{18}O$ surpasses 3.5‰. This threshold value appears to have occurred in conjunction with Heinrich events which are now widely recognised as important factors in climate and environmental change (Bond *et al.* 1992; Prokopenko *et al.* 2000) and even human evolutionary change (Mellars 1998; d'Errico *et al.* 2003).

Recent work by Rignot and Kanagaratnam (2006) has shown that air temperature in south-east Greenland has risen by 3°C in the last 20 years, a fluctuation not dissimilar to some of the $\delta^{18}O$ departures that characterised MIS 4 and MIS 3 observed in the GRIP and GISP2 ice-cores. Perhaps subtle temperature fluctuations are a feature of all phases of the IG-G cycle and smaller fluctuations such as the ones reported by Rignot and Kanagaratnam (2006) may not have resulted in terrestrial ecological disruption as predicted by many archaeologists with an interest in hominin environmental tolerance and adaptation. Large-scale terrestrial disruption across broad areas of the Neanderthal range in Europe may have only occurred when ice-caps approached or retreated from the $\delta^{18}O$ of 3.5‰ value. That 'dramatic' oscillations in $\delta^{18}O$ did not always lead to ecological upheaval can be tested by terrestrial evidence. If biomes remained largely stable during phases of sub/post 3.5‰ fluctuation, then one simply cannot extrapolate terrestrial environmental change from each and every deviation in the $\delta^{18}O$ record. With this in mind it is now pertinent to examine the terrestrial evidence for climate instability.

Field *et al.* (1994) attempted to identify and correlate episodes of instability in and between the La Grande Pile (SP), Bispingen (NP) and GRIP records. Both Bispingen and La Grande Pile catalogued a short-lived climate deterioration in the early Eem which very rapidly gave way to *ca.* 3.0 kyr of warm temperatures with constant MAT and precipitation. Between 6.4 and 6.1 kyr receding thermophilous tree values were recorded. *Corylus* declined to the lowest value since the severe deterioration at the Saale-Eem transition. Other elements e.g. *Taxus, Tilia* and *Ulnus* also reduced as boreal elements e.g. *Betula* increased. These data indicated a period of high-seasonality (i.e. moisture variation and MTCM variation). Kukla *et al.* (1997) concluded that much of France was characterized by deciduous forests and that by the late Eemian these gave way to coniferous forest which lasted to the end of the St Germain II interstadial (*ca.* MIS 5a). This largely stable deciduous/boreal forest was however interrupted by two discrete episodes of *Taxus*, coeval with a decline in deciduous elements during the first half of the Eemian. Kukla *et al.* interpreted this as "*signs of significant cold spells*" (Kukla *et al.* 1997:606). This apparent centennial scale cold-phase was also observed in Bispingen and La Grande Pile. However, it was much less-marked in La Grande Pile owing perhaps to the more westerly location. Bispingen, by contrast, is situated further to the east in and experienced presumably more continental climate (Field *et al.* 1994). But these data do not correlate with the MIS 5e variations of the GRIP ice core. It appears that the GRIP 5e2 and 5e4 fluctuations did not adversely affect the Eemian vegetation patterns nor promote the development of climatically linked biomes such as steppe or tundra appearing co-incident with the $\delta^{18}O$ (5e1-5) fluctuations.

Other attempts to identify rapid palaeoenvironmental changes were made by Boettger *et al.* (2000) who examined pollen and stable isotopes $\delta^{13}C$ and $\delta^{18}O$ from the Gröbern profile in central Germany (CP). The pollen evidence indicated some gradual cooling occurred however this could not be correlated with any of the $\delta^{18}O$ fluctuations observed in GRIP. Interestingly, $\delta^{18}O$ evidence from the Melisey I section indicates that a period of warming occurred that was comparable in magnitude to the MIS 5c signature, but no pollen change accompanied this oscillation. This is an important demonstration of how we must exercise caution before we make claims for environmental instability and ecological disruption, insofar as warm spikes such as this, comparable with Dansgaard-Oeschger events were not accompanied by vegetation change (in this case across the NP) which would allow one to infer that ecological disruption had occured.

Other evidence from seven major pollen sequences (fig. 4.5) located in the SP (La Grande Pile; Les Echets; Ribains; Le Brouchet and Saint Font) and two other sites Ibramowice and Glówcyzn in Poland do not suggest any significant ecological disruption occurred during the Eemian. It appears instead that a gradual cooling occurred and that by 5kyr into the Eemian *Carpinus* was a strong component of the European forests. This terrestrial evidence contrasts somewhat with the $\delta^{18}O$ data from ODP 658 which indicates a 'mid-Eemian cooling event' which saw temperature fall to glacial values (Cortijo *et al.* 1994). Diatom analysis from La Grande Pile, Les Echets, Lac du Bouchet and Ribains show optimum temperature was reached by *ca.* 127 ka followed by a gradual cooling for the rest of the phase (Rioual *et al.* 2001). Taken together, the long French sequences support the idea that the Eemian was stable and appear to contradict the ODP 658 evidence. Kukla *et al.* (1997) did report some oscillations between coniferous vegetation and deciduous vegetation in La Grande Pile during the second half of the Eemian and it has been suggested that this ties into the increased values of the cold-water foram *N. pachyderma* in V29-191. However, the contention that gradual changes in forest composition constitute the effects of oscillatory climate is difficult to uphold. Current evidence from terrestrial proxies does not indicate any sudden reversions from deciduous or coniferous taxa to open herbaceous environments that can be taken to be indicative of stadial or glacial climates.

As one would expect, there are local exceptions which may support the notion of intra-Eemian instability. The erosion of volcanic rocks via freeze thaw results in clays with strong magnetic fractions that produce strong susceptibility features. Conversely, organic gyttas and soil degradation features are suggestive of warmer, wetter climates because the dissolution of magnetic components leads to a weaker susceptibility signal (Thouveny *et al.* 1994). Low susceptibility at Lac du Bouchet accompanied by high values of *Quercus* and *Corylus* pollen characterized the Eemian optimum. However, Lac du Bouchet has several levels with high susceptibility values coeval with *Abies*, *Picea* and *Poaceae*. These indicate colder climate and more open environments respectively in which case they may correlate with the GRIP 5e2 and 5e4 perturbations (ibid.). The association between the GRIP and Lac du Bouchet appears to be unique as is not observed in other French pollen sequences (Cheddadi *et al.* 1998; Rioual *et al.* 2001) nor is it observed in sedimentological analysis of Saint-Font and Ribains carried out by Stockhausen *et al.* (1999).

4.6 Summary

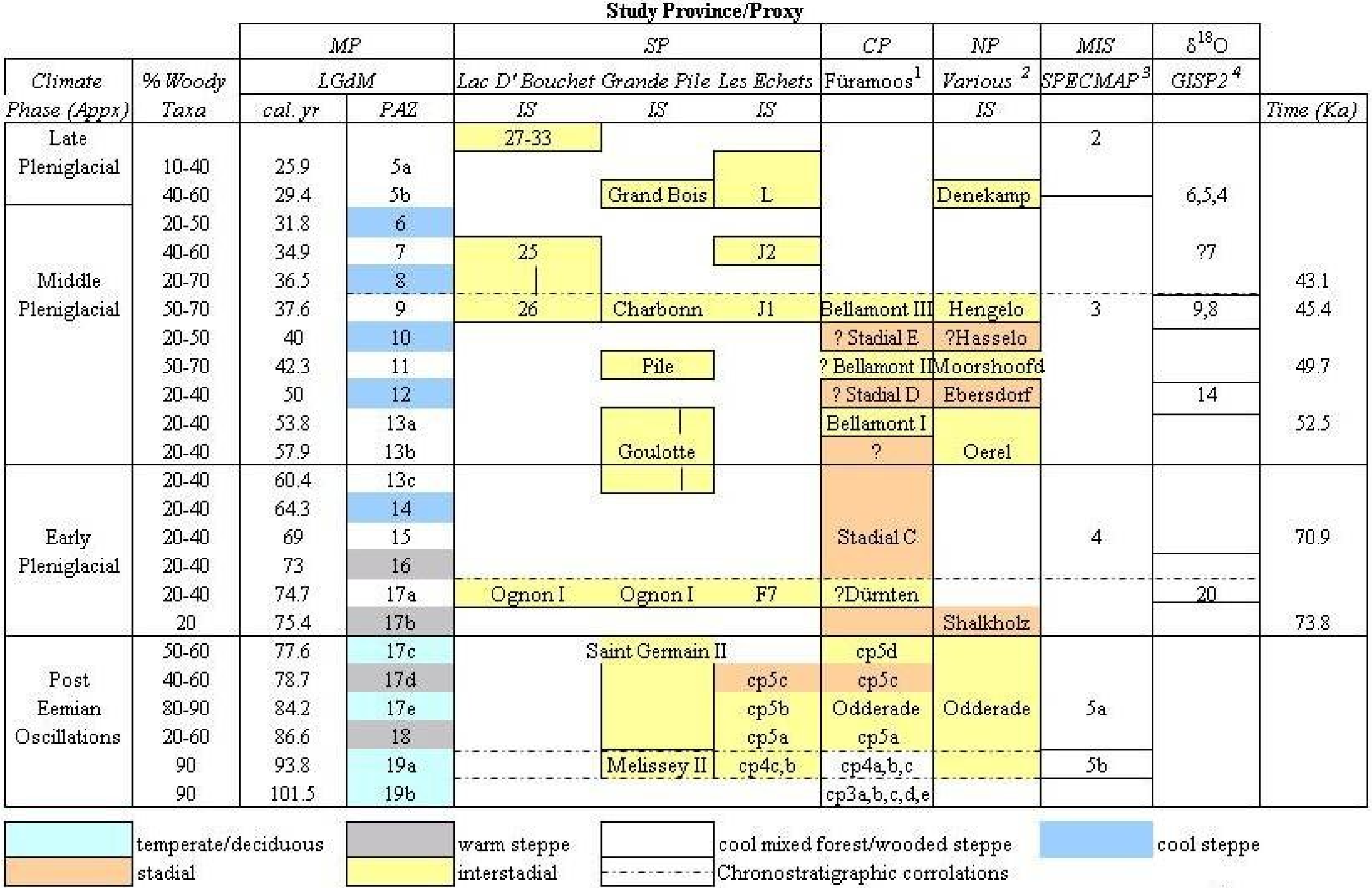
Palaeoenvironmental contrasts appear to have been more marked between the NP and SP either because of local factors such as regional variation in precipitation, or more controversially, because oscillatory climate change had greater effects on some regions of Europe more than others. The NP and the MP were structurally different in terms of forest composition, as well as in terms of the duration of the closed forest biomes, while subtle differences between the pollen records in France may attest to intra-regional environmental heterogeneity in this part of Europe. Susceptibility changes in Lac du Bouchet along with the differences between Bispingen and La Grande Pile illustrates that palaeoenvironments did undergo some subtle reshaping during the interglacial period however it is perhaps more parsimonious to view this as a local response to regional, non-climatic factors. This raises important questions regarding the conditions and resources which comprise climate regime types such as interglacial and how these may have varied within what is traditionally perceived as a stable and 'homogeneous' climate phase. Moreover, it would provide, both in the short-term (human lifetime) and long-term (cultural and biological adaptation) different ecological stages and presumably different contexts for selection to operate which could have resulted in more discrete or novel behavioural responses over this timeframe. This is not a novel claim. The current interglacial, the Holocene, has been by and large climatically stable when viewed over the course of recent history. Yet there is an immense range of different environments practically all of which have been inhabited or exploited by humans at one time or another. Some 70% of Africa is desert, open grassland and shrubland, while more than 8 tenths of east Africa is arid or semi-arid. Open savannah is characterised taxonomically by grasses with strong resistance to seasonality, yet these blend into semi-deserts or wetter savannahs which may be more productive. Hence it is clear that major differences in condition-resources occur in space and in time within one region of Africa. Europe under present interglacial conditions is characterised by tundra, taiga, steppe (grassland), temperate forest and Chaparral. This massive range of modern environments has necessarily led modern humans to develop environment-specific responses in order to survive and subsist.

Not just humans but other biota exerts significant controls on environmental settings. Andrews and O'Brien 2000 (after Bode 2006) have stated that large, herbivorous animals actively contribute toward the creation of mosaic as well as open habitats. The forest elephant is almost half the body mass of the bush elephant, while the Cape buffalo is about three times the size of the forest buffalo. Hence we see that resources (in this case fauna) utilised by hominins may have exerted indirect as well as direct affects on the environment. Therefore it is inaccurate to conclude that climate and tectonics were the major controls on the creation of open vegetation mosaics over an IG-G cycle.

4.7 The Weichselian

In this section I intend to explore the types of palaeoenvironments inhabited by Neanderthals across the post-Eemian and Middle Pleniglacial. Using a range of palaeoclimate and palaeoenvironmental data, a detailed appreciation of the last glacial cycle in the study provinces will be made. The reason for adopting this approach is to examine if general climate units are an appropriate terminology which advance our understanding of Neanderthal palaeoclimatic adaptation and whether such units are suitable terms to be partnered with hypotheses of *H. sapiens neanderthalensis* disappearance. As we have seen from the last section, the Eemian was characterised by variation both spatially and temporally between the higher and lower latitudes in Europe. A similar approach will be adopted for the Weichselian across the four study provinces described earlier.

The preceding sections have shown that $\delta^{18}O$ evidence alone is not the most accurate proxy for palaeoenvironmental reconstruction. $\delta^{18}O$ appears to be relatively coarse-grained and fails to cenvey a sense of the palaeoenvironmental reality. While the Eemian was probably climatically stable the Weichselian by contrast appears to have been characterised by pronounced palaeoclimatic oscillations even at the SPECMAP scale, and indeed such changes are more widely reflected in the palaeoenvironmental proxies of Europe. The Weichselian began in earnest when extensive ice-centres developed over Fennoscandia and the Kara Barents Sea (Denton and Hughes 1981). Periglacial features indicate that much of northern Eurasia was carpeted by vast tundra and steppe-tundra, while parts of the lower latitudes such as Mediterranean Europe which lay outside the direct influence of the ice-sheets maintained a temperate climate with relatively stable environments. This promoted the development of floral refugia (Tzedakis 2003) but also refugia for human populations (Mellars 1998; Finlayson *et al.* 2000; Zilhãu 2000). While SPECMAP indicates that the post-Eemian-pre-Holocene phase largely climatically stable but cold period, two other proxies, the GISP2 ice-core record and the Lago Grande di Monticchio pollen sequence provide an altogether vastly different insight into the palaeoclimatic complexity of an IG-G. These are high resolution and continuous catalogues of regional Weichselian palaeoclimate and terrestrial palaeoenvironments. Twenty interstadials are recorded over the first 75 kyr of the GRIP ice core (Dansgaard *et al.* 1993) and adjacent GISP2 ice-cores (Johnsen *et al.* 1992). Set within this context of interstadial warming is a host of sub-Heinrich event scale ice discharges, as well as six Heinrich events which preceded the strongest interstadial events (Broecker 1994). Fig. 4.5 summarises the major climatic events of the Post-Eemian oscillations, the Early and Middle Pleniglacial periods and how these events were manifested across the study provinces.



Study Province/Proxy

		MP		SP			CP	NP	MIS	$\delta^{18}O$	
Climate	*% Woody*	*LGdM*		*Lac D' Bouchet*	*Grande Pile*	*Les Echets*	*Füramoos*[1]	*Various* [2]	*SPECMAP*[3]	*GISP2* [4]	
Phase (Appx)	*Taxa*	*cal. yr*	*PAZ*	*IS*	*IS*	*IS*		*IS*			*Time (Ka)*
Late Pleniglacial				27-33					2		
	10-40	25.9	5a								
	40-60	29.4	5b		Grand Bois	L		Denekamp		6,5,4	
Middle Pleniglacial	20-50	31.8	6								
	40-60	34.9	7	25		J2				??	
	20-70	36.5	8								43.1
	50-70	37.6	9	26	Charbonn	J1	Bellamont III	Hengelo	3	9,8	45.4
	20-50	40	10				? Stadial E	?Hasselo			
	50-70	42.3	11		Pile		? Bellamont II	Moorshoofd			49.7
	20-40	50	12				? Stadial D	Ebersdorf		14	
	20-40	53.8	13a				Bellamont I				52.5
	20-40	57.9	13b		Goulotte		?	Oerel			
Early Pleniglacial	20-40	60.4	13c								
	20-40	64.3	14								
	20-40	69	15				Stadial C		4		70.9
	20-40	73	16								
	20-40	74.7	17a	Ognon I	Ognon I	F7	?Dürnten			20	
	20	75.4	17b					Shalkholz			73.8
Post Eemian Oscillations	50-60	77.6	17c		Saint Germain II		cp5d				
	40-60	78.7	17d			cp5c	cp5c				
	80-90	84.2	17e			cp5b	Odderade	Odderade	5a		
	20-60	86.6	18			cp5a	cp5a				
	90	93.8	19a		Melissey II	cp4c,b	cp4a,b,c		5b		
	90	101.5	19b				cp3a,b,c,d,e				

temperate/deciduous
stadial
warm steppe
interstadial
cool mixed forest/wooded steppe
Chronostratigraphic correlations
cool steppe

sources : Grootes *et al* . (1993); Allen *et al* . (2000)[Fig. 2 & Table 1]; Allen & Huntley (2000); [1]Klotz *et al* . (2004), Muller *et al* . (2003); [2]Emontspohl (1995); Caspers & Freund (2001); Huijzer & Vandenberghe (1998); [3] Martinson et al. (1987); [4] Grootes et al. (1993).

Figure 4.5 Regional chronological associations

MIS 3 in particular appears to have been punctuated by at least three major interstadial events visible in GISP2, Lago Grande di Monticchio, the major French pollen sequences and the discontinuous northern pollen profiles.

The variability witnessed in terrestrial and ice-core proxies contrasts somewhat with the apparent stability of marine $\delta^{18}O$ records which by and large do not centennial or millennial scale oscillatory climate change but instead display long-term trends. For example the Early Pleniglacial (MIS 4 *ca.* 75 ka to *ca.* 58 ka) corresponds to the second coldest phase of the last 130 ka, while the Middle Pleniglacial (MIS 3 *ca.* 58 ka to *ca.* 27 ka) is viewed as a period of generally warm climate. Finally the Late Pleniglacial (MIS 2 *ca.* 27 ka to *ca* 11 ka) is seen as the coldest phase of the cycle (Martinson *et al.* 1987 see fig. 1 Watts *et al.* 2000).

Archaeologists have relied on rather broad or coarse units of analysis from which to infer or recreate the types of environments inhabited by Palaeolithic humans. Typically a resolution to the interstadial or stadial climate regimes (mainly ascertained from ice-core data) is deemed accurate enough to draw secure inferences about environment. Often such inferences are broadly applied over a range of spatial and temporal scales. This has perhaps created a bias especially in the general literature and a form of consensus that such records can in fact shed light on the tempo of terrestrial ecological change when in fact such records may obscure the complexity of change that occurred over a range of spatio-temporal scales. For example Stringer and Gamble (1993) saw the early Weichselian (MIS 5d-5a) as a 40 kyr phase between 115 ka to 75 ka characterized by semi open/wooded environments under ‘temperate/cool conditions’. Some returns to temperate conditions resulted in *Pinus/Picea* woodland re-establishing across northern Europe (north Germany and Holland), subsequently recognised as the Amersfoort, Brørup and Odderade interstadials. These were followed by a further period of glacial conditions, followed by moderate climates punctuated by three further interstadials: the Moershoofd, Hengelo and Denekamp. These early MIS 3 interstadials are viewed as warm events in an otherwise mid glacial/interglacial climate stage.

Pollen profiles provide high-resolution insights into local and regional climate change on a decadal time scale. However, preservation is dependent on favourable geographic and climate conditions (Müller *et al.* 2003). Unfortunately many pollen records especially those in the higher latitudes are often discontinuous because of periglacial processes (Tzedakis *et al.* 1997). In relative terms, then, we have reconstructions of varying quality over wider areas of Europe. For instance we have ‘floating’ interstadials such as the

Oerel and Glinde of the Oerel core (Behre, 1989; Beaulieu and Reille 1992b) and the north European Moershoofd, Hengelo and Denekamp (Zagwijn 1974) with uncertain chronological controls (but see Müller *et al.* 2003), making broader comparisons (i.e. inter-regional) problematic. Aligned to this is a series of methodological problems i.e. whether regional catalogues can be extrapolated over broader areas (Behre and van der Plicht 1992). Likewise, high-resolution data from marine sediments or ice cores are encumbered with similar drawbacks with respect to how such apparent changes were reflected (if at all) in terrestrial environments. Despite these limitations they have provided a general basis from which to develop more sophisticated methods and questions relating to Neanderthal and modern human adaptation. They have provided a palette from which to paint the palaeoenvironmental backdrop to human evolution. They have highlighted the existence of stadial and interstadial events within the larger framework of the IG-G cycle and in doing so have provided some illustration of the complexity of the post-Eemian character. Such general reconstructions and approaches have for example greatly influenced our expectations and limitations of Neanderthal behaviour. For instance, some archaeologists feel that Neanderthals were forced to track favourable habitats as tundra and steppe environments encroached across vast areas of Europe. Unable to adapt to new circumstances, Neanderthals were bound to old habitats, trapped in the inertia of a shrinking ecological niche as the Late Pleniglacial approached. The inflexibility of their social systems to modulate and adapt to climate change facilitated their extinction (Gamble 1986:381). Such strongly presented and seemingly explanatory frameworks have been adopted and applied to the European peninsula as a whole: they have provided an overly simplistic model from which to constrain the behaviour, palaeoenvironmental and palaeoclimatic tolerances of the Middle and Upper Palaeolithic Eurasians.

The following discussion will refer to MIS 5d-MIS 5a and terrestrial correlates as the *post-Eemian oscillations* which were initiated at 118 ka in the NP and 107 ka in the SP lasting until 75 ka. MIS 4 will mark the onset of the Weichselian proper (Early Pleniglacial) and MIS 3 will correspond to the Middle Pleniglacial.

4.8 Northern Province during the Post-Eemian

The post-Eemian oscillations in the NP are referred to under regional nomenclature. Four major climate events have been reported. The first and third of which are stadials and are known as the Rederstall/Herning I and II (the Melisey I and II in other parts of Europe) while the second and fourth events are interstadials and are referred to as the Amersfoort/Brørup and Odderade (the St. Germain I and II in France). The Eemian was categorized largely by homogeneous forest environments across the study regions. The Mediterranean saw evergreen woodland stretch north, blending into deciduous and mixed conifer/deciduous woodland over south-west and central Europe, Poland, The Russian Plain, Finland and Sweden, with boreal forest characterizing the environments of Norway (van Andel and Tzedakis 1996). The first major discernible effect of post-Eemian palaeoclimatic change occurred with the onset of the Herning stadial (~MIS 5d). Caspers and Freund's (2001) publication represents a comprehensive study of the vegetation and climate of the Early- and Pleni-Weichselian in northern and central Europe. By comparing the relative character of pollen sequences situated in the adjacent northern and central provinces (e.g. the Rederstall, and Gröbern respectively) they demonstrated that the Herning I was characterised by two stages (WF Ia & WF Ib). Generally speaking, more coastal sites such as the Rederstall, or those which experienced higher levels of precipitation are characterised by higher values of *Calluna vulgaris*, while sites in more continental areas such as Gröbern appear to have been characterised by lower values of *Calluna* and proportionally higher values of Gramineae and *Artemisia*. While modern distribution of *Calluna* extends into eastern Europe, it is more abundant in the humid Atlantic to subantlantic climate zones. The changing distribution of *Calluna* during the Herning then, across central Germany and into northwest Europe (e.g. between Gröbern and Rederstall) charts the transition between oceanic to sub-continental climate zones. Other sites situated in the NP such as Chelford, England (Worsley *et al.* 1983) and Gröbern, central Germany show that MST fell to 10˚C or 12˚C (Walkling and Coope 1996) while periglacial features and coleoptera indicate MWT dropped below -20˚C (Aalbersberg and Litt 1998). Coleoptera and periglacial structures indicate MWT remained quite high at *ca.* -8˚C in parts of the NP (eastern Germany) (ibid.). Emonstpohl (1995) reported the full post-Eemian sequence in stratigraphic superposition based on work at the Watten profile located near Nord (North France). *Pollen zone 2* (Watten) is believed to correspond with the Herning stadial (MIS 5d). The principal arboreal elements from this phase are *Pinus* and *Corylus* which constitute between 19-58% of the spectra. These values were considered low by the author, yet based on the relatively high value (58%) one could equally argue that a significant forest component persisted in this particular area of the NP during the Herning. These data support the idea that the forest and tundra ecotone was probably set somewhere further to the north and east, near north Germany and Holland (Huntley and Birks 1983; Behre 1989). In contrast to parts of the CP (as discussed below) it appears that the Herning stadial did not significantly alter the palaeoenvironments of the more oceanic sector of the NP, and that considerable forest habitats (of late Eemian type) still persisted. Palaeoenvironmental change did not occur 'overnight'.

Palaeoclimatic improvement occurred with the onset of the Brørup interstadial (~MIS 5c) which saw MST rise in the colder parts of northern Europe from 4˚C to 15˚C yet the MWT remained at Herning values i.e. -13˚C (Walkling and Coope 1996; Aalbersberg and Litt 1998). Caspers and Freund's (2001) study subdivided the Brörup into three phases: i) WF IIa: well-developed birch ii) WF IIb: well-developed pine iii) WF IIb: subsidiary values of *Quercus*, *Ulmus Tilia* and *Carpinus*. Studies of the northern and central profiles have clearly shown some important differences in forest structure and composition. More northwestern sites such as Loopstedt and Oerel saw a well-expressed *Betula* forest (>60%) while more northern sites (e.g. Brörup) were characterised by *Betula* values between 40-50%. In central Germany (e.g. Gröbern) *Betula* and *Pinus* prevailed. Warm loving deciduous trees such as *Alnus glutinosa* and *Alnus incana* migrated into the southwest portion of the NP (Amersfoort and Quackenbrück) and even reached higher latitudes at Brörup. A late Brörup climatic deterioration was recorded across several sites in the northern and central provinces as MST fell from 15°C to 12°C coinciding with *Betula* and *Pinus* forests giving way to birch forests. However as we have seen, parts of the NP maintained an oceanic climate throughout the Herning stadial, so temperature change was no doubt greater in the more northern and eastern areas of the province.

The picture was similar in more western parts if the province where pollen zone 3 in Watten, broadly coeval with the Brørup, shows a significant increase in arboreal pollen to percentages between 50% and 96% across the phase. The dominant taxa were *Pinus*, *Corylus* and *Betula*; however, some temperate forest elements e.g. *Corylus* and *Quercus* were also reported (Emontspohl 1995). Thus it appears that a mixed-forest prevailed and that some deciduous trees were located as refugia within the NP. Further to the east in North Germany boreal forest obtained along with some deciduous flora (Huntley and Birks 1983) while Zagwijn (1961) reported deciduous forest across Holland. In England, *Betula* and *Picea* open woods were the dominant vegetation (Morgan 1973) in contrast to the mixed forest of Watten (Huntley and Birks 1983; Emontspohl 1995). These various findings from several sites across the NP indicate that the Herning/Brørup phase was marked by some overriding similarities in conditions (temperature), resources (vegetation) as well as some similarities in terms of succession from pioneer type forests, through to deciduous forests yet it is implicitly understood in terms of distinct 'stadial' and 'interstadial' entities. It may be more accurate to visualise the environmental dynamics of parts of the NP during the first of the post-Eemian couplets as a dynamic environmental continuum; the expression of boreal and thermophile forests appears to have varied both in terms of timing and structure hence the use of 'stadial' and 'interstadial' terminology obscures the finer-grained change which evidently took place over this timeframe.

The transition from the Brørup interstadial to the Rederstall stadial (~MIS 5b) saw MST decline to 10˚C, while MWT based on the absence of periglacial features at Gröbern seems to have remained at Brørup values i.e. above ~ -8˚C (Aalbersberg and Litt 1998). Coastal sites can be broadly divided into two subzones WF-IIIa, which is *Gramineae* poor, and WF-IIIb which is *Gramineae* and herb rich (Caspers and Freund, 2001). More continental sites do not however display this two-stage pattern and are instead rich in *Gramineae* and *Artemisia* throughout the stadial (e.g. Gröbern). MST and MWT in central Germany appears to have been 11°C and -12°C respectively, while the latter half of the stadial saw higher MST of 12°C to 13°C. According to Caspers and Freund evidence for permafrost is exceptional and largely discontinuous however the oceanic-continental interface appears to have shifted some 250km to the west-northwest during the Herning based on *Artemisia* pollen isoclines.

Pollen zone 4 at Watten corresponds to the Rederstall. It was characterised by some low quantities (10-25%) of arboreal pollen principally *Pinus*, *Picea*, *Corylus* and increasing *Betula* values along with some thermophile taxa such as *Quercus*, *Ulmus*, *Tilia* and *Carpinus*. Poaceae and *Artemisia* were strong understudy components. One can envision a park-like landscape characterised parts of the NP at this time (Emontspohl 1995). Further to the east, *Stadial B* in the Füramoos catalogue was characterised by mixed *Quercus*, *Corylus*, *Poaceae* and *Artemisia* grasslands and was in terms of vegetation structure comparable to the NP. Behre (1989) reported similar forest-tundra environments in north Germany at this time. These reconstructions indicate that the Rederstall was no doubt a cold, dry phase, but that north European environments were heterogeneous. A final period of amelioration prior to the onset of pleniglacial conditions is referred to in terrestrial sequences as the Odderade interstadial (~MIS 5a). Sites in England and North Germany show that MST rose rapidly to 15°C (Walkling and Coope 1996) yet MWT remained comparable to the Brørup, at -13°C (Aalbersberg and Litt 1998). Caspers and Freund (2001) again saw fit to divide this phase into two zones: WF-IVa (*Betula*) and WF-IVb (*Pinus*). Zone WF-IVa is poorly represented in most of the northern and central European pollen proxies in contrast to WF-IVb, where *Pinus* appears to have migrated from a southeastern 'refuge' into northwest Europe. This was followed by the migration of *Picea* and *Larix* into the central European lowlands and its rapid appearance and consolidation suggests that it survived both the Herning and Rederstall stadials. Plant macroremains and beetles indicate that MST in the more continental area of Gröbern reached 15°C or 16°C (comparable to the Brörup interstadial). Pollen zone 5a from Watten shows a high arboreal pollen value (52-88%) indicative of a well-established *Pinus-Picea* forest, while zone 5b was marked by considerable amounts of *Corylus* and a strong arboreal pollen signature (42-78%) (Emontspohl 1995). These findings suggest that north Germany (Behre 1989), north France and Belgium (Emontspohl 1995) were characterised by a mixed boreal pine forest with some deciduous elements. This diverse forest was probably an outcome of northern France set in a transitional area between cold North winds and warm Mediterranean winds (Bowen 1990). The NP during the post-Eemian oscillations, then, was characterised by considerable heterogeneity as well as variation inter- and intra-regionally. It certainly does not appear to have been comprised of 'mixed habitats' that were stable on geological timescales.

4.9 Northern Province during the Early Pleniglacial

Huijzer and Vandenberghe's (1998) study of the Early Pleniglacial northwestern and central regions offered some valuable insights particularly with regard to palaeotemperature reconstruction over this phase. Coleoptera data suggest MST reached 13°C in England. Based on periglacial evidence the boundary between the discontinuous and continuous permafrost zone lay broadly along the modern France-Belgium border. MWT in the discontinuous zone, which covered the best portion of the NP was around -20°C, and indeed similar MWT appears to have also characterised sites situated further to the east. MAT in the continuous permafrost zone dropped to -8°C and to -4°C in the discontinuous zone. As the authors take care to emphasise, periglacial evidence (e.g. ice wedge casts, sand wedges etc) while indicative of mean annual air temperature between -4° to -20° C, only form in certain substrates or during extreme and short-lived periods of cold therefore cannot be viewed as representative means of the entire Early Pleniglacial.

4.10 Northern Province during the Middle Pleniglacial

As we have seen most northern stratigraphic records are discontinuous and no single unbroken sequence records of the events shown in table 4.2. Over the 60 to 30 kyr period it seems that there were several distinct palaeoclimatic events that resulted in quite differently expressed palaeoenvironmental circumstances across the NP.

Table 4.5 **Major climate phases discussed in text**

Phase	**Duration (Kyr BP)**	**Reference**	**GISP2 ?**
Oerel Interstadial	57.7-?	Caspers and Freund (2001)	17,16
Ebersdorf Stadial	?55-50	Caspers and Freund (2001)	
Moershoofd Interstadial	50-43	Huijzer and Vandenberghe (1998); Caspers and Freund (2001)	14,13,12,11
Upton-Warren Interstadial	43-42	Huijzer and Vandenberghe (1998)	12
Hasselo Stadial	42-40	Ran and Van Huissteden (1990)	?Heinrich 4
Hengelo Interstadial	39-37; 38.7-36.9	Huijzer and Vandenberghe (1998; (Caspers and freund (2001) after Kasse *et al.* (1995:411)	8,7
Denekamp Interstadial	32,000-28,000	Caspers and freund (2001) after Ran (1990)	5,4,3

Some evidence for Early Pleniglacial warming is evidenced by the *Oerel* interstadial from the Oerel core situated in Lower Saxony, Germany. This phase began at *ca.* 57,700-55,400 ^{14}C uncal. Yr BP and saw only limited environmental improvement. Tree stands appear to have been absent or rare and open shrub tundra was the dominant biome. MST was probably around 9°C to 10°C with very cold MWT of -17°C (Caspers and Freund 2001). A period of cooling known as the *Ebersdorf* stadial followed the Oerel and is thought to have lasted some 5 kyr. Only limited data is available but it points to a MST of 7°C with MWT of -26°C. Houmark-Nielsen (1989) recognised that the Bø-Older Dösebacka-Hirtshals interstadial in Denmark and southern Scandinavia appears to be coeval with the Moershoofd interstadial in Holland and north Germany. Temperature at this time, especially during the winter remained low. In Germany periglacial structures show that MAT dropped below -1˚C and that MWT reached -20˚C however temperature was somewhat higher in Holland, averaging between -11.5°C to -13°C (Huizjer *et al.* 1998). Palaeobotanical data show that MST was between 7˚-11˚C across Denmark, Holland and Poland. A further period of rapid climatic change was recorded at the Upton Warren Complex (England) at 43,140±1520/1280 yr BP (Huijzer and Vandenberghe 1998 citing Coope *et al.* 1975). Mollusc and coleopteran data indicate temperate conditions (?GISP2 DO 12), with MST of 15°C or 18°C and MWT of ~ -13°C - 1°C. However, these improvements were not accompanied by any significant palaeoenvironmental change such as the development of boreal vegetation. Establishing the regional character of Upton Warren type events and comparing these on an inter-regional basis is difficult because stratigraphic discontinuities, chronological uncertainties as well as the fact that local edaphic and microclimatic factors (e.g. wind inclination) often have strong if not principle control on the vegetational succession. Indeed, Caspers and Freund (citing Kasse *et al.* (1995:411) point out that 'major' sedimentological changes are more parsimoniously explained by local hydrological factors as opposed to strictly climatic factors. A correlation between the purported changes at Upton Warren with the Lafelt palaeosol developments at Kesselt (Belgium) has been made despite the rather broad chronological control of the Lafelt palaeosol (dated between 40 and 27 cal kyr BP Van Huissteden 1990). Vandenberghe *et al.* (1998) suggest MST of 10°C obtained between 38 ka and 28 ka, and that stronger amelioration (e.g. Upton Warren type) could have resulted in meaningful environmental changes, such as palaeosol development across some areas of the NP. This having been said, the grounds for claiming that the Upton Warren and Lafelt palaeosol reflect broad inter-regional environmental improvement is tentative at best and in no way unequivocally demonstrates that strong Weichselian amelioration of this sort resulted in broad palaeoenvironmental change. These uncertainties regarding the environmental responses during 'pronounced' ameliorations such as the Upton Warren event have implications for how other apparent warm events are interpreted (such as the GISP2 DO oscillations) which are at present largely inferred to have caused significant environmental change across broad areas of Europe. Caspers and Freund emphasise this point:

> "Correlation of the terrestrially defined interstadials and intervals with the δ^{18}O values of the GRIP ice core is feasible for the early Weichselian, but very uncertain for the Weichselian pleniglacial. Peaks in the δ^{18}O values do not necessarily reflect the temperature regime in northern Europe".
>
> Caspers and Freund (2001:45)

The Upton Warren example is cautionary for it shows that not all rapid climate changes were linked to environmental change (i.e. rapid ecological changes caused by e.g. reforestation). Sensitive proxies such as coleoptera (Huijzer *et al.* 1998) and isotope variations e.g. maar lakes (Thouveny *et al.* 1994) certainly record some significant temperature changes, but it would seem that in most cases they fell below a critical threshold, both in terms of magnitude and/or duration to impart noticeable and meaningful palaeoenvironmental changes and in turn disrupt the habitats of Middle Palaeolithic humans.

The Hasselo stadial occurred after the Upton Warren phase and lasted between *ca.* 41-38 kyr. To me it seems that the Hasselo is in some way linked to Heinrich Event 4 which occurred at *ca.* 40-38 ka. Palaeoenvironmental deterioration appears to have been far reaching. Environmental deterioration was observed in Norway as the Jaeren-Göteburg II Vennebjerg stadial (Houmark-Nielsen 1989), and in France at Les Echets and La Grande Pile. MST dropped to between 7˚C-12˚C in Holland and England, while MAT in these areas was between -4°C and -8°C (Huijzer *et al.* 1998). Periglacial features place the continuous permafrost zone in southern Germany while increased aridity may have exerted a stronger control on vegetation than temperature (Ran *et al.* 1990).

The onset of the Hengelo saw permafrost retreat across the Netherlands (Huijzer and Vandenberge 1998). The Hengelo is thought to correspond to GISP2 DO 12. Interestingly the reconstructed MAT for the Hengelo based on Coleoptera data in England at this time is somewhat low at 9.5°C to 11.5°C, while further to the east in Belgium and the Netherlands, MAT is estimated between 8.5°C and 11.5°C (ibid). Huijzer and Vandenberge (1998) have questioned whether in fact MAT substantially declined during the post-Hengelo/pre-Denekamp phase and suggest that temperature remained stable. Environments at this time across the UK, Belgium and Holland appear to have been characterised by tundra biomes (Guiter *et al.* 2003). MST peaked at 10°C; however, MAT appears to have varied intra-regionally. For example, Van Vliet-Lanoë (1989) reported that MAT reached -7˚C, while Vandenberghe (1992) suggested MAT was much warmer at -1˚C. If such temperature variation is real, then human populations would have faced different challenges depending on the nuances of the local settings. Estimates of mean annual temperature (MAT) across the northern and central provinces are broad. Frost cracks in Belgium, Germany and the Netherlands indicate MAT of -2°C to -1°C, while Coleoptera data points to values between -11°C to -2°C. This is not to say that that the higher latitudes were essentially uninhabitable for humans during this time – in fact far from it. A more refined understanding of the waxing and waning of the Fennoscandian ice-sheet has emerged in recent years, and there is an emerging consensus that it was far-smaller than typically acknowledged during the Denekamp interstadial at *ca.* 32 ka BP (van Andel 2003). Palaeoenvironmental studies have complimented these findings and support the view that high-latitude environments were not as harsh as a cursory reading of 'glacial' would suggest. Ukkonen *et al.* (1999) has shown that macrofauna were present across Norway, Sweden and Finland at this time. AMS dated mammoth bones in Finland suggest regions as far north as at 60˚N and 20˚E could have provided a viable habitat for human occupation which has hitherto been considered essentially barren and uninhabitable (*sensu* Stringer and Gamble 1993:49). The grim scenario offered by Stringer and Gamble may be an over simplification in light of the emerging palaeoenvironmental and ecological diversity of the northern regions.

4.11 Central Province during the Post-Eemian

The Füramoos sedimentary basin (47°59°'N and 9°53°'E) records the sequence of palaeoclimatic changes over the Riss-Holocene cycle (Müller 2001). The transition from the late Eemian coniferous forests into the first of the post-Eemian oscillations, known locally as Stadial A, is characterised by the replacement of arboreal vegetation with a tundra-steppe biome which lasted *ca.* 3,500 yr (Müller *et al.* 2003). The local equivalent of the Brørup interstadial was marked by the rapid appearance of *Picea* accompanied by some thermophilous elements (*Corylus*) very early in the interstadial. Müller (2003) suggests that the early appearance of deciduous elements in the sequence was probably because forest refugia were located north or west of the Alps complementing the view of Willis *et al.* (2001) that northern and central Europe never experienced fully open conditions until the Weichselian proper. The Brørup in central Europe was interrupted by a severe environmental change that was recorded widely across Europe in other proxies e.g. Amersfoort (Zagwijn 1961), Lac du Bouchet (Reille *et al.* 1992) and Lago Grande di Monticchio (Allen *et al.* 1999) though not in the ice-core records. Dated in Lac du Bouchet to 103 ka it is known as the *Montaigu Event.* The palaeoenvironmental effects were considerable. *Picea* declined inversely to *Artemisia* expansion, which was in turn followed by a gradual *Picea* recovery. The late Brørup saw a decline in coniferous forests over *ca.* 3 kyr into steppe environments of *stadial B*, before the onset of the Odderade interstadial which saw *Pinus*, *Picea* and thermophilous woodland re-established. This suggests (as in stadial A) that refugia woodland existed north of the Alps or even within central Europe (Müller *et al.* 2003). Interestingly, the mid-Odderade experienced a *Pinus* and *Picea* decline and rapid *Artemisia* steppe expansion. This represents *stadial C*, a pre-

MIS 4 cool phase which was succeeded by yet another warm phase, the *Dürnten interstadial*. The Dürnten is unusual as it has no broad equivalent in MIS or other terrestrial proxies yet it represents a well-expressed forest stand north of the Alps. The Dürnten oscillation may in fact date to MIS 4 contra Müller *et al.* (2003) because similar palaeoenvironments characterized the Mediterranean (Lago Grande di Monticchio) during the Early Pleniglacial (Allen *et al.* 1999). In this sense it could represent a strong amelioration principally driven from refugia located in the MP. In either case it represents a rapid oscillation akin to the MIS 3 oscillations.

4.12 Central Province during the Early/Middle Pleniglacial

In the Füramoos sequence the first major phase of open palaeoenvironments is referred to as *stadial D*. This phase probably correponds with early MIS 4 and was characterized by steppe biomes consisting of *Artemisia* and *Gramineae* (Müller *et al.* 2003). The strong presence of steppe palaeoenvironments throughout this phase suggests that thermophile refugia were, by now restricted to the Mediterranean regions (*cf.* Allen *et al.* 1999).

The CP witnessed three Middle Pleniglacial interstadials (Bellamont 1, 2 and 3) and two stadials (E and F). Only limited chronological control is available. The Bellamont 1 and 2 have AMS ^{14}C dates of 51,300±2,400/1,800 yr BP and 43,930±930/830 yr BP respectively (Müller *et al.* 2003). The interstadials were characterized by an increase in *Betula* and *Pinus*, while Bellamont 3 saw *Betula albus* indicating perhaps even warmer conditions. The Bellamont I was a 7,000 yr phase which began at *ca.* 54,000 and lasted until *ca.* 47,000 ka BP. However it did not reach optimum warmth until *ca.* 51,000 ka BP. According to Müller *et al.* (fig. 6, 2003) it corresponds to GRIP IS 15, 14 and 13. This is in good agreement with the GISP2 sequence which has an independent chronology (based on varve counts) to *ca.* 50 ka. Under the GISP2 schema, DO IS 15, 14 and 13 and their intervening colder phases encompass the period between *ca.* 54.1 and 47.2 ka, some 6,900 yrs. The Bellamont II interstadial also appears to have a good correlation with the GRIP and GISP2 records. Müller and co-workers suggest that the Bellamont III correlates with GRIP DO 12 at *ca.* 40 ka, however the GISP2 sequence would place the Bellamont III more closely in line with DO 9 (40.5 to 40.7 ka) or DO 10 (41.1 to 41.4 ka).

Not all of the GRIP DO interstadials e.g. DO 19 through to 16 appear to have synchronous palaeoenvironmental responses across the CP. This is interesting because

GISP2 DO IS 19 and 17 in particular were two of the most lengthy and pronounced of the early Middle Pleniglacial. While it is possible that the palaeoenvironmental evidence for these more substantial DO has been destroyed through erosion, it seems likely that even these strongly-expressed DO events were insufficient in terms of magnitude and/or duration to facilitate the recolonisation across the higher latitudes by arboreal taxa immediately after the harsh Early Pleniglacial phase. In other cases (as with the Upton Warren amelioration) palaeoclimatic improvement simply did not last long enough to permit reimmigration of arboreal taxa.

Despite the fact that not all DO oscillations can be observed in the CP profiles, this region was characterised by extensive palaeoenvironmental heterogeneity throughout most of the Weichselian. Loess deposits located in Hungary between 46° and 48°N and 18°E and 24°W have produced plant/tree remains dated to 35.5 kyr BP (Willis *et al.* 2001). These dates cluster around the purported catastrophic ice discharge and associated cold water pulse of H3 (Bond *et al.* 1993) which some (Mellars 1998, Finlayson *et al.* 2002, d'Errico *et al.* 2003) believe provided the final blow to *H. sapiens neanderthalensis*, and by implication offered unknown but presumably neutral or positive conditions for contemporary *H. sapiens sapiens* populations. Table 4.3 shows a series of dates on woody plant materials that convincingly demonstrate boreal woodland obtained in the CP (Hungary) during the DO events and colder HE discharge phases of MIS 3.

Table 4.6 Boreal woodland in central Europe during the late Middle Pleniglacial (Willis et al. 2000)

	Flora	*Age* ^{14}C yr B.P.
1.	*Pinus* sp., *Picea* sp., *Juniperus* sp.	32,000 ± 2,170
2.	*Pinus sylvestris*	30,174 ± 1,101
3.	*Pinus sylvestris. Betula* sp.	29,828 ± 554
4.	*Pinus sylvestris-P. cembra*	29,800 ± 600
5.	*Picea* sp.	27,200 ± 1,400

That central Europe saw significant tree refugia in areas north and west of the Alps (Willis *et al.* 2000; Müller *et al.* 2003) is interesting, for it clearly demonstrates greater ecological complexity and enhanced resource opportunities in regions generally considered treeless and open during stadial and interstadial phases. The macrofossil data suggest a mix of open coniferous forest and sporadic deciduous palaeoenvironments characterised by MST of 16°-18°C (Willis *et al.* 1996, 2001) were juxtaposed against open, periglacial and ecologically homogeneous landscapes in north Germany and Holland. This evidence suggests other evidence for mixed landscapes during the Middle and Late Pleniglacial previously explained away by processes such as long-distance pollen transport (e.g. Woillard 1979) may have alternative explanations. Certainly these mixed ecotones would appear analogous to the supposed preferential habitats of *H. sapiens neanderthalensis* that workers such as Finlayson *et al.* (2003) have argued were restricted to southern Iberia late in MIS 3. The existence of forests in northern regions is not a far-fetched probability, as Korotaev (1987) has shown. Moreover, the *apparent* reduction of forest episodes observed in many Middle Pleniglacial pollen sequences may be a feature of reduced pollen productivity during glacial periods (Hicks 1994, 2006) as opposed to a reduction of total plant biomass (Magri 1994).

4.13 Southern Province during the Post-Eemian

Our understanding of the palaeoenvironments of the IG-G cycle has been greatly enhanced by many of the classic pollen sequences located across the SP. The most important of these include: La Grande Pile, Les Echets, Lac du Bouchet/Ribains and Le Velay. They essentially catalogue the climatic and environmental changes that occurred throughout the northern, eastern and central sections of the SP during the Middle and Late Pleistocene. Estimates on when the Melisey I (Herning stadial) began vary e.g. Stringer and Gamble (1993) and Guiter *et al.* (2003) citing Rioual *et al.* (2001) suggest *ca.* 110 ka lasting until *ca.* 104 kyr, while Fauqette *et al.* (1999) prefer 115 ka to 104 ka. For the purposes of the this discussion I will follow the reasoning of Kukla *et al.* (1997) who argued a convincing case for the onset of MIS 5d stadial conditions at 107 ka. All of the French pollen sequences illustrate major changes in both climatic and environmental conditions with the onset of the stadial. Guiter *et al's* (2003) synthesis, drawing on a variety of sources showed that parts of northern and eastern France was characterised by a herbaceous arctic tundra or steppe biome with MAT between -2°C and -4°C. Between *ca.* 104 ka and 92 ka a phase of climatic improvement now recognised as the Saint Germain I saw the rapid replacement of arctic biomes with temperate deciduous vegetation (*Quercus* and *Carpinus* forest). MAT was between 8°C and 12°C with precipitation between 800 to 1200 mm (ibid.). The Saint Germain I was interrupted by a short-lived but significant climatic downturn (the Montaigu event) which saw thermophilous taxa replaced by a mixed *Pinus* Poaceae biome. Deciduous vegetation returned after the Montaigu Event but was soon replaced once more by coniferous forests prior to the onset of the Melisey II/Rederstall stadial. Guiter *et al.* (2003) have estimated the duration of the Melisey II based on the La Grande Pile, Les Echets and Le Velay sequences to have been *ca.* 8 kyr between 92 ka - 84 ka, while Fauqette *et al.* (1999) suggest it was considerably shorter, lasting 93 to 88 ka BP. It is of course eminently plausible that the duration of any given climatic event would vary depending on the proxies used which (in the case with vegetation) were clearly influenced by local, non-climatic influences such as hydrology, competition and edaphic factors. The eastern and northern parts of the SP at this time were apparently devoid of forest biomes. The Odderade/Saint Germain II marked *ca.* 12 kyr of improvement between *ca.* 84 ka and *ca.* 72 ka with *Quercus* and *Carpinus* forests across large areas of south France, before replacement by *Picea* and *Pinus* forests prior to the onset of the Early Pleniglacial (Guiter *et al.* 2003). At least in the SP both the Saint Germain I and II appear to have been structurally and temporally similar. As a final point of note it is relevant to point out that the transition between stadials and interstadials at, for example La Grande Pile, were similar to the Riss/Eemian transition: each were characterized by low precipitation values (100 to 650 mm) with low MAT (La Grande Pile -2°C to 5°C; Lac du Bouchet -7°C to -2°C).

4.14 Southern Province during the Early/Middle Pleniglacial

Periglacial structures and loess deposits from Nussloch (Germany) dating to 67, 65 and 60 ka indicate that the NP was periodically very cold in the Early Pleniglacial. MAT dropped to -7°C with MST of 7°C to 8°C (Aalbersberg *et al.* 1998; Rousseau *et al.* 2002). Conversely, it appears that parts of the SP witnessed significant ameliorations during the early Middle Pleniglacial. La Grande Pile and Le Velay each record two warm phases: The Ognon I (Oerel) and II (Glinde) events (fig. 4.6) were characterised by well-established taiga woodland (Guiter *et al.* 2003). One of these events (unknown precisely which owing to chronological uncertainties) appears to have been quite significant in climatic terms as Klotz *et al.* (2004) report a similar environmental improvement in the Early Pleniglacial section of the Füramoos profile. The later stages of the Early Pleniglacial appear to have been exceptionally arid, a fact supported by increased loess accumulation in parts of Europe at this time Shi *et al.* (2003). In all cases warm events were followed by cold steppe with intermittent tundra episodes. It is not possible to determine at this stage if the tundra episodes were products of rapid cold snaps or the result of cumulative changes in the floral structure (Faquette *et al.* 1999).

The onset of the Middle Pleniglacial (MIS 3) at *ca.* 60 ka heralded in one of the most interesting and complex phases of the entire climate cycle. Far from extremely cold, it appears to have been marked by several phases of climatic improvement which may have led to more temperate biomes becoming temporarily re-established across favourable sub-regions of Europe. Zagwijn (1974) was one of the first workers to report the presence of organic layers interspersed between the Middle Pleniglacial sediments in the north European region. Hengelo and Denekamp represent the stratotypes for two of the best known of these 'interstadial events'. Subsequently, these have been recognised by other workers in different pollen sequences located widely across Europe (but see Caspers and Freund (2001) for a critique of this idea). Table 4.4 shows some principal palaeoclimatic changes observed in the SP proxies during the Middle Pleniglacial.

Table 4.7 Middle Pleniglacial events recorded in the SP

Event	*Vegetation*	*Duration (Ka BP)*
H6		65
Moershoofd	boreal taiga/birch	50 ka to 43 ka
H5		50
Hasselo		41-38
Hengelo	taiga/birch	38 ka to 37 ka
H4		35
Grand Bois (Denekamp)	taiga/birch/pine	34 ka to 29 ka
H3		28

(Summarised from Guiter et al. 2003)

One of the earliest phases of climatic amelioration that is also visible in adjacent provinces is the Moershoofd interstadial. To date, there are no chronometric dates that can be used with any confidence to constrain this phase in time. Several workers e.g. Huijzer and Vandenberghe (1998), Caspers and Freund (2001) and Guiter *et al.* (2003) have all suggested a *ca.* 7 kyr duration between 50 and 43 ka, with Guiter *et al.* reporting 7 kyr as a minimum value. It is perplexing why the term *interstadial* is used to signify a period of 7,000 yrs during which 'warm peaks' in temperature approached Holocene values but concede that because of the sudden rise and fall in temperature there was insufficient time for forests to migrate and become established. This begs the question as to what was happening during the rest of this 'interstadial' phase. If boreal and deciduous forests did not become established, then are we even dealing with an interstadial at all? If not, it is simply wrong to perpetuate the use of such terminology over broad timeframes when the evidence to substantiate its use is dubious or lacking.

> "An interglacial has to embrace the complete succession from pioneer forests to thermophile forests ending with boreal forests. The term 'interstadial' is used for both the long periods of considerable amelioration which permit forest cover to develop, as well as shorter periods which are only slightly warmer so as to enable herb and shrub bush tundra to develop. Thus the current definition of the term 'interstadial' is too wide. We suggest the term 'interstadial' be restricted to climatic amelioration that facilitates vegetation succession that can be recognised in the pollen record. All other pleniglacial events that have so far been defined as interstadials should be called intervals, a term proposed previously by Lüttig (1958)".
>
> Caspers and Freund (2001:44)

Huijzer and Vandenberghe (1998) reported that northern France during the timeframe broadly equivalent to the Hasselo stadial was not as severe as one may expect and the absence of ice-wedge casts in the loess district suggest that MAT remained above -4°C. The so-called Goulotte interstadial was recognised in La Grande Pile and appears to have been an early Middle Pleniglacial amelioration. The subsequent palaeoenvironment was characterised by tundra woodland along with a broad intra-regional *Picea* expansion. More westerly sites such as Les Echets saw more pronounced forest expression (Klotz *et al.* 2004). La Grande Pile records the Hengelo-Charbon at *ca*. 38–37 ka which resulted in shrub tundra environments consisting of *Betula* and Poaceae. MST is estimated to have been at or above 10°C while MWT was as low as -20°C (Guiter *et al.* 2003)**.** A further period of 'improvement' was recognised with the onset of the Denekamp interstadial. As with the case of the Hengelo, the growing season was probably too short and summer temperatures to low to permit any meaningful forest expression across this part of the SP at this time. Indeed, *Picea* is even absent the more westerly sites such as Les Echets. Temperature and environment appears to have been comparable across both of these phases.

4.15 Mediterranean Province during the Post-Eemian

As we have seen, many of the palaeoenvironmental proxies situated in the higher latitudes of Europe were adversely affected by periglacial processes during colder episodes of the IG-G. These factors played a negligible role in the Mediterranean region where pollen records situated across the Greek and Italian peninsulas tend to be more continuous. However, the applicability of these records for reconstructions of the palaeoenvironmental dynamics in other regions must be critically scrutinized if erroneous or over interpretive generalisations across broad areas are to be avoided, based on the pretext of using the most coherent data available.

Located in the Mediterranean province, the two lakes (Lago Grande and Lago Piccolo di Monticchio) set within the crater of the extinct Monte Vulture volcano were formed after an explosive eruption at least 132,000 years ago (Allen and Huntley 2000b). Lago Grande di Monticchio (LGdM) has been accumulating sediments continuously for at least 101,530 years and although it is not annually laminated throughout the whole sequence, it provides an unbroken catalogue recording events over the last 76.3 kyr with a very good mean sample resolution of 197 ± 157 years (Watts *et al.* 1996; Allen and Huntley 2000). LGdM also catalogues some of the more widely reported climate events such as the post-Eemian oscillations, including *some* oscillations which appear to be in close synchrony with the GISP2 DO fluctuations (Allen and Huntley 2000). It is also said to resolve the regional character of climate and vegetation over an area between 300 to 8000km^2 (Allen *et al.* 2000). Fig. 4.6 summarises the pollen assemblage zones from LGdM relevant to this discussion and their probable equivalents in other regions.

In two comprehensive papers by Braüer *et al.* (2000) and Watts *et al.* (2000) the post-Eemian and Middle Pleniglacial phases of the LGdM catalogue were considered and in a third paper (Allen *et al.* 2000) issues of chronology and correlation between LGdM and other European proxies were reviewed. For the purposes of this discussion the phases of interest are pollen assemblage zones (PAZ) 4 which ended at *ca.* 25.9 ka through to PAZ 19b which began at *ca.* 101.5 ka. The transition between PAZ 19b/a essentially corresponds with the Saint German I/Brørup interstadial, a phase which was strongly registered across the NP, CP and SP (see fig. 4.6). For the most part the post-Eemian (101,530 ka to 86,600 ka BP) MP saw dominantly closed deciduous forest biomes (Allen and Huntley 2000). The onset of PAZ 18 (*ca.* Melisey II/Rederstall stadial), a relatively short phase lasting some 2.4 kyr (86,600 ka to 84, 200 ka BP) heralded in the first major period of palaeoenvironmental disruption, which Braüer *et al.* (2000) reported as the most *sustained* period of climate instability between 100 ka and 73 ka. Several pollen sequences situated in the in MP show that steppic environments comprised principally of Chenopodiaceae with *Artemisia* and Gramineae prevailed at this time, while those situated further to the west such as Padul saw pollen of *Quercus ilex* throughout this phase. Lac du Bouchet at this time saw a tripartite palaeoenvironmental change, initially characterised by a greater persistence of *Picea* forest, followed by a distinct episode of *Artemisia* and finally by *Pinus*, *Betula* and *Juniperus* prior to the St. Germain II interstadial. Palaeoenvironmental complexity, change and restructuring were features of 'stable' interstadial phases, a fact that we saw previously where steppe and intermittent forest episodes were differentially expressed between the NP and CP. The Odderade/St. Germain II interstadial appears to be coeval with PAZ 17e-c at LGdM. This was an 8.8 kyr phase between 84, 200 ka and 75, 400 ka BP (Allen and Huntley 2000). PAZ 19 and 17a represent closed woodland comprised of *Quercus*, *Fagus* and *Ulnus*, while further to the west at Padul, herbaceous elements of Gramineae and *Artemisia* were interspersed with *Quercus* and *Pinus* attesting to open woodland. The latter half of the interstadial saw some considerable palaeoenvironmental changes as the *Picea* ecotone shifted further toward the south (Allen and Huntley 2000).

4.16 Mediterranean Province during the Early Pleniglacial

PAZ 17b was a short 700 year phase that saw mixed steppe emerge as the dominant biome at LGdM (Allen and Huntley 2000 table 4). This phase may correspond to the Shalkholz stadial observed in some northern European pollen records (fig. 4.8). This event probably coincides with the onset of the Middle Pleniglacial proper. It was followed by a considerable period of climatic and environmental improvement. Recognised as PAZ 17a in LGdM, a 2.7 kyr phase which probably corresponds with GRIP interstadial 20, and the early MIS 4 Ognon I warm phase (Watts *et al.* 2000). This amelioration led to the return of woody taxa at values between 50-60%. Presumably, it was the MP provided refugia for a variety of thermphilous flora and fauna which bore the brunt of palaeoenvironmental disturbance during such short ameliorations. But this is not to say that ecological disruption did not occur in other regions. As we have seen proxies at Füramoos (CP) and Les Echets (SP) also testify to some limited palaeoenvironmental disruption at this time. PAZ 16b saw a return to more open landscapes occurred during PAZ 16, a phase with high herb values (70-80%). From a more general perspective, the phase of time captured in PAZ 17b to 16 represent a series of millennial scale palaeoclimatic and palaeoenvironmental oscillations over a period of *ca.* 6 kyr. It is quite clear that the Mediterranean at this time was an increasingly unstable province, in ecological terms and thus does not immediately support the notion that Neanderthal populations retreating south at this time from the harsh Early Pleniglacial northern environments met environmental stability in lower latitudes of Europe. The late Early Pleniglacial saw a final period of amelioration (PAZ 15 69 ka-64.3 ka). This phase more than all others of the Early Pleniglacial appears to have been temporally and environmentally the most stable with some *ca.* 5 kyr of wooded steppe environments. Clearly PAZ 15 represents a relatively stable climate phase but it has no comparable equivalents in NP, CP or SP. PAZ 14 was characterised by a closed *Pinus* forest with some intermittent *Artemisia* and *Chenopodicaea* – indicative of drought, and not necessarily extreme cold. In conclusion, the MP was characterized by an interplay between closed and open environments with the disruption during PAZ 17b and 16 being particularly pronounced. PAZ 17a to PAZ 12 was similarly characterised by fluctuating wooded-steppe and steppe episodes often on centennial time scales (see below). PAZ 11 represents the strongest forest signature, yet this was weaker than PAZ 19 or PAZ 17. These oscillations represent definitive proof that ecological disruption and environmental change occurred prior to MIS 3 in the Mediterranean region.

4.17 Mediterranean Province during the Middle Pleniglacial

The early Middle Pleniglacial from 60.4 ka to 53.8 ka was characterised by 6.6 kyr of wooded steppe environments (PAZ 13c-a) which have correlates in several European pollen records e.g. Goulotte of La Grande Pile in France and the Oerel core from Germany (fig. 4.8). PAZ 12 saw a return to steppe with some intermittent wooded episodes over 3.8 kyr. Open steppe habitats again gave way to PAZ 11 characterised by a well-developed broadleaved deciduous taxa (>60% of the pollen count) between 50.0 kyr and 42.4 kyr. Indeed Allen and Huntley (2000) reported that PAZ 11 was the most fully forested phase of time between 77.6 ka and 25 ka. Despite the length of this interstadial, some 7.7 kyr, the continued background presence of *Artemisia* shows the dominant biome was probably open woodland, with *Artemisia* indicative of seasonal droughts as opposed to specifically low temperature. PAZ 11, GRIP interstadial 14, the Pile interstadial (La Grande Pile) and the Moorshoofd interstadial in south and north Europe may all be in close chronological proximity, testifying to a climate amelioration that influenced broad areas of western Europe. Palaeoclimatic amelioration, and by implication, palaeoenvironmental change was more significant in terms of the frequency and magnitude of change in the MP than either the SP or NP (*cf.* Allen and Huntley 2000; Klotz *et al.* 2004). In the latter regions, the Pile and Moorshoofd phases were not characterised by any real deciduous forest growth while the evidence for environmental change is less than that of the former regions. PAZ 10 through 5 was a 12kyr phase marked by alternating steppe and steppe-woodland. PAZ 10, 8 and 6 represent in total some 6.5 kyr of *Artemisia* steppe with negligible deciduous pollen values. Pollen zones 9, 7, 5a and 5b were saw rapid increases in deciduous (*Betula*/*Quercus*) pollen values to 60%. The *Betula*/*Quercus* signature was particularly strong in PAZ 9, a 2.4 kyr phase between 42.3 and 40.0 ka. This interstadial is widely recognised across the study areas (Fig. 4.8) and corresponds to interstadial event 12 of the GRIP ice core (Watts *et al.* 2000) and possibly the Hengelo (NP) and Charbonn (SP) interstadial. However, the evidence for broad inter-regional amelioration has been questioned by Allen and Huntley (2000) who reported that Tenaghi Philippon (Greece) shows 'fluctuating' *Pinus* values which cannot be convincingly correlated with PAZ 12. At best, it appears that the Hengelo/PAZ 12 saw the emergence of a predominantly wooded-steppe biome thus should not be regarded as unduly different from other phases such as PAZ 11, 13a and 13c. There seems to have been some interesting and considerable structural differences between the interstadial events, especially in the SP where it appears that limited deciduous woodland developed during the Hengelo with boreal forest development in more northern regions. It could be that non-climatic factors better account for the palaeoenvironmental differences reflected across the NP, SP and MP particularly in the case of Tenaghi Philippon and northern Europe which appear to have been characterized by similar ecological changes across the interstadials.

Allen and Huntley (2000) reported PAZ 5b as a 2.4 kyr phase characterised by *ca.* 50% woody taxa e.g. *Pinus*, *Juniperus*, *Quercus*, *Fagus* and *Abies*. It, along with the Grand Bois/Denekamp interstadials (SP and NP respectively) appears to have been the last major phase of environmental improvement until the post-glacial period. Again, environmental change seems to have been less substantial in the SP and NP pollen records which show that *Pinus* increased to no more than 45% during this phase while proxies in the NP show that *Betula*, *Pinus* and *Quercus* were present in far lower percentages.

The emerging picture is, then, that full temperate forests prevailed during PAZ 17c, 17e, 19a and 19b. Mixed temperate forests accompanied by herbs and grasses include PAZ 9, 11, 13, 15, 17a, as well as discreet episodes during PAZ 18, a phase most notable for its extreme oscillatory nature. These conform to three principal biomes: (i) forest, (ii) wooded-steppe and (iii) steppe (Allen *et al.* 2000). However in the same publication Allen *et al.* (2000) emphasised that these biomes were in themselves apparently highly heterogeneous at a lower scale of resolution e.g. PAZ 18 was comprised of both steppe and mixed forest type biomes. It also appears that the dominant tree taxa changed between one interstadial and another, as did the structural/floral composition from one stadial to another e.g. Chenopodiaceae may have been dominant at one time and *Artemisia* during another. In other words, no two stadials or interstadials were the same. This alternating pattern of woodland (*Quercus*) and steppe (*Artemisia*) is also mirrored in the western Mediterranean at Cueva Negra (Iberia) and Sima de las Palomas (Iberia). Carrion (2003) reported that deciduous biomes replaced open steppe palaeoenvironments rapidly in these regions supporting the idea that major thermophilous refugia were located in Iberia during the Middle and Upper Pleniglacial. Similarly, it appears that more northern regions of Iberia e.g. Abric Romani (NE Iberia) supported substantial boreal forests as high boreal pollen values of 40-60% characterised palaeoenvironments between 70 ka to 40 ka BP (Burjachs and Julia 1994). Similar evidence is seen in continental Iberia, where mesophilous taxa are recorded (Pons and Reille 1998). Deciduous refugia apparently persisted until the Late Glacial Maximum, e.g. Silas between 20 ka to 17 ka BP while pollen from hyena coprolites also show populations were well established at *ca.* 12,780 cal yr BP (Carrión *et al.* 2003). These data may contradict d'Errico & Sánchez Goñi (2003) who argue that the Mediterranean side of Spain was arid and open during most of the Middle/Late Pleniglacial.

Sánchez Goñi (2003) reported that pollen data from marine core MD95-2042 (37°48' N-10°10'W) shows a broad parallel with some observed changes at Lago Grande di Monticchio record between 50 to 30 kyr. Despite the fact that only the much larger oscillations can be reliably correlated to the GRIP or GISP2 records. Sánchez Goñi *et al.* (2003) follow Shackleton's (2002) assumption that all DO events, based solely on Greenland temperature changes drove palaeoenvironmental change. This may be a flawed assertion. As we have seen, it cannot be assumed DO warming/cooling etc always resulted in terrestrial responses over broad areas. It must also be stressed that the palaeoenvironmental response to 'minor' (DO) and 'major' (HE) palaeoclimatic events was very similar (Sánchez Goñi *et al.* 2003). Hence in the Mediterranean it may be unrealistic to assume specific events created increased stress on human populations based on stronger quantitative contrasts in the isotope trend.

There seems to be little doubt that the MP and to a lesser degree, the SP witnessed rapid environmental change during the Early and Middle Pleniglacial with one extreme event (PAZ 18) being particularly conspicuous in the post-Eemian. This suggests that rapid, oscillatory turnovers between open and closed environments were not in fact unique phenomena associated with MIS 3. Lago Grande di Monticchio shows that palaeoenvironmental changes increased in magnitude and frequency from the Early to the Middle Pleniglacial. However, some DO events interpreted as the so-called 'triggers' for these changes are asynchronous in time. Therefore *environmental instability* may not have followed closely on the shoulders of DO cycles it could be more parsimonious to view such changes as the result of the cumulative effects of several shifts in palaeoclimatic conditions.

4.18 Discussion

By the late Eemian it appears that forests in the higher latitudes of Europe (namely the NP and CP) had begun to diminish. While forests did by no means disappear, parts of the NP and northern SP were by now more open and environmentally heterogeneous (*cf.* Emontspohl 1995). The MP by contrast, was environmentally more homogenous. As the post-Eemian oscillations continued the NP and CP experienced greater levels of environmental variation and by implication more frequent ecological disruption than the adjacent SP and MP which at this time were still characterised by more fully-closed, ecologically stable forests. This was probably because the forests in the NP and CP were far more sensitive to periods of short-lived climatic improvement, resulting in multiple, well-expressed environmental changes throughout the course of the post-Eemian as open biomes were replaced by semi-closed boreal forest biomes and vice-versa. By the later stage of the post-Eemian oscillations, the northern forests had practically disappeared, by which time the Mediterranean forests (as shown by LGdM) were prone to disruption. But it was not until during the Early Pleniglacial that the Mediterranean forests were substantially reduced to refugia by which time steppic biomes became established with increasing frequency on the millennia that followed. Thus it required a longer process of attrition before the Mediterranean ecologies reached a dynamic from which the worsening Middle Pleniglacial conditions could initiate situations similar to those that occurred in the northern and central regions during the post-Eemian oscillations.

Episodic phases of amelioration during the late Early Pleniglacial but especially during the Middle Pleniglacial Dansgaard/Oeschger events were, in geological terms, relatively short-lived events. Thus it follows that any phase of climate amelioration would have resulted in the most significant environmental changes in those parts of the landscape which were suitably structured in ecological terms. Other regions, perhaps those which were more homogenous and open, or situated well-outside the influence of the refugia probably remained stable during short-lived phases of improvement. By contrast, other areas more proximal to refugia would have witnessed an overall change in existing ecological variables or the influx of new variables as a function of climatically mediated reorganisation. It is precisely these areas and these areas only which would have been more sensitive to the effects of rapid climate change such as DO events and Heinrich events which represent significant events in $\delta^{18}O$ proxies. In terms of geological time, the cooling associated with Heinrich events appears to have been far more rapid than Dansgaard-Oeschger cooling which is characterised by a gradual saw-toothed downstepping pattern in the $\delta^{18}O$ trace. Based on this pattern we can propose that Heinrich events may have exerted some of the greatest pressure on terrestrial ecologies during the Upper Pleistocene. This having been said, the single most important factor involved in the processual deterioration of closed forests into open biomes from the higher to lower latitudes was undoubtedly the overall cummulitative effect of glaciation across the Early Pleniglacial. Extreme, short-lived Heinrich events would have been insufficient in terms of magnitude and duration to completely homogeneise vast areas of Europe. Even the course of several IG-G cycles over the Pleistocene never totally extirpated Mediterranean refugia suggesting the cumulative stresses associated with progressive cooling were insufficient to homogenize these settings in contrast to the situation in the northern and central regions of Europe.

The idea that rapid palaeoclimatic and environmental change was unique to MIS 3 is wrong. The post-Eemian oscillations saw a range of disruption in the MP, SP and CP (Allen *et al.* 1999, 2000a, 2000b, Klotz *et al.* 2004). Some of these earlier Dansgaard/Oeschger-type fluctuations do not appear to have been recorded in the GRIP/GISP2 records, thereby enhancing what appears to be the 'uniqueness' of MIS 3 oscillatory climate. That oscillatory palaeoclimate and environments affected Europe prior to MIS 3 has clear implications for those models which envisage MIS 3 palaeoclimate changes as the dominant cause of demographic change and/or Neanderthal extinction in Europe. From an archaeologist's perspective, DO events are heavily implicated in cultural and demographic changes during the Late Pleistocene. For example Paul Mellars believes that the GRIP DO oscillations resulted in,

> "[temperature] drops to mid glacial or mid-interglacial values within a human lifetime'… it is inconceivable that ecological changes of this scale could have occurred without some very significant behavioural adaptations and demographic shifts amongst the contemporaneous human populations".
>
> (Mellars 1998:494)

While it is agreed that that the SP and MP saw some major environmental reorganisation during the Middle Pleniglacial, it remains uncertain that palaeotemperature changes inferred from GRIP/GISP2 data: (i) Were translated into real palaeoenvironmental changes in the NP and SP during the Middle Pleniglacial; (ii) That they resulted in high-frequency and high-magnitude palaeoenvironmental changes. One must attempt to gauge the tempo and timing of environmental change in order to measure the disruption potential on human habitats. In this respect, Allen *et al.* (2000) have provided some useful insights into the timescale of biome change. They have shown how a 20% increase between herb/tree pollen took place in a 142 yr section of the profile; a 30% change over the next 134 yrs and a 40% change over the next 107 yrs. These palaeoenvironmental changes, while agreeably considerable, insofar as they represented a 90% floral change in 383 yrs would have been unlikely to have disrupted habitats within the span of a human lifetime as Mellars (e.g. 1998) has argued.

Temperature, while important, is not the single controlling factor parameter involved in forest growth, expression and viability. Watts *et al.* (1990) reminded us that moisture and CO_2 were factors equally as important as temperature on the expression and equilibrium of forest conditions. Moisture deficiency could have been balanced by increased CO_2 however the low levels during the Weichselian (90 parts per million by volume (ppmv) suggest that temperature and moisture were the most important variables after all. Nevertheless, these factors must be born in mind. If moisture levels were sufficient it follows that stable forested palaeoenvironments could have been maintained throughout the DO cycles. Those areas with moisture deficiencies or variable moisture levels may have been characterised by mosaic landscapes as forests alternated with hardier herb communities. Assuming that temperate/boreal flora was by and large restricted Mediterranean refugia (e.g. Tzedakis 1997) temperate flora would have migrated in a radial manner during climatic amelioration, diffusing north at varying rates, no doubt influenced by topography etc. In contrast it can be hypothesised that palaeoenvironmental deterioration, for example during the post-Eemian warm phases did not lead to a unidirectional (southward) retreat of forests but rather a gradual *in situ* depletion. It was probably the intermediate environments which would have experienced significant palaeoenvironmental changes at the *sub-regional* scale as local-refugia expanded during the much more rapid short-lived periods of warming. Therefore environmental disruption was more pronounced during the upward limb of the DO events (forest radiation in the Mediterranean and in southern France) but perhaps less so on the downward limb (gradual retraction or limited changes in refugia). In contrast van Andel (1996) concluded that it was the downward limb of the DO event i.e. the cooling as the most significant in terms of environmental disruption. This raises implications for the popular contention that Neanderthals had no choice but to 'retreat' south into 'favourable' 'predictable' and temperate environments during the later Middle Pleniglacial. Humans moving into these Mediterranean and southern European refugia, ironically, did not *re-encounter* their *favoured* habitats but met instead potentially some of the most unstable configurations of the IG-G. I argue that the palaeoenvironmental reconstructions for the MP, particularly from MIS 4 to MIS 3 indicate that human populations experienced several phases of palaeoenvironmental instability. If the Neanderthals were 'driven' 'pushed' and 'marginalised' into 'less favourable' environments following the appearance of *H. sapiens sapiens* in Europe, then how much archaeology and over what time phases is required to demonstrate a successful adaptation? Does their apparent disappearance from these regions have an alternative explanation?

4.19 The post-Eemian oscillations: pre-MIS 3 climate instability in the Northern and Central Province

The first of the post-Eemian stadial/interstadial couplets was the Melisey I/St. Germain I. In quantitative terms, the Melisey I and St. Germain I phases are indeed 'distinct' climatic phases when based on the presence (or absence) of permafrost features (Melisey I) and boreal pollen (St. Germain I). However as we have seen, periglacial structures can occur during episodic, short-lived phases of cold thus they cannot be used to infer that temperatures were uniformly low on geologic timescales i.e. for the duration of the Melisey I. Similarly, low-values of boreal pollen do not necessarily mean that by implication steppe or tundra biomes prevailed. We have seen that boreal/deciduous forests remained well-established (Willis and van Andel 2004) across parts of northern and central Europe during the Middle Pleniglacial. So the idea that low tree pollen percentages in palynological sequences are indicative of extreme cold is probably an overly simplistic one. Certainly across both the Melisey I and St. Germain I any periods of cooling do not appear to have been severe enough to have completely extirpated the forest biomes of the higher latitudes. Therefore it seems reasonable to suggest that the Melisey I and St. Germain I shared some similarities at least in terms of floral (and faunal?) structure, variation and the frequency and magnitude of change. Palaeoenvironmental structure was highly variable across Europe during this phase. One can perhaps broadly summarise this first post-Eemian couplet as follows: the MP and parts of the SP saw dominantly *Quercus-Pinus* forests, closed broad-leaved forests prevailed in the northern parts of Italy and the CP, while boreal forests set in open parkland prevailed in the more eastern and northern parts of Europe. The key point is that ecotones between these biomes shifted on several occasions during and between the Melisey I and St. Germain I periods. For example Allen and Huntley (2000) have suggested that during the first half of St. Germain I the ecotone between the cool temperate broad-leaved and boreal forests was initially some 1000 km to the south of the present position but by the second half of St Germain I (*ca.* PAZ 19b at LGdM) the same ecotone shifted a further several hundred kilometres to the south. Hence this example illustrates a key point: palaeoenvironments appear to have been highly dynamic and subject to major reorganisation even during a supposed warm and stable stage – the St. Germain I interstadial.

By contrast the Melisey II probably marked the first real phase of major forest dissipation. However some forest remnants or refugia were still locally situated in favourable contexts within the NP and CP. Subsequent climatic improvement during Dansgaard/Oeschger fluctuations or 'interstadials' such as the St. Germain II caused some major intra-regional palaeoenvironmental changes as these local refugia waxed and waned. I suggest that these disruptions in the MP were analogous to MIS 3 disruptions because they resulted in clear ecological turnover and appear to have impacted on the cold-adapted flora and fauna which had probably begun to migrate and settle in the high northern and central European regions during the Melisey II. In qualitative terms a broad parallel exists between the post-Eemian oscillations and those of MIS 3. It is for these reasons that we can speak of the post-Eemian oscillations as the first phase of major, rapid environmental change of the last IG-G. By implication, we can infer that the Neanderthal lineage did not experience rapid climate change for the first time in MIS 3 and this theme will be explored in more detail in chapter 5.0.

MIS 5a-MIS 4 = Interstadial to Glacial transition
MIS 3 - MIS 2 = Interstadial to Glacial transition

By suggesting that there were some shared traits in ecological terms between the stadials and interstadials of the post-Eemian is not to say that high-latitude forest biomes were unaffected by the cumulative cooling as the Early Pleniglacial approached. Certainly by the time of the Melisey II, temperate flora across northern and central Europe had diminished in relation to the earlier St. Germain I and Melisey I. However amelioration during the St. Germain II was *still* sufficient to act on those temperate biomes (the Melisey II remnants) leading to palaeoenvironmental disruption at the inter-regional level. Evidence for this hypothesis is supported by an important paper by Klotz *et al.* (2004) who have shown that the Melisey I – St. Germain II phases were variable in environmental terms and anything but stable.

Henceforth we can proceed with the view that the *post-Eemian oscillations* appear to have been the first of two distinct phases of palaeoenvironmental disruption that occurred over the last IG-G (the second occurring during parts of MIS 3). During this first phase the NP, CP and probably parts of the SP experienced several major shifts in steppic and forest biomes and even these varied in their magnitude and frequency. Certainly, the emerging evidence suggests that a simple dual couplet of environmentally homogenous and climatically stable stadial-interstadials does not reflect the palaeoenvironmental reality over this phase. By the later stage of the post-Eemian oscillations the northern boreal forests had certainly reduced in extent, while refugia for more deciduous flora was probably restricted to parts of the SP and the MP. Nevertheless, open and expansive steppe palaeoenvironments did not really occur across northern and central Europe until the Early Pleniglacial at *ca.* 74 ka. The post-Eemian probably represents an important period in which to explore the demographic responses of the Neanderthals to rapid palaeoclimatic change prior to MIS 3.

4.20 MIS 3 climate instability: southern and Mediterranean provinces

The ecological disruptions envisaged for northern and central Europe during the post-Eemian oscillations did not lead to any significant periods of disruption on the same scale in the Mediterranean regions. This is because Mediterranean forests were well-established and not enduring as *refugia* as was the case in northern latitudes. Hence, the Mediterranean forests were largely stable in ecological terms and predictable components of the landscape. Perhaps the Mediterranean forests were inhibited from advancing into southern and northern regions because amelioration during the intra-Melisey I/St. Germain I/Melisey II/St. Germain II operated over insufficient lengths of time to promote forest advance. It was not until after the Early Pleniglacial that Mediterranean forest experienced sustained attrition and eventual contraction into refugia. By which point the Mediterranean ecologies reached a dynamic from which the worsening Middle Pleniglacial conditions could influence in a similar fashion to to the way that the post-Eemian oscillations had acted on northern and central European refugia (fig. 4.6)

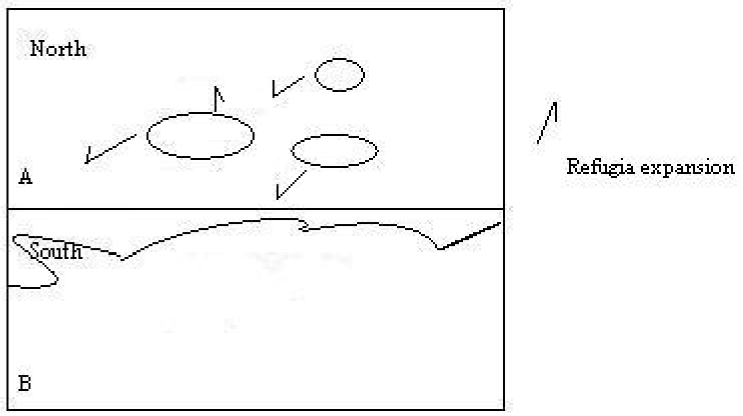


Figure 4.6 The Mediterranean Province during the Post-Eemian. Cartoon showing ecologically stable Mediterranean/southern region during Melisey 2 to St. Germain 2 (MIS 5b-MIS 5a) in contrast to heterogeneous northern/central provinces with pocket refugia. A: Northern and central European woodland 'waxed and waned' during the post-Eemian oscillations. B: This contrasts with more homogeneous, stable southern/Mediterranean regions.

There is some tantalizing evidence that environmental disruption may have even begun in the Mediterranean before the Early Pleniglacial, however. Allen *et al.* (1999, 2000a, 2000b) reported that by 75 ka environmental fluctuations with no GISP2/GRIP equivalent are observed at LGdM. These fluctuations represent, in a sense the result of cummulatitive stress, which had already significantly modified the northern and central European landscapes, and which had by 74 ka had percolated into the lower latitudes. Fig. 4.7 cartoons this process and illustrates the ecological disruption zones following periods of rapid and/or sustained warming (Dansgaard/Oeschger events) and relatively (temporally) shorter periods of cooling.

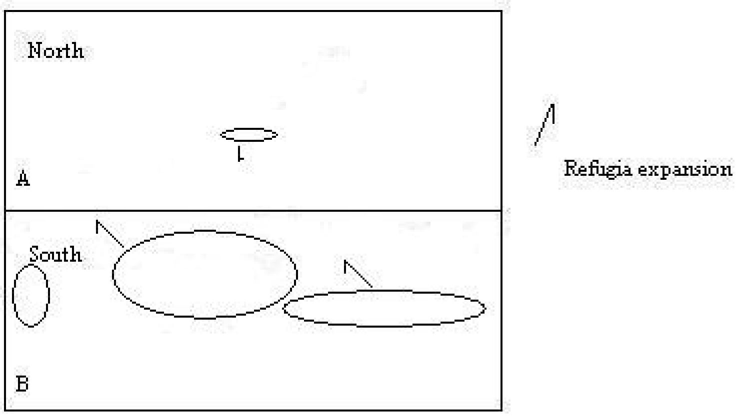


Figure 4.7 The Mediterranean Province during the Middle Pleniglacial. Cartoon showing post-70 ka ecological and environmental contrasts between northern and Mediterranean/southern Europe. A: Cryptic forest refugia were negligible across northern Europe so little qualitative or quantitative environmental changes occurred during climatic amelioration and deterioration. B: Cumulative climate changes during the Early/Middle Pleniglacial resulted in forest reduction. Southern and Mediterranean Europe was now characterised by forest refugia in the truest sense. Late Early Pleniglacial and Middle Pleniglacial Dansgaard/Oeschger events result in rapid forest expansion; cooling events and Heinrich events result in retreat.

It is argued here that two major phases of environmental disruption occurred during the IG-G. The first of which - the post-Eemian oscillations - had the greatest impact on the higher latitudes of Europe. The second phase resulted in the greatest level of disruption in the lower latitudes, specifically, the SP and MP. It was the rapid propagation of refugia which had the greatest impact on human behaviour and not necessarily extreme cold or open homogenous habitats. While open and cold settings were no doubt challenging in their own right and required a different (although not necessarily more sophisticated) adaptive strategy, they were by comparison with the temporal and spatial zones identified here, ecologically stable, and it is this fact which forms the main difference between the two habitats.

Chapter five will look more closely at how Neanderthal demography was arranged during the post-Eemian and MIS 3 phases. It will also examine Neanderthal demographic structure from the broad perspective of the IG-G and focus in on specific temporal periods and climate events in order to investigate the synchrony between human response to climate and/or environmental change.

Chapter 5 Neanderthal Population History

5.1 Introduction

That the Neanderthals were a rather distinctive looking human and the first member of the Genus *Homo* to have permanently settled in vast areas of Eurasia are points well known. That the Neanderthals appear to have occupied parts of Europe for an incredible amount of time (*ca.* 300 kyr) before disappearing prior to the last glacial maximum is a fact as remarkable as it sobering. How could these humans, so similar to us in so many ways, have seemingly faded away in the manner prescribed by some students of the Palaeolithic? Were the Neanderthals really specialized humans? Were they biologically constrained by a narrow range of climate zones and ecological circumstances? Did climate change really transform the Neanderthal habitats of necessity to such a degree that they simply had nowhere left to survive? Were the Neanderthals cognitively and/or biologically ill-suited to cope with the 'fundamentally' new situations as the course of the Middle Pleniglacial progressed? Are the socio-behavioural differences between the Neanderthals and Aurignacians (whoever the early Aurignacians were) really so significant that in the event of direct competition, the Neanderthal would have been excluded? These questions remain the subjects of current and ongoing research.

One of the most important gains in archaeology has been the application of science-based dating methods to archaeological materials. A chronometric framework can allow one to develop ideas, and in some cases, to make informed judgements regarding the questions of *when* and *were*. For the purposes of this study, the vast array of chronometric data collated by other workers has facilitated the work presented in this chapter, which in turn is directed toward some of the themes described above: specifically, what range of environments did the Neanderthals exploit and were they over specialized? This question necessarily precedes the test of one of the most interesting hypotheses put forward to account for Neanderthal extinction in recent years – that climate change killed-off the Neanderthals.

To approach this question further requires an understanding of how Neanderthal populations were structured in space and time, preferably viewed over the course of an IG-G cycle. It is of primary importance to gain this understanding of the broad demographic structure so that population adjustment, decline and growth can be contextualized. In this chapter I will continue to use the study province approach adopted in the previous chapter. Hopefully, with these regional climate and environmental reconstructions still fresh in mind, one will be better equipped to appreciate the range of environmental variation experienced by regional Neanderthal populations.

More finer-grained scale of analysis will center on the theme of Neanderthal response to rapid climate change and the ensuing environmental disruption. These specific phases are shown in table 5.1.

(Study Province)

	North	*Central*	*South*	*Mediterranean*
1	?127	?127	127	127
2	123	123	123	123
3	111	111	-	-
4	111	111	-	-
5	-	-	107	107
6	85-75	85-75	-	-
7	75-60	75-60	?75-60	?75-60
8	-	-	?75-30	?75-30

Table 5.8 Climate phases of interest (all dates ca. Ka BP). Key: 1: Saale/Eemian transition; 2: Eem optimum; 3: Eem downturn; 4: Eem termination (north/central Europe); 5: Eem termination (south/Mediterranean Europe); 6: Post-Eem oscillations (north/central Europe); 7: Glacial; 8: Weichselian rapid environmental change (south/Mediterranean). (- = NA)

The method adopted here and outlined below follows to an extent that taken by some recent publications which have taken a rather broad and novel approach to try and reconstruct the population history of a region during a given timeframe using radiocarbon determinations as proxies for prehistoric populations. These include Gamble *et al.* (2004) and Shennan and Edinborough (2006). These publications attempt to reconstruct the population events in Western Europe and the population events in Late Neolithic central and northern Europe respectively. The approach of Gamble *et al.* (2004) was to interrogate the S2AGES database, a collection of some 2000 calibrated determinations from the period 25-8 ka, and plot the frequency distributions of these determinations using the CalPal program (Weninger and Jöris 2000). Gamble e*t al.* (2004) recognised five 'population events' which they infer represent demic expansion and contraction within Iberia, northern Europe and France. Based on the GRIP chronology they argue that the first of the events was a *refugium* situated in Iberia between 25-19.5 ka where population levels were correspondingly low across the north of Europe and France. The situation at this time was quite different in Iberia which was characterised by a relatively smooth upward trend in the frequency of determinations. Iberia, principally the regions of Cantabria and Portugal, was recognised as,

> "The principal southern refuge for human populations in this region as shown by the more consistent numbers of radiocarbon determinations through time".
>
> (Gamble *et al.* 2004:247)

That the demographic structure of modern human populations in the late glacial appears to have some close parallels with the terminal Neanderthal populations is interesting because it points to Iberia as having been a glacial refugium in the truest sense for a range of fauna and flora. In this light the argument that the Neanderthals were forced into Iberia during a period of major crisis may be overstated. The second event referred to as the *initial demic expansion* took place between 19.5-16 ka. It is clearly represented as a steady increase in the radiocarbon dates in Iberia, however the increase in France coincides with a plateau in the Iberian data (Gamble *et al.* 2004: fig. 1). Interestingly, northern Europe does not witness any significant increase in the number of determinations at this time and only a marginal increase toward the termination of 'event 2'. Between 16-14 ka Gamble *et al.* (2004) recognised a third event the *main demic* *expansion*. They note that the archaeological model of major population expansion normally places it in the Bølling and Allerød interstadials. But the authors point out that this view is only possible if the Greenland ice core catalogues and the radiocarbon curve of archaeological settlement are not time-locked, leading to a discrepancy of some 700 years between the two proxies. To resolve this problem an alternative to the archaeological/time transgressive model is proposed which instead suggests that humans were extremely cold tolerant, and that they rapidly expanded during Heinrich event 1 - a period of massive ice surging and low sea surface temperature. This alternative view is based on the finding that the marine core MD95-2040 off the Portuguese coast indicates a good temporal agreement with GRIP, suggesting that modern humans were expanding during a period of extreme cold across much of Europe. A marked decline in population across Iberia, France and northern Europe occurred during population event 4, a 2kyr period between 14-12 ka which Gamble *et al.* (2004) refer to as *population stasis*. However on examining Fig. 1 we see that event 4 coincides not as much with stasis or plateau as a real decline in population across all regions. Gamble *et al.* (2004) recognise population event 5, *population contraction*, as coincident with the Younger Dryas. This was a 1.2 kyr period between 12.7-11.5 ka and saw a general decrease in sites across northern Europe, France and Iberia before site numbers increased again during the second half of the event particularly in northern Europe and France. Gamble *et al's* (2004) study concluded that population-scale expansion took place in a variety of different climate states (as inferred from the GRIP record) was less strongly linked to climate than contraction.

Gamble *et al.* went much further and claimed that this pattern of modern human settlement during cold climate reflected the underlying difference between the socio-behavioural responses of Neanderthals and modern humans. This is summarised as follows.

> "…the Neanderthal response to climate change was to continue in the southern refuges and wait for a widespread change in conditions before re-expansion occurred".
>
> (Gamble *et al.* 2004:251)

They go on to argue somewhat confusingly, that,

> "Dispersal is a search for those **normal** habitats that, once encountered, become **preferred**".

(Gamble *et al.* 2004:241 bold my emphasis)

Whatever a 'normal' habitat is remains poorly constrained and its use in the context of dispersal, which by its very nature conveys meanings of discovery and challenge, is somewhat paradoxical. They argue that, in line with the theme shown in fig. 4.8, that *"patches of rapidly developing preferred habitats"* (ibid.) were maintained, and that modern human social systems provided the adaptive basis to exploit these cryptic refugia which were intermittently scattered over the landscape via "saltation dispersal". In other words, modern society acted as the binds between habitats of choice located in an ever increasing matrix of less attractive resources. Neanderthals, it is claimed, lacked the ability to implement and co-ordinate such social threads: Neanderthals lived inside the mosaics.

The Archaeological Database

In order to expolore these themes of how Neanderthals responded to the vast spectrum of climatic and environmental changes discussed in chapter 4.0 it is necessary to spell out in more detail the methodological approach taken and the means and limitations of analysis both in terms of procedure and inherent in the data. A database of chronometric determinations from which both Neanderthal and early modern human presence in Europe could be inferred was complied. These were obtained from Stringer and Gamble (1993); Gamble (1999 table 5.2); Bocquet-Appel and Pierre Yves Demars (2000); d'Errico and Sánchez Goñi (2003) and the Stage 3 Project archaeological data base (2003). Many of these data were not relevant to the study regions either because they were not relevant to the four study provinces chosen, because data were redundant (i.e. featured in more than one source) or had undeterminable affiliation with Neanderthals. The data were housed on a Microsoft Access database (.dmb) and grouped accordingly into their northern, central, southern and Mediterranean provinces. The final dataset comprised of 787 determinations (521 of which were attributed to the Neanderthals by direct affiliation with Mousterian, or other Middle Palaeolithic archaeology). The remaining 266 determinations were attributed with modern humans again by way of affiliation the Aurignacian (early, ancient and Dufour, Aurignacian I to IV). They were obtained from a total of 304 western European archaeological sites extending over *ca.* 100 kyr between *ca.* 27 ka to *ca.* 126 ka. They were collated together using Microsoft Excel and are summarized in appendix A. Archeological determinations were aggregated into 10 kyr time periods so that a broad perspective in terms of population history could be obtained for the whole of the interglacial-glacial cycle. More specific phases (specifically Heinrich events and some D-O events) worthy of greater focus were subsequently identified and against which Neanderthal demographic trends were examined. The vast majority of radiocarbon determinations used in this study have been age-converted so that they are in closer synchronicity with the climatic and environmental records used in this study which themselves operate on calendrical time-scales. For further information on how dates were calibrated refer to van Andel *et al.* (2003a).

5.2 The use of ^{14}C determinations: limitations, caveats and assumptions

It is a fact that each individual ^{14}C datum interpreted in this study carries the implicit chance that it may be subject to revision at a later stage. This is to say that as new breakthroughs are made in the ^{14}C dating community, more finer-grained calibration may be made. Therefore the arguments put forward here are tentative and conclusions are working ones. New insights into the ^{14}C method and its limitations has led some researchers to state that the anomalous behaviour of the ^{14}C curve cannot be used alone to provide the required temporal framework to address the question of Neanderthal and modern human population movements in Europe (Fedele *et al.* 2008). This study, which at its heart seeks to shed light on Neanderthal biogeography, ideas of past human movement, and the speed, direction and tempo of such movement, is dependent first and foremost on a combination of chronometric dates determined from quite different archaeological contexts in space and time. The methods used to determine such dates are themselves subject to revision as the scientific methods by which the dates are obtained evolve (e.g. AMS ultrafiltration). A relative sea of data can no way obfuscate this reality. And the relatively large body of data used in this study can in no way be assumed to iron out or *smooth* outlier data and produce a confident reconstruction of human demography over the last climate cycle. I wholeheartedly acknowledge this and understand the broad biogeographic patterns that I set forth here, may be remodelled as each archaeological site is better understood and more rigorous and accurate methods are applied to the datable archaeological material in question. As in the case of the Stage 3 Project's historical science application of ^{14}C determinations, this study will follow a similar route. For the purposes of this study it is simply not feasible to examine each determination in question, critically testing its validity given the uncertainty among experts regarding the best way to calibrate the interval 25-45 ka BP (van Andel *et al.* 2003: 23).

Before I proceed with any presentation it is desirable to address some other methodological issues further and to make the reader aware of the limitations of chronometric data use here, and elsewhere.

Adler *et al* (2008) reminded us that researchers are too quick to accept all chronometric dates as of equal quality and reliability, and worse still, that there is a willingness to reject data that does not fit *a priori* assumptions. This is of course a pretty straightforward methodological consideration and one that I acknowledge, in an ideal situation, one I would have preferred to apply to all of the dates used in this study indicating *why* they were used, and the *limitations* of each datum. Adler *et al* (2008) have highlighted some key aspects relevant to all archaeological datable material. They are:

1. Stratigraphic and archaeological context: a sample must be in accord with the archaeological sequence. Taphonomic forces can severely distort the three-dimensional accuracy of small datable material.
2. Pretreatment and contamination: samples are discarded if they do not pass pretreatment criteria of each chronometric technique.
3. Accuracy and precision: samples are rejected if they are minimum estimates.

One must acknowledge, in view of the inherent problems and challenges associated with the accurate dating of archaeological material, and the lack of an *eligibility criteria* such as that touched on above, that the application of radiocarbon dating over the past 60 years has recreated a framework which is at best blurred, and at worst skewed to such a degree that our very models and frameworks for Upper Pleistocene human bio-cultural studies are inherently flawed. It is not unrealistic to say that many of the recent debates, none more so than the Neanderthal/modern human interaction question, could be artefacts of this unstable framework. Workers such as Higham *et al* (2009) acknowledge that reliable data must emerge from clear and systematic methodological practises including but not limited to e.g. pre-treatment method description etc. However these fit for purpose tests are rarely available for data obtained from sites excavated, studied and dated over the last several decades. And it is acknowledged here that much of the data used throughout this study may well fall into the category of the uncertain and the unreliable. Put simply, owing to the sheer number of determinations used here it has not been possible to examine the provinence and exactitude of each determination in question. Such an endeavour is beyond the scope of the thesis and clearly a project in its own right.

Higham *et al* (2009) in a review of the radiocarbon evidence in the SP and the 'MP/UP Transition' further remind us of some of the inherent methodological challenges associated with age determinations obtained across the Italian peninsula, challenges which are course implicit in and relevant to many other age determinations in other regions. They point out that there is a dearth of Mousterian/Uluzzian determinations and these are greatly by the available Aurignacian material. Owing to the wide standard errors they say that it is impossible to discuss with any confidence the possible relationships of these sites to one another, and equally improbable to infer the route by which the Aurignacian entered the region. Clearer understanding of the age of the Campanian Ignimbrite (CI) and its tephra distribution has shown that this event can be dated to 39.3 ka BP has offered some isochronic control on the region. In doing so it has further illuminated an uninspiring picture. Sites sequentially 'pre-dating' the CI are turning out to be much younger. Again, contamination by exogenous carbon is felt by the authors to be the main limiting factor associated with the Italian dates and elsewhere. With regard to age determinations taken from charcoal samples there have been some advancement in recent years in treatment procedures. For example, ABA (acid-base-acid) pre-treatment has been shown to remove carbonate and humic elements to an acceptable degree, however even this treatment is of questionable import for material approaching the radiocarbon limit (Chappell *et al* 1996 cited by Higham *et al* 2009). Further developments on pre-treatment protocol termed ABOx (acid-base-acid with a wet oxidation pre-treatment in an acid solution) has proved successful on AMS charcoal. Additional treatment in the form of stepped combustion (SC) improves the removal of contaminants prior to graphitisation. Higham *et al* (2009) have reported that samples pre-treated by ABA and ABOx-SC methods produce real differences in age – especially on samples pre-dating 25 ka BP – the latter method apparently being more rigorous in removing decontaminants and resulting in ages up to 5 kyr older than those obtained by ABA alone.

The need for further complimentary and exploratory work and revision of existing archaeological age determinations cannot be overstated. Fedele *et al* (2008) have reported how many radiocarbon ages of carbonized wood and charcoal fragments embedded in CI pyroclastic material range between 42-27 ^{14}C BP. This fact alone is not new.

Archaeologists have been aware for some time of anomalously young dates on material excavated from archaeological sites right across Europe both pre- and post-dating the CI event. Of course, greater understanding of the role played by variable solar activity coupled with episodes of reduced geomagnetic field strength have combined over the critical period in question to contribute to greater levels of cosmic radiation penetrating the earths atmosphere and being absorbed by life organic life forms on earth. It must be stressed here that many of the dates used in this study, especially those particular to the H4 phase which 'appear' to be coeval with the radiocarbon anomaly may well be significantly older, and even several kyr earlier in time than the critical climate change event (H4) analysed here. So it must be clearly stated here that the demographic reconstruction for this time phase is clearly a work in progress and preliminary.

Pettitt's (1999) publication serves as an important review of the statistical precision of radiocarbon dating at the earlier range of its efficacy. It discussed some of the problems, that is to say, assumptions behind how the dates are actually used. One longstanding issue which can seriously undermine any argument based around a chronological organising principle relates to whether ^{14}C dates are statistically meaningful. It is well known that ^{14}C dates are often far younger than dates obtained by other methods such as thermoluminescence. One of the principal reasons for this, besides contamination with younger residual carbon, is that for much of the Middle Pleniglacial, ^{14}C in the upper atmosphere appears to have been produced at different rates (van Andel *et al.* 2003 chapter 3) and may have at times been between 20%-40% higher than it is today (Pettitt 1999). Pettitt (1999) identified '^{14}C plateau' as perhaps the single most problematic aspect associated with the use of ^{14}C dates. This problem is particularly pronounced in during the phase of time most critical - the last 10 millennia or so of Neanderthal presence in Europe. Pettitt (1999) reported that speleothems dated by non ^{14}C with ages between 35 ka and 45 seem to cluster at the 30 ka date when dated by conventional ^{14}C methods. This leads Pettitt to concede a hard truth,

> "...plateaux will have severe effects on our reconstructions of Neanderthal extinction, and for this reason alone one must accept that dates in the 30-40 ka BP time period are provisional at best...the outlook is not bright".
>
> (Pettitt 1999:225)

As the Stage 3 Project emphasised, it is of critical importance to calibrate as accurately as possible ^{14}C dates in calendrical terms because all time-series displaying climate changes (such as the GISP2 ice core and the Lago Grande di Monticchio pollen sequence) are themselves calendrical time-series catalogues. Other methodological issues involved with the use of ^{14}C determinations as proxies for human occupation include the fact that erosional and preservational factors were not constant across all the study provinces. For example, higher latitudes bore the brunt of glacial activity which, amongst other things drastically remodelled river courses and landscape topography. These processes in all probability removed many open-air sites, while ameliorations may have caused some coastal sites to be lost as sea-levels rose. Therefore it is extremely unlikely that these dates offer anything more than a very-blurred insight into the demographic structure of Neanderthal and early modern human populations during the IG-G.

Ongoing procedural improvements such as more refined methods of pre-treatment and contaminant removal will obviously necessitate wholesale reviews not only of individual site data, but also the models and hypotheses of population movement, migration and settlement. It was profoundly beyond the scope of this thesis to investigate each and every chronological determination used in this study and develop a reliability index for each datum used, however I do anticipate that the coming years will see the development of a standardised radiocarbon database for Upper Pleistocene archaeological sites across Europe (see Jöris & Adler 2008), and that the application of such data, as set forth here, may be reviewed not insubstantially.

Associating culture with a single biological species: justifications and limitations for associating the EUP of the NP with the Neanderthals

As we have seen in chapter two, the dominant conception of recent years has been to attribute all Aurignacian and derivative Upper Palaeolithic industries as direct evidence for modern human authorship (e.g. Mellars 1999, 2006a, b). While direct and unequivocal associations between modern humans and the Aurignacian industry were (and are) essentially rare especially during the crucial phase when modern humans are purported to have first appeared in Europe at *ca.* 45 ka, the modern human/Aurignacian association is a working assumption at best and an established fact at worst. More recently, some workers have begun to seriously question the longstanding assumption of a strict modern human/Aurignacian relationship and in doing so shake one of the fundamental foundations of Palaeolithic research upon which several important explanations, models and modes of population change have rested (chapter 2.0). This having been said, for the purposes of this study I will proceed, albeit tentatively, along this methodological course and infer that Aurignacian and non-Aurignacian archaeology can be used to delineate modern human and Neanderthal populations respectively (unless of course stated otherwise). One exception to this rule and a point of departure from the Stage 3 Project is that I will attribute some of the Early Upper Palaeolithic sites situated in southern England (NP) to the Neanderthals and not to modern humans. The inclusion of several sites situated in the NP represents perhaps the most contentious use of data in this thesis. It is readily acknowledged that many of these dates are far from unequivocally reliable in terms of the wide ranging errors of margin, nor do they have any clear evidence of human fossils securably attribuitable with them. Other problems include the patchy distribution pattern of the sites themselves, and this combined with sparse numbers of determinations, or more numerous determinations from only a limited number of geographically discrete and closely situated locales, makes the problem of population reconstruction one of the most contentious issues in European prehistory.

If we maintain the widely held notion that modern humans were intrusive into Europe and that their mode of entry was broadly along the circum-Mediterranean (this premise not entirely unequivocal (e.g. Conard & Bolus 2008) then this leaves the issue of EUP industrial designation and authorship all the more critical to define. If indeed modern human entry into Europe did occur in the lower latitudes then the question of whether EUP industries in the higher latitudes (specifically here those localities of the NP) were the product of acculturation or independent design requires address. Upper Palaeolithic tool techniques such as prismatic blade production and tools such as burins and endscrapers associated with Middle Palaeolithic technological methods and tools such as Levallois and Mousterian scrapers is key in this respect.

It is not the intention to develop here a systematic review of the EUP localities situated in the NP and discussed herein. Such an attempt is beyond the ability of the author and the scope of this thesis. I will however turn to some of the evidence in support of the notion of a relatively deep time depth for Neanderthal occupation in the NP, and from this a tentative support of the view (suggested by others too) that Neanderthals may well have inhabited this province over the timeframe of interest (MIS 3 and earlier). One important site in this regard is the site of Pin Hole Cave (Creswell Crags) in the east Midlands, England. Jacobi *et al* (1997) reported that a Middle

Palaeolithic stone assemblage is bracketed by U-series dates on speleothem to c. 64 ka and radiocarbon dates on associated mammalian fauna to >40 ka, placing the assemblage at least somewhere within MIS 3. Several clearly pre-UP dates reported by Jacobi *et al* (1997) were deemed reliable, and consequently were used in this study. They are: OxA-4431 42.7±2.1 ka; OxA-4430 44.9±2.8 ka; OxA-3408 43.9±2.3 ka; OxA-3406 37.45±1050. These determinations are variously situated in post-H6 and H5 contexts. The authors see this data as well as other British Late Middle Palaeolithic and Early Upper Palaeolithic as significant, and perhaps all belonging to MIS 3:

> "…not only does the whole of the British early Upper Palaeolithic belong within this stage but also the last of the whole cold stage Middle Palaeolithic…and the site [Pin Hole Cave] is the more interesting for being at the very geographical limit of Old World Palaeolithic Settlement".
>
> (Jacobi et al. 1997:41)

Aldhouse-Green & Pettitt (1998) reported that that the earliest evidence at Paviland may date back to MIS 7, and that the earliest of the Upper Palaeolithic assemblages (leaf points) dated between ca. 38-27 ka b.p may in fact have been of Neanderthal manufacture. Dealing more generally with the more reliable evidence for Neanderthal occupation of the NP one can turn to the *'useful results'* (Aldhouse-Green & Pettitt 1998:763) of Cresswell Crags (OxA 3418 42.7±1600), (OxA 3417 37.2±1300) Hyaena Den 40,400k1600 b.p. (OxA-4782), 34,900+1450 b.p. (OxA-4113) and Coygan Cave 38,684+2713/-2024 b.p. (BM-499).

In the context of the Heinrich event analysis presented below, this would place Hyaena Den inhabitants (which were presumably Neanderthals) present during pre-H4 and during H5 and Coygan Cave inhabitants (also Neanderthals) present in post-H5.

With regard to the chronometric dates associated with the leaf points of the NP, they are more equivocal. Two such determinations (OxA 1620 and 5691) from bone found in close chronological association with a leaf point dates to 34,500+1400 b.p 32,500+1200 b.p respectively. This places the Neanderthal occupation in a pre-H4 context. However the authors stress that all dates associated with the leaf points are from unmodified bone and are associated with stratigraphically disturbed contexts, making the evidential worth of the material open to question. Nonetheless, the apparent pre-UP chronology of these dates, the typology and Neanderthal affinities, coupled with the clear evidence for earlier

Mousterian Neanderthal occupation at least provides enough material to form the basis for the hypothetical Neanderthal demographic patterns I set forth below.

Neanderthal Biogeography in Europe over the last climate cycle

We have more than three times the amount of chronometric dates from the Middle Pleniglacial than from any other period. In other words, some 72% of the dates used in this analysis fall within a temporal period corresponding to 25% of the last IG-G. This disparity is illustrated in fig. 5.1.

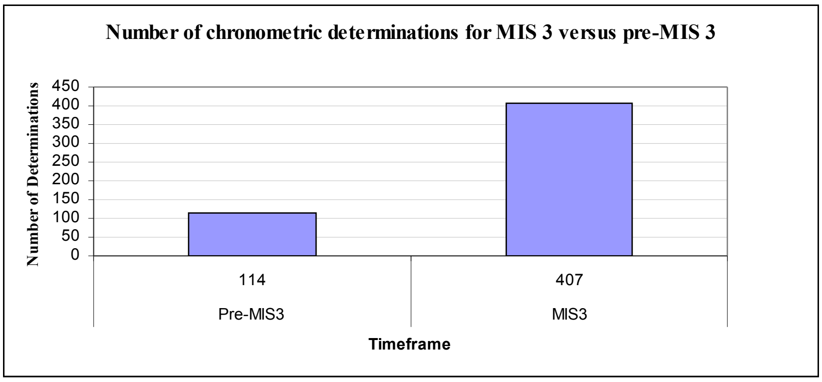


Figure 5.1 Pre-MIS 3 and MIS 3 absolute dates

Clearly, then, our understanding of Neanderthal response to climate change over the course of an IG-G cycle to must remain, until more data are available, coarse at best.

The greater number of dated sites during the Middle Pleniglacial can be explained by the fact that the radiocarbon method can be far more effectively applied to this timeframe than in earlier periods. Fig. 5.2 shows the number of dates per marine isotope stage used in this analysis.

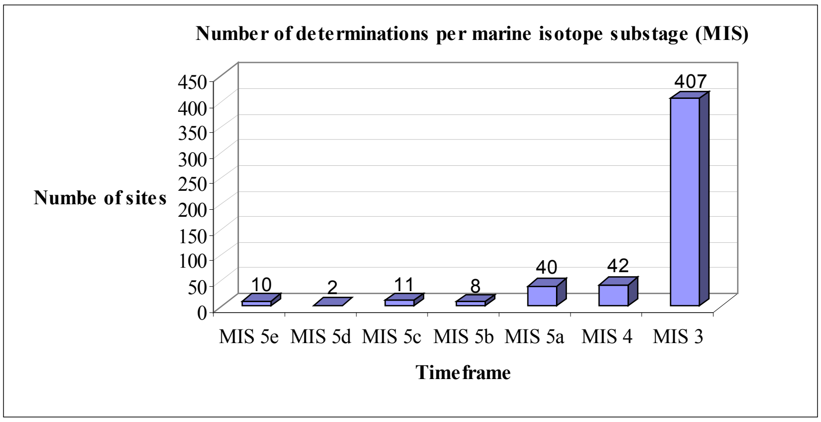


Figure 5.2 Determinations per Marine Stage

Archaeologists are also faced with the further problem of delineating those sites which were more frequently occupied from those which happen to have more material that falls within the remit of the radiocarbon method. Some later sites may have multiple dates leading one (perhaps erroneously) to infer longer periods of occupation, while older sites at the fringe or outside the scope of the radiocarbon method may well have been occupied more consistently, but a deficit in available determinations would obviously indicate sporadic or opportunistic occupation. A related issue is how to interpret sites that have several closely related dates in time and untangling whether these are the result of more long-term or short-term occupation. Several dates that span several thousand years may reflect either scenario. It seems difficult to untangle which explanation is preferable owing to the error margins associated with many chronometric dates, and this is even more of a problem with dates at two sigma. Other methodological issues associated with the use of radiometric data include the following. Firstly, dates that are derived from bone samples are more susceptible to contamination with modern carbon than samples of charcoal for example. A sample that has a real age of 45 ka would be reduced to 35 ka with only a 1% addition of modern carbon. This problem is exemplified by charcoal and bone data recovered from the same layer at L'Arbreda, which date to *ca.* 39 ka and *ca.* 35 ka respectively (Zilhão and d'Errico 1999). The fact that most conventional ^{14}C dated Mousterian archaeology was not pre-treated to remove contamination adds further complications to hypotheses relating to the issue of population responses to palaeoclimatic changes during the Late Pleistocene, and also has major implications for the veracity of claims of Neanderthal and modern human contemporaneity.

The radiocarbon dates taken from the Stage 3 Project Archaeological database were converted from radiocarbon years to calendrical years in order to allow meaningful comparison with climate change proxies such as GRIP/GISP2 which are all in calendrical years. These dates were converted using the CalPal program and for a more detailed review of this method I refer the reader to that which is described by van Andel *et al.* (2003 chapter 3).

In this study the first part of this analysis will examine the nature of demographic patterning across the four study provinces over the course of the IG-G. Because many archaeological dates are associated with large uncertainties, particularly those during the first half of the IG-G cycle, the archaeological dates were grouped into 10 kyr time slices. While it is agreed that 10 kyr is rather course, this does at least provide a useful first-order perspective from which to obtain an understanding of Neanderthal demographic structure in time and space across the IG-G.

5.3 Neanderthal distribution across the Northern, Central, Southern and Mediterranean Provinces

Fig. 5.3 shows the distribution of dated Neanderthal archaeology and fossil remains per study province across the IG-G cycle. It is clear that the southern and Mediterranean provinces display a far stronger concentration of determinations than the northern and central study provinces. However as we have seen, this may be an artefact which owes more to the higher numbers of determinations pertaining to MIS 3, than a reflection of a systematic geographic preference or limitation on the part of the Neanderthals.

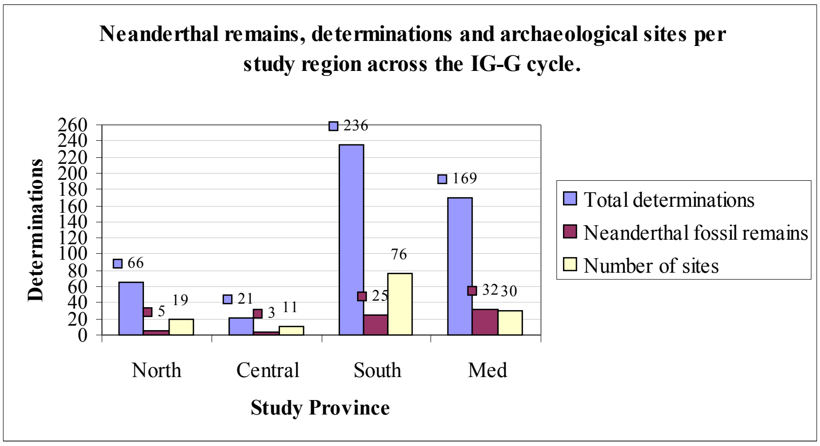


Figure 5.3 Neanderthal fossils, sites and determinations per Province

5.4 Northern Province: general trends

Neanderthal presence in the NP throughout the course of the IG-G is shown in fig. 5.4. Dated archaeology is sparse, but two occupied sites corresponding to the pre-Weichselian: (Weimar and Ehringsdorf) can be identified.

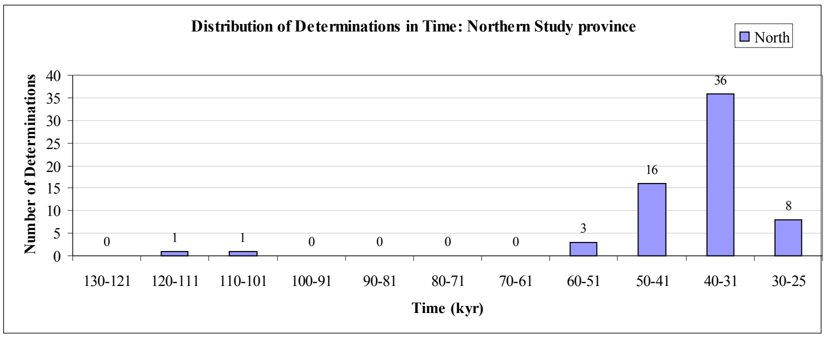


Figure 5.4 Determinations in the Northern Province

Not until the earlier stages of the Middle Pleniglacial (with an increase in the number of dates between (47 ka to 42 ka) do we begin to see more consistent levels of occupation e.g. Pin Hole Cave (UK). Several other sites in the British Isles such as Kent's Cavern, Hyena Den and Ash Tree Cave attest to a more visible level of occupation at the extreme edge of *Homo's* northern range. The period between 31 ka to 39 ka witnessed relatively consistent occupation of the southern boundary of the British Isles e.g. Picken's Hole, Layer 3; Paviland Cave, Hyaena Den, Pin Hole Cave, Bench Quarry cavern and Coygan Cave all attest to a considerable, presumably Neanderthal presence. These dates precede, fall within and follow the Hengelo interstadial (*ca.* 38 ka) a phase which saw MST of 9.5°C to 11.5°C in England and Holland, values which seem to have been comparable with the earlier Hasselo stadial at *ca.* 40 ka (Huijzer *et al.* 1998). During periods of climate downturn it is certainly probable that the Neanderthals in these regions would have experienced incipient periglacial conditions with MAT dropping between -1°C and -4°C, and MWT between -31°C and -16°C (*Ibid.*). Owing to the essentially short-lived nature of the climate amelioration, the Neanderthal inhabitants of the NP probably continued to exploit stable but more open environments because warming was insufficient duration and magnitude to instigate re-forestation from any central European forest refugia. A series of dates from Paviland Cave, Trou de l'Abime, Couvin (Belgium) and Schnurenloch (Switzerland) fall between 27 ka and 30 ka. This smaller dataset may reflect the general trend across all provinces of a decline in Neanderthal culture at *ca.* 30 ka. Yet it is also true that periglacial and preservation biases may also account for this "decline" in Neanderthal presence.

5.5 Central Province: general trends

Neanderthal presence in the CP throughout the course of the IG-G is shown in fig. 5.5.

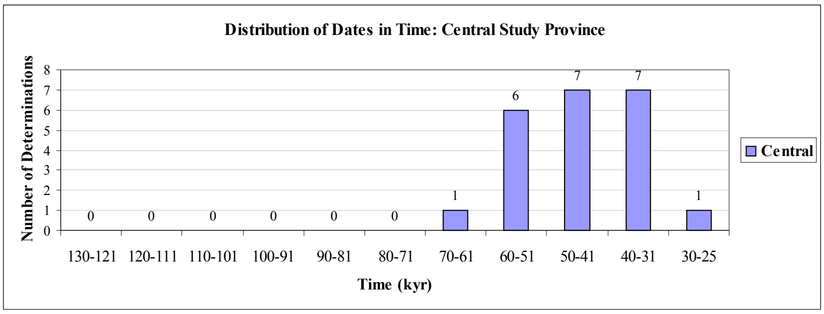


Figure 5.5 Determinations in the Central Province

On the strength of these data it appears that Neanderthals were absent until *ca.* 70 ka (e.g. Salzgitter-Lebenstedt, East Germany). Neanderthal presence becomes more conspicuous by *ca.* 58 ka at Konigsaue, with several sites e.g. Trou de l'Abime, Couvin, Sesselfelsgrotte, Sclayn Cave, Konigsaue and Das Geissenklosterle indicative of a regional presence across Belgium and Germany to *ca.* 52 ka. Several other sites e.g. Das Geissenklosterle; Salzofenhohle; Sesselfelsgrotte; Sclayn Cave; Feldhofer Cave and Trou Al'Wesse attest to Neanderthal presence in areas which probably experienced the vacillating Bellamont (1, 2 & 3) interstadials and the stadials (E & F) as recorded in the Füramoos sedimentary record. These palaeoenvironmental changes were recorded as a series of alternating *Betula albus* steppe/tundra episodes. Bellamont 1 and 2 have been dated by AMS ^{14}C to 51,300±2,400/1,800 yr BP and 43,930±930/830 yr BP which would place the Neanderthal occupied sites of Das Geissenklosterle (level IV) and Sclayn Cave (1A) closely in time and space with these disruptions. Neanderthals certainly seem to have been present in these environmentally unstable regions of Germany and Belgium up until *ca.* 32 ka. These data along with the evidence for flexible subsistence practises presented earlier in chapter 3.8, suggest that some Neanderthals had by now developed coping strategies to deal with ecological fluctuations in those climatically sensitive environments adjacent to regional faunal and/or floral refugia.

5.6 Southern Province: general trends

Neanderthal presence in the SP throughout the course of the IG-G is shown in fig. 5.6. France seems to have provided Neanderthal populations opportunities to maintain a significant demographic presence throughout the Eemian interglacial, with La Chaise, Abri Vaufrey and Combe Grenal all apparently occupied during this time. Interestingly La Chaise has provided four Neanderthal specimens dating between *ca.* 126 ka to *ca.* 113 ka.

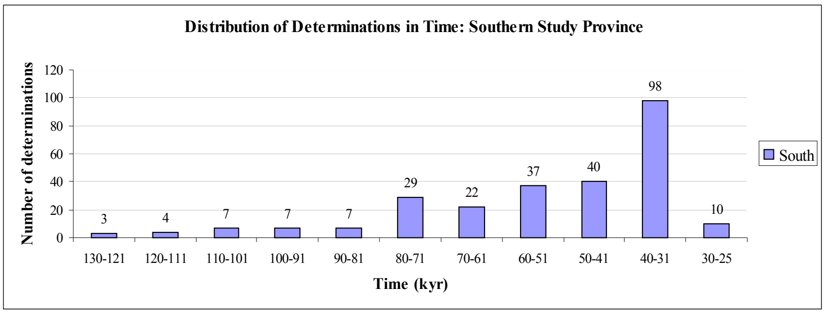


Figure 5.6 Determinations in the Southern Province

It is clear that many of these sites may not correspond to the Eemian owing to large standard deviations associated with the determinations; indeed authoritative claims can only be made where diagnostic pollen or mammalian data are in unaltered and reliable stratigraphic proximity. Fig. 5.7 displays the available data within one standard deviation of the Saalian/Eemian transition.

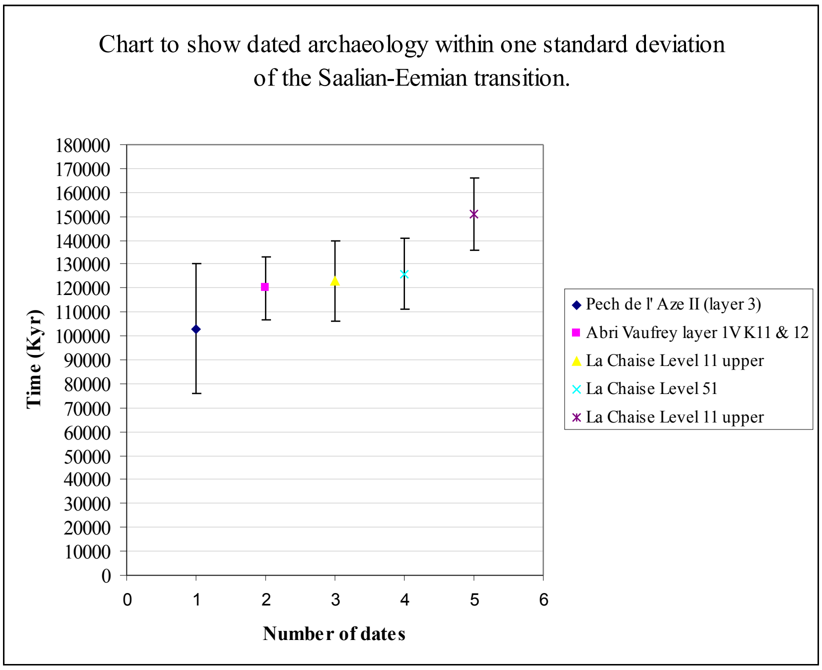


Figure 5.7 La Chaise, Level 51 (Laville et al., 1986); La Chaise level 11 (Laville et al., 1986); Abri Vaufrey layer 1V K11 & 12 (Huxtable, 1998); La Chaise Level 11 upper (Laville et al., 1986) Pech de l' Aze II 3 (Laville et al., 1986) (All dates after Stringer and Gamble, 1993).

Several sites e.g. La Chaise, Abri Pie-Lombard, Combe Grenal, Seclin, Pech de l' Aze II, Moscerini, Grotte Vaufrey, El Castillo, Montagne de Girault, La Salpetriere, Abri Laborde, Gr. Guattari and Les Canalettes indicate a strong Neanderthal presence was maintained throughout the post-Eemian fluctuations between *ca*. 93 ka to *ca*. 71 ka. Pech de l' Aze II in particular saw sustained occupation between 71 ka to 80 ka. During chapter 4.19 and 4.20 I hypothesised that the northern regions and parts of northern and central France saw severe ecological upheaval particularly during the early post-Eemian fluctuations (*ca*. MIS 5b and MIS 5a) and that Neanderthal presence during these earlier oscillations should caution against accepting notions that Neanderthals lacked the adaptive flexibility to survive environmental change. I am mindful that Pech de l' Aze II represents 19 of the 25 archaeological sites in the southern study region between 71 ka to 80 ka. This strong concentration of dates from a single site may also point to the existence of local ecological settings which were favourable to the existence of a discrete population. The essential idea put forward here is that the post-Eemian fluctuations were disruptive, and this may be reflected by the dearth of archaeological evidence in the NP and CP over this 10 kyr timeframe (assuming taphonomic factors have not distorted the destroyed the archaeological record). Ironically, conditions may have actually improved for Eurasian populations with the onset of the Early Pleniglacial in parts of France, where the archaeological record indicates a broader Neanderthal distribution. Sites including La Chaise, Pech de l'Aze II, Brugas, Aldene, Pied Lombard Cave and Tourrettes-sur-Loup all demonstrate a degree of continuity through the Early Pleniglacial probably because conditions were palaeoclimatically and environmentally more stable than the preceding post-Eemian oscillations. This pattern continues well into the early Middle Pleniglacial with Pech de l'Aze II again providing a consistent archaeological record over this 10 kyr phase. There appears to have been a much broader Neanderthal presence during the 50-41 kyr phase. This is attested by sites which include: Le Moustier, Fonseigner, Pech de l'Aze II, La Chapelle-aux-Saints, Neron, Abri du Ranc de l'Arc, Grotte du Renne, Arcy-sur-Cure, Combe Grenal, Roc de Combe, Barbas III, Combe Sauniere and St.-Cesaire. A stronger more regionally consistent increase in Neanderthal occupation in the southern province also occurred between 40-31 kyr, and this can be inferred from sites which include: Caune de Belvis, La Quina, Camiac-et-St-Denis, Grande Grotte de Bize, Les Cottes, A. Moula, Jaurens, A. Dubalen, Brassempouy, Perte de Bramarie, Sirejol, La Ferrassie, Les Rivaux, A. Sabourin, Sirejol, Vergisson, La Falaise, Les Pecheurs and Esquicho-Grapaou.

The evidence for Neanderthal settlement during the Saalian/Eemian transition is poor and is summarized in fig. 5.8. Only one site, La Chaise, level 51 (France) with its associated remains attests to a Neanderthal presence during the transition. But even this date (126±15 ka BP) has a generous standard deviation so any assertions that Neanderthals were present or absent in the NP and SP during major climate transitions must remain tenuous at best until more evidence is at hand.

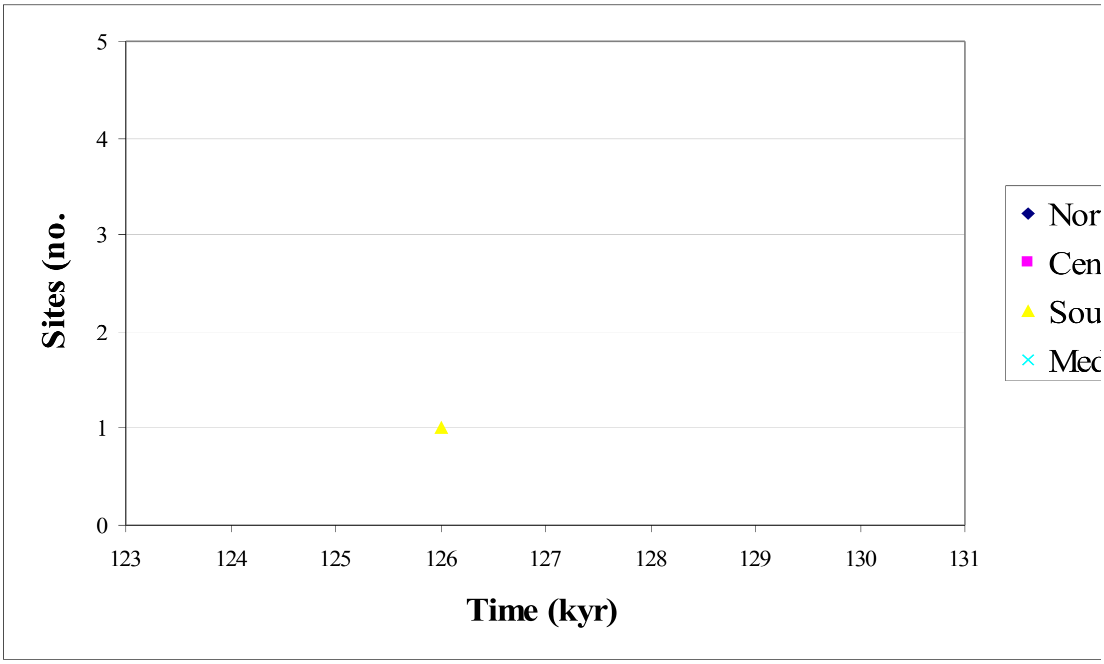


Figure 5.8 Neanderthal presence at the Saale/Eemian transition

5.7 Mediterranean Province: general trends

Neanderthal presence in the MP throughout the course of the IG-G is shown in fig. 5.9.

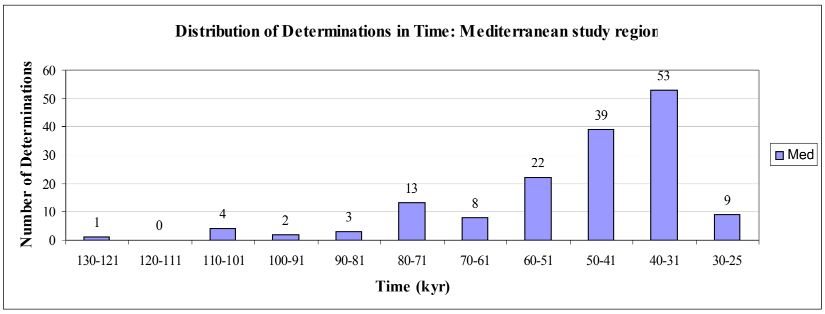


Figure 5.9 Determinations in the Southern Province

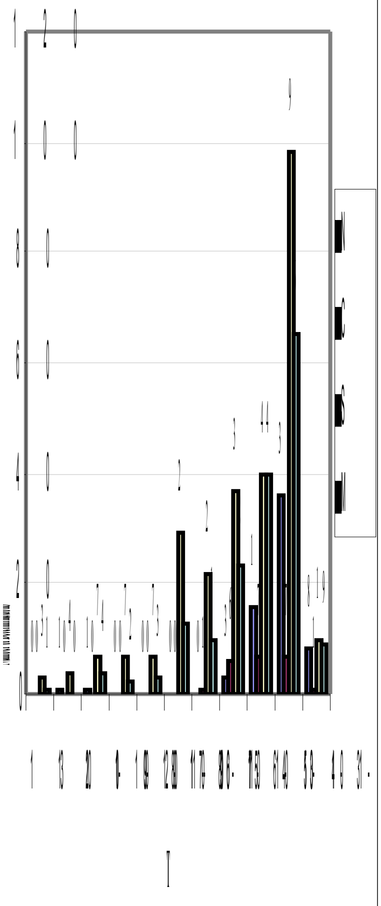
During the Eemian and post-Eemian oscillations, the Neanderthals, as far as these data show, do not appear to have been present in any significant numbers. As we have seen in chapter 4, this province was essentially stable in ecological terms and was probably characterised by fully closed forests. Only limited data e.g. Cova de Bolomor (level 2) date to within the Eemian, while several others e.g. Asprochaliko (level 18), Caverna delle

Fate, Gr. Del Principe E and Furninha (3rd ossiferous layer) have standard deviation which places these data theoretically within that timeframe.

A similar pattern of local occupation seems to have been maintained during the post-Eemian oscillations. However, as chapter 4 has shown, the MP did not witness 'oscillations' in the same sense as the NP and CP clearly did, and remained largely stable in ecological terms until the late post-Eemian and Middle Pleniglacial. Only a handful of sites are attributable to the post-Eemian-pre-Weichselian phase. These are: Caverna delle Fate, Grotte del Principe, Furninha, Gotte dei Moscerini, Grotte Guattari, Conceicao and Canale delle Acque Alte. In summary the MP during the post-Eemian is an unusual and interesting phase of time. Perhaps the MP maintained 'optimum' interglacial conditions longer than other regions making this area more problematical for colonisation.

After comparing figs. 5.6 and 5.9 (SP and MP) we see that there is a gross structural similarity in terms of the settlement history between the two provinces and that it is not until the late post-Eemian and early Weichselian that we observe some moderate levels of population increase and/or demographic expansion as inferred from the dated archaeology. It is worth restating again that parts of the SP were characterised by more fully-closed habitats during this time and thus were largely unaffected by the post-Eemian oscillations. One could conclude that the relative absence of Neanderthals during this period may support the idea that they were unsuited to fully-closed interglacial forests. Similarly, Neanderthal settlement in the NP and CP seems to have been limited. However in this case I argue that this purported absence was the result of a combination of ecological disruption as boreal forests dissipated into steppe-tundra, reflecting an altogether colder and more continental climate in these higher latitudes. It is envisaged that the magnitude of the post-Eemian oscillations which foreshadowed the MIS 3 oscillations was greater principally because of continentality. It was not until the Weichselian forced the retreat of the forests into refugia that the NP and CP began to witness more stability, while conversely, the MP forests began to diminish as the Weichselian approached. The idea that Neanderthals had by now moved into the MP during these earlier disruptions may be supported by data from two sites dated to *ca*. 82 ka: Caverna delle Fate and Grotte del Principe. These sites may be tentatively placed within what Allen *et al.* (1999) recognised as probably the most sustained period of climate instability of the pre-Weichselian. During this phase, much of central Europe and parts of France were characterised by treeless steppe, while Italy and Greece witnessed sparse montaine forests alternating with episodes of herb and shrub landscapes. This shows that some Neanderthal populations were capable of facing extreme ecological contrasts over geologically short time-frames. Indeed it appears that further episodes of pre-MIS 3 climate instability disrupted the environments of the MP between *ca.* 75 ka to *ca.* 60 ka. Sites including Grotte del Principe, Conceicao, Grotte dei Moscerini, Canale delle Acque Alte, Castillo, Oliveira Cave (Almonda cave system), Grotte Guattari, Vilas Ruivas and Vanguard Cave all date within this period which witnessed at least 8 kyr of millennial and centennial scale palaeoenvironmental oscillations (fig. 4.5 PAZ 17b to 14). This pattern of a stronger Neanderthal presence against a backdrop of alternating woodland and steppe episodes appears to have continued across the Middle Pleniglacial. For instance a distinct phase of Neanderthal occupation between 42.4 ka and 40.0 ka (PAZ 9) is attested by several archaeological sites: Cova Beneito, Castelcivita, Cueva Morin, Gr. di Sant'Agostino, Oliveira Cave, Cueva Millan, Ermitons Cave, Caverna delle Fate and Gr. Romanelli. These sites are temporally close to the Hengelo interstadial (GRIP IS 12), which appears to have been a palaeoclimatic amelioration recorded in several climate records throughout Europe. These data show, albeit tentatively, that some Neanderthal populations were successfully adapting to these regions which experienced severe ecological disruptions. Moreover, this increase in Neanderthal presence began in the early Middle Pleniglacial (from *ca.* 50 ka) and was expressed across broad areas of the Mediterranean (Spain, Portugal and Italy). These data do not necessarily support the notions that Neanderthals were 'forced' into temperate regions due to competition, or because of the uninhabitable, cold higher latitudes, and then subsequently underwent population fragmentation. Rather these data indicate that the period *ca.* 40 to 31 ka witnessed perhaps the greatest Neanderthal population levels across the northern, central, southern and Mediterranean provinces (see fig. 5.10), hardly a suitable starting position from which to infer a rapid Europe-wide population crash over the next 10 kyr, during climate and environmental oscillations that were actually habitually managed by Neanderthal populations since the post-Eemian oscillations. Thus we have a situation where increasing ecological disruption in the MP appears to have occurred broadly co-incident with increasing numbers of Neanderthal sites over broader areas of the MP (e.g. Spain, Portugal and Italy). Because Neanderthal populations were largely absent in the MP during the Eemian and post-Eemian oscillations, one can propose that their migration and settlement of the lower latitudes was only made possible as more exploitable habitats opened up. The data between *ca.* 50 ka and *ca.* 31 ka all point to *increasing* Neanderthal presence (see fig. 5.9) in a region which was experiencing *increasingly* more frequent ecological disruptions as woodland episodes alternated with grasslands on millennial timescales. This is a vastly different settlement history to the pattern which prevailed in higher latitudes during the post-Eemian oscillations.

F i g . 5 . 1 0 S



5.8 Eemian Interglacial: general trends

Neanderthal presence in the Eemian is summarized in fig. 5.11. There are several sites situated in the SP (France) that can be placed within the Eemian interglacial and these include: La Chaise, Level 51; La Chaise, Level 11 upper; Abri Vaufrey layer 1V K11 & 12; La Chaise 7; Combe Grenal 60 and Abri Pie-Lombard. Further north, at Taubach and Weimar (Germany), Uranium-series dating combined with faunal and floral proxies in conjunction with flint tools and human teeth can be attributed to the Eemian (Henning *et al.* 1983). Flint tools associated with thermophilous mollusc species from Burgtonna show that Neanderthals were present in the Eemian thermal optimum (Roebroeks *et al.* 1992). Lake sediments of Eemian age at Lehringen provided a yew spear, while flint tools associated with *E. antiquus* remains (Conard and Niven 2001). Gröbern has provided what appeared to be scavenged *E. antiquus* remains and flint tools from a setting corresponding to the Eemian thermal optimum (Roebroeks *et al.* 1992). Several other Saalian-carved basins across northern and western Germany indicate human presence in the form of stone tools associated with full interglacial flora (e.g. oak). These include Rabutz, Grabschutz, Veltheim and Neumark-Nord (ibid.). These data lead Roebroeks *et al.* (1992) to explicitly reject Gamble's claims (e.g. 1986) that humans prior to the Holocene lacked the capabilities to colonize interglacial forests, or that they lacked, in Whallon's (1989) lexicon *displacement* - that is the capacity to reference past and future actions such as seasonal hunting, and the association of distinct areas of the landscape with specific tasks or meanings within the conceptual framework of time.

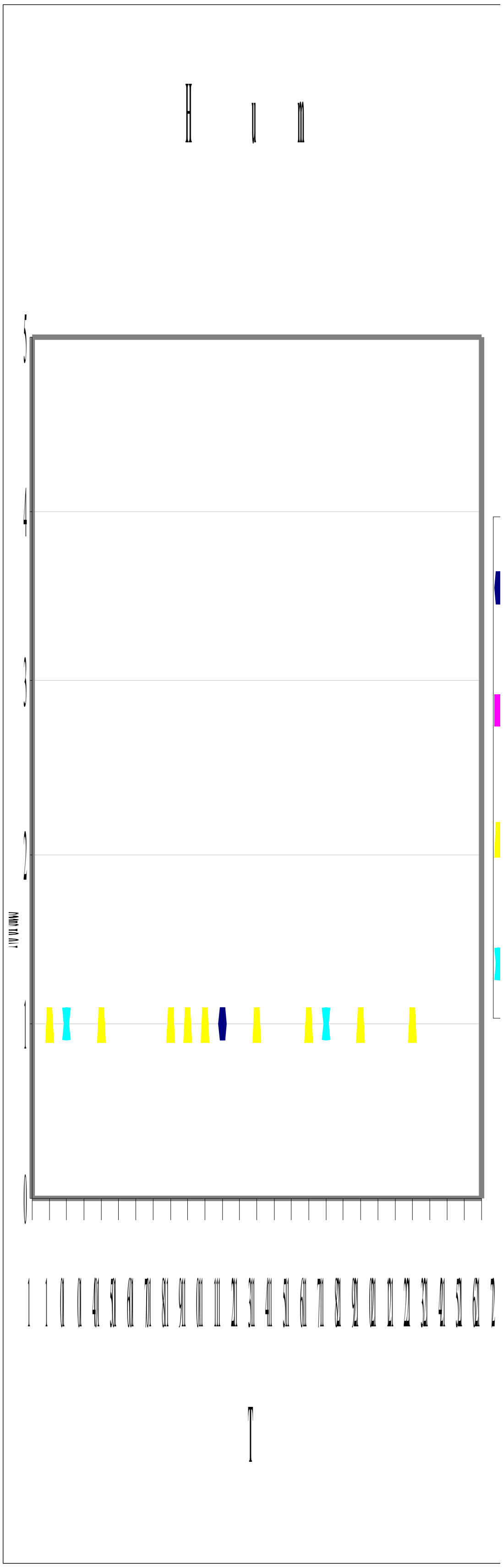


Figure 5.11

As discussed above, it was hypothesised that the much lower levels of Neanderthal presence in the northern and southern provinces during the post-Eemian oscillations may have been a function of palaeoenvironmental changes as the Eemian forests waned and remnant forest became established as refugia. In other words, a major environmental reorganisation occurred as predominantly boreal forest gave way into tundra, steppe-tundra biomes. In contrast, there was some limited human presence during the post-Eemian oscillations in the more stable southern and Mediterranean provinces (fig. 5.12). The sites of Abri Pie-Lombard and Combe Grenal in the south, along with Moscerini 3, stratum 33 in the Mediterranean show Neanderthal presence was probably facilitated by much lower-levels of condition-resource change. It is clear that not all Neanderthal populations responded in the same way, and indeed some seem to have coped well with ecological disruption and change. One of the first major phases of disruption associated with the post-Eemian was probably experienced by the inhabitants of Combe Grenal, who seem to have been present during the particularly severe episodes of climatic and environmental deterioration at *ca.* 105 ka (recorded in La Grande Pile as the Woillard event). Indeed, a severe climatic downturn seems to have affected broad areas of France between *ca.* 111-107 kyr, where *Picea-Abies-Carpinus* forests gave way to boreal taiga. Neanderthals witnessed these harsh changes, as evidenced by La Chaise, level 11 upper; Abri Pie-Lombard; Combe Grenal 60; Seclin, 7 and Pech de l' Aze II, 3.

5.9 Neanderthals during the Post-Eemian Oscillations

Using the available chronometric data alone it would appear that Neanderthal presence during the Eemian-Melisey I transition was low or non-existent across northern and central Europe and minimal in the southern and Mediterranean study regions (fig. 5.12).

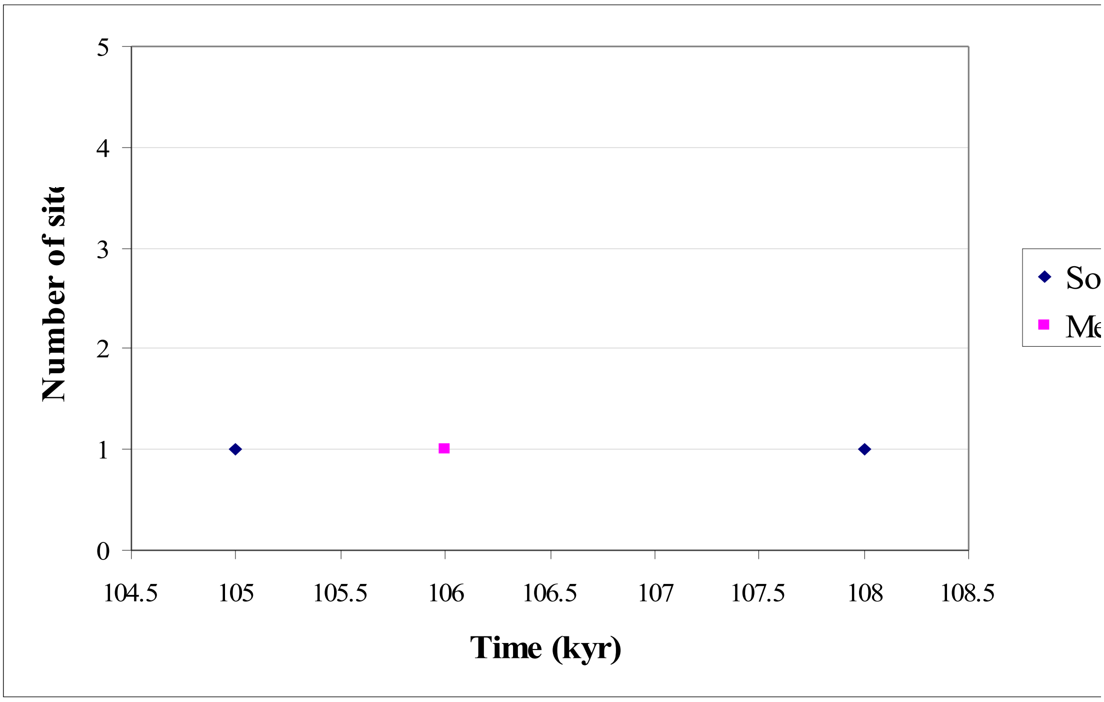


Figure 5.12 Neanderthal presence across the Eemian-Melisey I transition

The southern province, and to a lesser extent the Mediterranean saw more sustained presence particularly towards the later stages of the Melisey II and St. German II events. Fig. 5.13 displays the changing settlement history during the post-Eemian oscillations. Neanderthals were undoubtedly present in the southern province particularly during the late post-Eemian as refugia diminished, and dampened the source for ecological disruptions. However it may be possible that the large 'occupation spikes' between *ca.* 78 to *ca.* 71 ka are the result of locally favourable contexts for human occupation. Thus we cannot simply conclude that Neanderthals occupying this province were socio-behaviourally suited to cope with ecological change. In the NP it appears that Neanderthals were probably present during the post-Eemian sites of Tönchesberg and Wallertheim (Germany). Both sites indicate that open and cool conditions prevailed at the time of occupation, with stone tools and a variety of fauna including bison particularly at Wallertheim (Roebroeks *et al.* 1992). Tönchesberg and Ariendorf are interesting because the evidence points to a degree of continuity across the post-Eemian oscillations as stone tools are associated with both cold and warm fauna. These examples show Eurasians either rapidly moved into northern regions during the terminal Eemian or that closed-environment adapted humans, such as those discussed above modulated their behaviours across this major condition-resource transition, and in doing so, demonstrate demographic continuity throughout these phase changes.

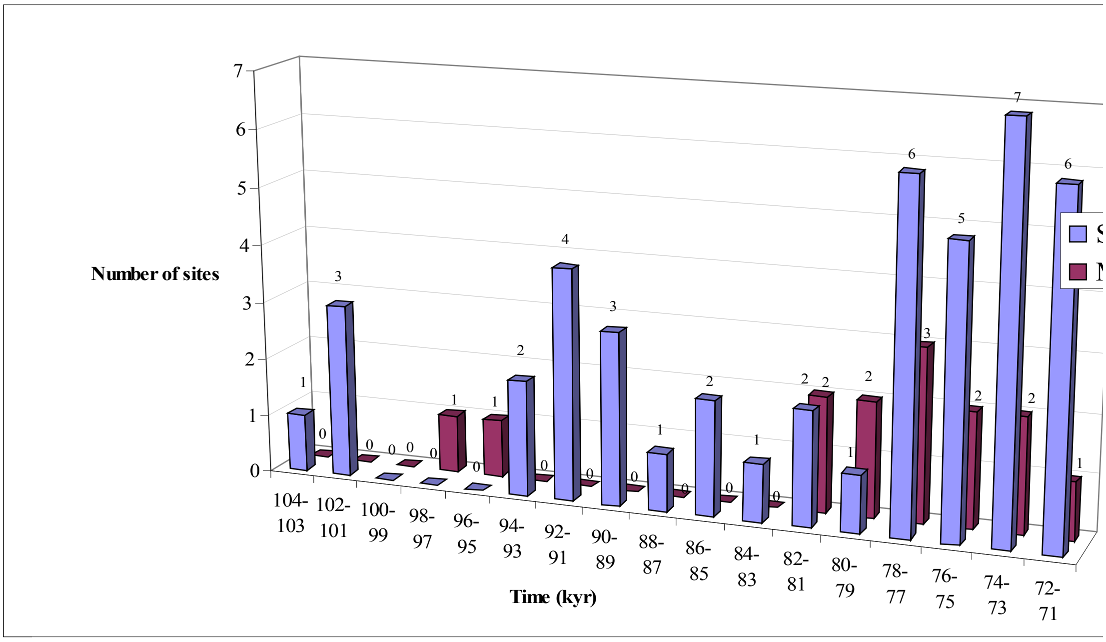


Figure 5.13 Neanderthal presence in the SP & MP during the post-Eemian oscillations

The transition into the Early Pleniglacial again saw negligible human presence in the northern and central provinces. Fig. 5.14 displays the archaeological pattern during the Early Pleniglacial (71-60 ka) in the southern and Mediterranean provinces. Again, much of the human occupation in the southern region is centred on Pech de l'Aze II with more local occupation in other areas of France (A. Brugas, Combe Grenal, Aldene, Pied Lombard Cave and Tourrttes-sur-Loup). The Mediterranean saw occupation across Portugal (Columbeira, Gruta Nova, Vilas Ruivas, Oliveira Cave) Gibraltar (Vanguard Cave), Spain (Castillo) and Italy (Grotte Guattari). Neanderthals then, were present in the south during the Early Pleniglacial. There appears to be inferential grounds at least to suggest that Neanderthals preferred these localized contexts in lower latitudes and that their apparent absence from northern Europe suggests that something, most probably environmental factors prevented Neanderthal populations from moving into higher latitudes. Certainly by this time, the Neanderthal populations located across these broad Mediterranean regions must have required new adaptations and a shift in behaviour in order to cope with the changing condition-resources which by now had begun to characterise the southern and Mediterranean provinces.

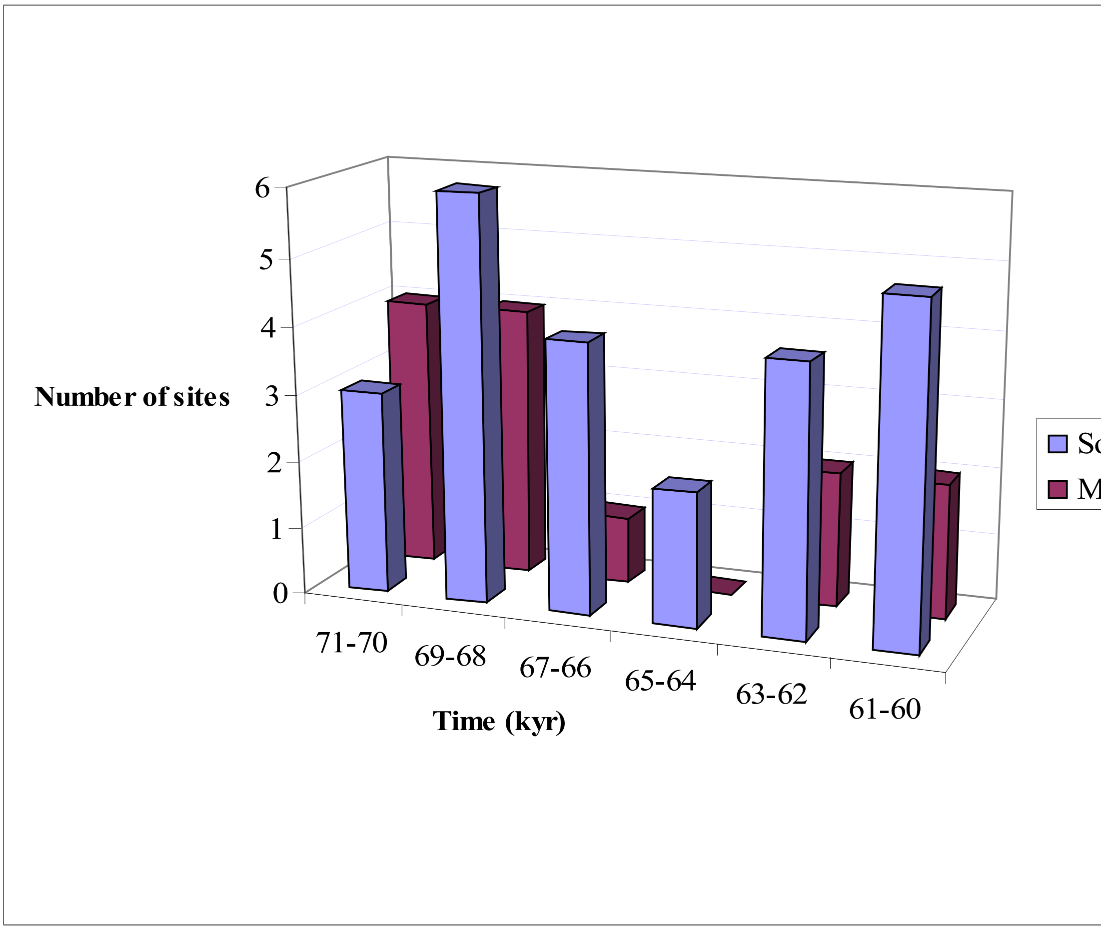


Figure 5.14 Neanderthal presence in the SP & MP during the Early Pleniglacial

5.10 Neanderthals and the Middle Pleniglacial Oscillations

Blade and flake industries dated by thermoluminescence to between 100-70 kyr BP at Seclin (north France) indicate that Neanderthals were present during the post-Eemian fluctuations (MIS 5d-a) or the early Weichselian (MIS 4). Lithic remains at Königsaue (Germany) are associated with sub-arctic steppe fauna such as mammoth, reindeer, woolly rhino and horse, while the Neanderthals at Salzgitter-Lebenstedt were seemingly exploiting sub-arctic fauna such as reindeer, horse, woolly rhino and mammoth at 58 ka BP (Roebroeks *et al.* 1992). Other Middle Pleniglacial German sites include Balve, where lithics are associated with cold fauna; Kartstein, where the Mousterian is associated with horse and reindeer; Bocksteinschmiede and Bockstein loch (Lone Valley) where lithics are associated with cold and open landscapes.

Hahn and Kind (1991 cited by Roebroeks *et al.* 1992) have shown that the Upper Danube region of the southern section of the North German Plain was utilized by (presumably) Neanderthals prior to the appearance of Aurignacians. They also suggested that gallery forests (i.e. woodland refugia) were present in sheltered valley regions. Roebroeks *et al.* (1992:565) go on to argue,

> "earlier Middle Palaeolithic occupation [was] marked by even colder and more extreme conditions [than those experienced by the Aurignacians]"

Therefore it appears that late Middle Palaeolithic Neanderthal populations were as equally capable of withstanding severe cold as the later Aurignacian inhabitants. Indeed this is a point supported by recent findings by Davies and Gollop (2003) who reported that the simulated temperature, wind-chill and snow tolerance variables were all remarkably similar for Mousterian and Aurignacian sites.

These data suggest that Neanderthal populations really began to make a more visible appearance in the northern and central provinces during the Middle Pleniglacial (fig. 5.14). Again, many of these dates come from a handful of sites situated perhaps in favourable contexts which may or may not point to relatively long-term occupation e.g. Paviland Cave, Kent's Cavern and Hyaena Den (British Isles). Alternatively this pattern may simply be a function of the greater number of radiocarbon determinations obtained from these sites relative to others. Whatever the case, a similar pattern characterises central Europe, with sites such as Sesselfelsgrotte (Germany) showing repeated visits over some 20 kyr but with an significantly lower number of available determinations than elsewhere. We see from fig. 5.15 that dated Neanderthal archaeology is rare across much of the Middle Pleniglacial and does not mirror the apparent increase which took place during the second half of the Middle Pleniglacial in the NP. It is proposed here that the period between *ca.* 38 to *ca.* 31 kyr witnessed some important demographic restructuring of Neanderthal populations which was either facilitated by modest Hengelo and post-Hengelo amelioration, or via emerging socio-behavioural traits which may have included for example, the Aurignacian and other Early Upper Palaeolithic industries. It remains to be seen if any faunal/floral indicators in these more northern sites support the former and more traditional view that contends Neanderthals only intermittently colonized the higher latitudes of Europe during major temperate phases, in which case, many of these dates may well be associated with the Hengelo warming.

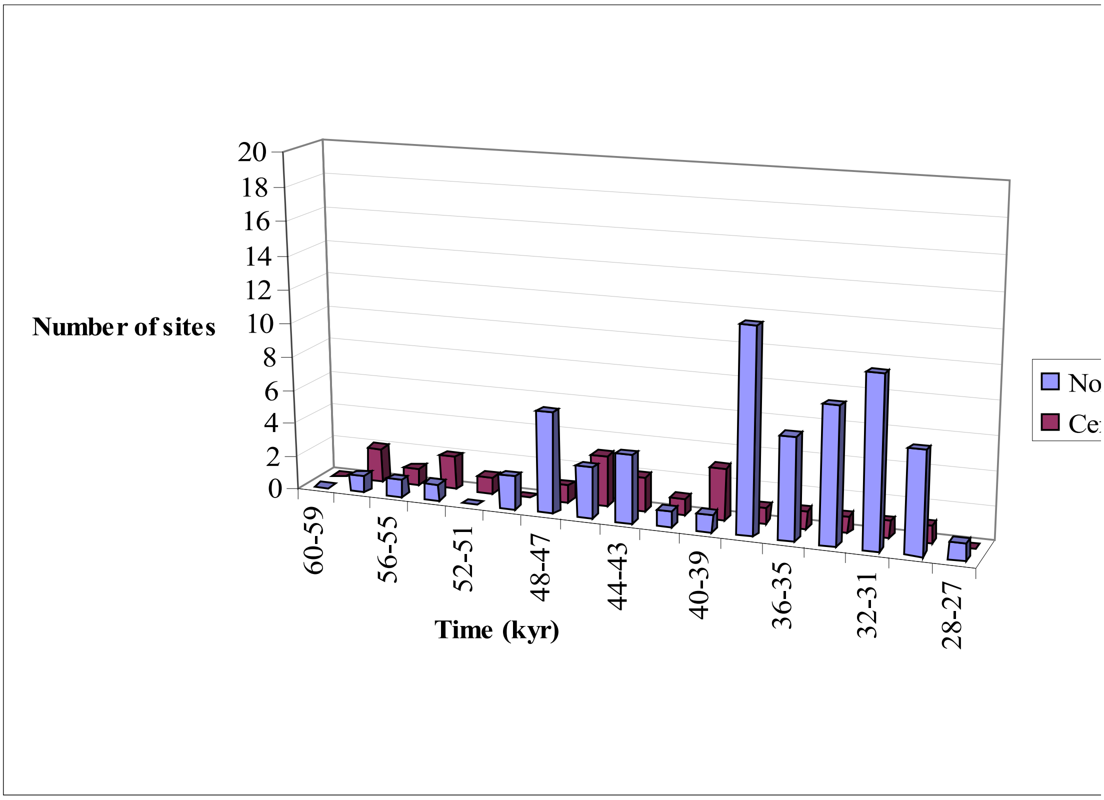


Figure 5.15 Neanderthal presence in the NP & CP during the Middle Pleniglacial

The richer archaeological record that characterizes the northern and central provinces at this time is echoed in a similar fashion in the southern and Mediterranean provinces (fig. 5.16). We see a clear increase in the number of occupied sites between *ca.* 58 to 53 ka, after which a reduction in population density appears to have occurred across both the southern and Mediterranean provinces. This population increase probably coincides with the Goulotte interstadial (La Grande Pile) and PAZ 13a in Lago Grande di Monticchio (fig. 4.6). This was a *ca.* 7 kyr phase characterised by major reforestation with some intermittent returns to steppe across broad areas of southern and Mediterranean Europe between 60.4 ka and 53.8 ka. This was followed by a return to a longer-term *ca.* 3.8. kyr open/steppe episode between 53.8 ka to 50 ka (fig. 4.6 PAZ 12). This open episode coincides with a distinct fall in dated archaeology (figs 5.15 & 5.16). This open episode seems to have been followed by a major expansion of deciduous taxa between 50.0 kyr and 42.4 kyr. Indeed it appears that as terrestrial environments changed in response to climatic amelioration, so too did Neanderthal populations, a point supported by the data pattern in fig. 5.16. Certainly by *ca.* 44 kyr Neanderthal populations had recovered across broad areas of southern and Mediterranean Europe (fig. 5.16). These data allow one to tentatively suggest that Neanderthal populations were not only utilizing a wider array of sites in space during late MIS 3, particularly across the SP and MP, but that more long-term occupation (inferred from the greater number of determinations) may also have been practiced by the inhabitents. The real question is whether the increase in dated sites was the result of a climatically mediated demographic displacement southward of the European Neanderthal population (either because of more extreme cold or environmental fluctuations - this latter point least likely based on the environmental data for this time) or whether this pattern reflects a process of local demographic expansion as the regional Mediterranean Neanderthal population expanded. To date only the former idea has been considered in any detail in the literature.

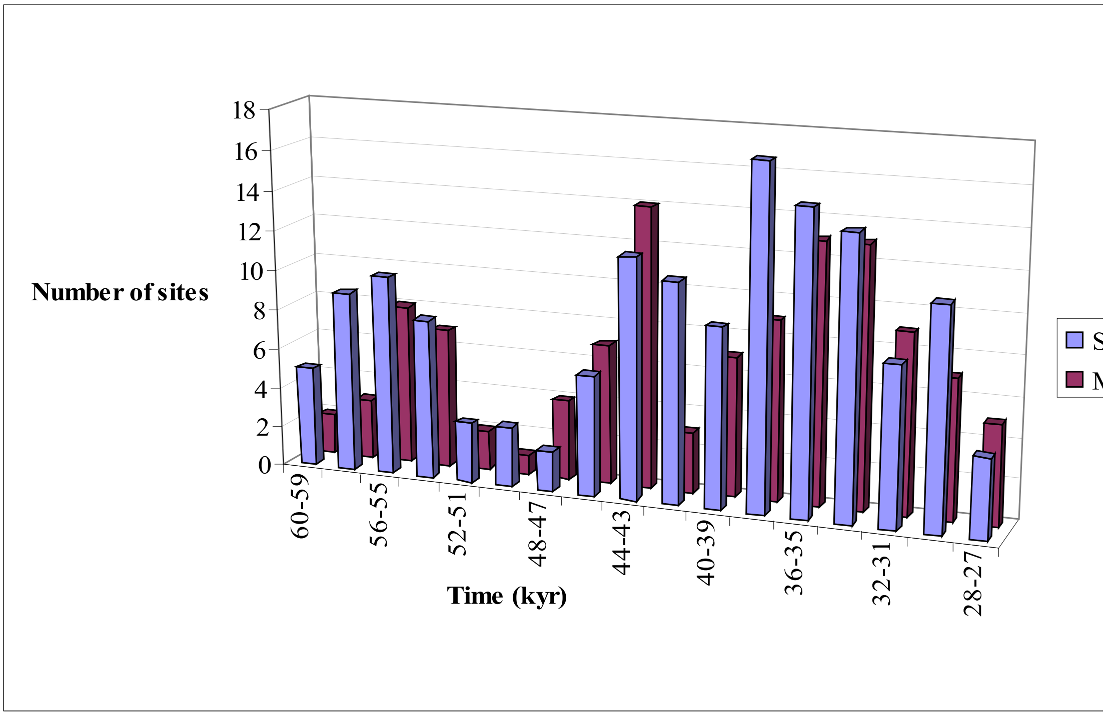


Figure 5.16 Neanderthal presence in the SP & MP during the Middle Pleniglacial

Fig. 5.17 summarizes the dated archaeological evidence for the appearance of anatomically modern humans by inferring their presence from the Aurignacian culture. It is apparent (based on these data) that no significant modern human presence is observable in any study province between *ca.* 52 ka to *ca.* 47 ka. This coincides with a major low in Neanderthal presence in the northern and central provinces and the trough witnessed in the southern and Mediterranean provinces between *ca.* 52 ka to *ca.* 47 ka. Between *ca.* 46 ka to *ca.* 41 ka it appears modern humans had entered Spain as several sites including Castillo, Reclau Viver and L' Arbreda record the Aurignacian while the Neanderthals also appear to have maintained a broad presence across Spain (e.g.

Cariguela, L' Arbreda, Kurtzia and Banyoles) and Portugal (e.g. Oliveira Cave and Figueira Brava Cave). Some of these sites e.g. L' Arbreda BE116 (Mousterian, 45,852 ± 2,335) and B1 (Aurignacian, 45,013 ± 2,266 indicate that Mousterian and Aurignacian cultures were in close temporal and spatial proximity. Between *ca.* 43 to *ca.* 36 ka a significant increase in modern human presence can be inferred from a increase in occupied sites across the central province. For example Das Geissenklosterle (Germany) and Willendorf II (Austria) indicate a strong modern human presence. Neanderthals on the other hand seem to have been largely absent in this region and are recorded as fleeting visitors at sites such as Sesselfelsgrotte (Germany) and Salzofenhohle (Austria). The strong Aurignacian signature relative to the Mousterian in the central province suggests modern humans had by now gained a real territorial footing in Europe. As we have seen the central province at this time was far from open and barren as Finlayson (2004) has argued. Loess deposits in Hungary (46˚ and 48˚N and 18˚E and 24˚W) are associated with intermittent plant/tree remains dating to 35.5 kyr which suggest that tree refugia were in fact present in higher latitudes (Willis *et al.* 2001). These findings are supported by pollen data from central Germany (Müller *et al.* 1993). Modern humans, then, far from seizing opportunities based on their pre-adaptations to 'open' environments (e.g. Finlayson 2004) were colonizing regions that were largely comprised of condition-resources not dissimilar in make-up to those experienced by Neanderthal populations: semi-open landscapes prone to disruption as amelioration acted on refugia elements. It appears that both modern human and Neanderthal numbers appear to have increased across France over this timeframe. This phase also saw the appearance of the Châtelperronian industry, which may have begun as early as *ca.* 55 ka, as recorded at Grotte du Renne, Arcy-sur-Cure (level IX) (Stage 3 Project Database 2003).

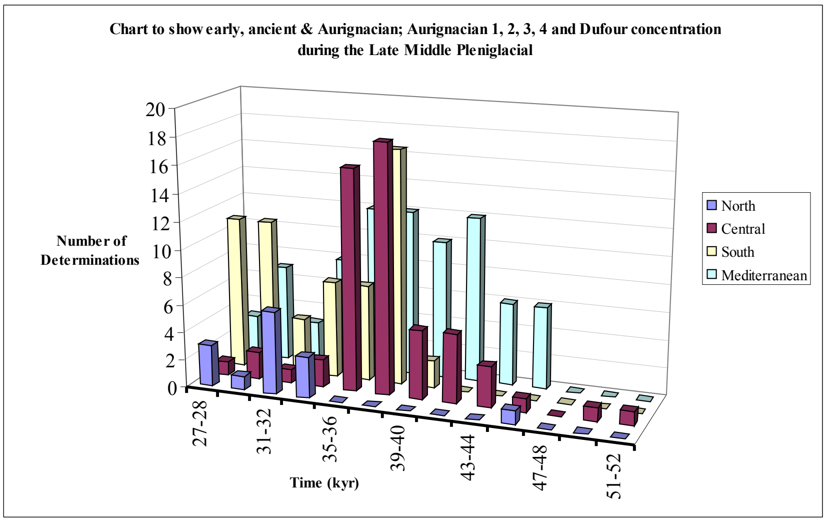


Figure 5.17 Aurignacian and Dufour concentration during the Late Middle Pleniglacial

As we have seen, Neanderthals were quite widespread across the NP between *ca.* 38 to *ca.* 31 ka. Modern humans however do not appear to have been present to the same degree. It appears then, in terms of dated sites, site diversity and concentration, that Neanderthals maintained a strong presence over this late Middle Pleniglacial phase. Vandenberghe *et al.* (1998) argue that MST in the northern province was as high as 10˚C between 38 ka and 28 ka and that climate amelioration, such as that recorded at Upton Warren, would have resulted in palaeosol development across some areas of northern Europe. Yet it appears that the northern regions remained predominantly cold and open. Amelioration, when it did occur, was typically too short or not strong enough to result in terrestrial palaeoenvironmental changes. It is interesting that a strong Neanderthal presence and weak modern human presence is observed in northern Europe at and around the time of the Hasselo stadial (41 to 38 ka). This saw MST between 7˚C to 12˚C in Holland and England with MAT between -4˚C and -8˚C (Huijzer and Vandenberghe 1998). Periglacial features suggest that the continuous permafrost zone lay in southern Germany. We can only conclude that Neanderthals, then, were present in regions which were experiencing widely fluctuating conditions and even thriving in stadial conditions in northern Europe. Moreover, late MIS 3 cold does not appear to have forced *all* Neanderthal populations into more temperate, lower latitudes.

Neanderthals and modern humans: competitive exclusion

Fig. 5.18 displays the relative contribution of Neanderthal (Mousterian and derivatives) and Modern Human (Aurignacian) archaeology in the NP. It is clear, based on current dated-archaeology that for 32 kyr out of 34 kyr Neanderthals appear to have maintained a more significant presence than modern humans in this region. Modern human presence is archaeologically invisible between *ca.* 52 ka to *ca.* 35 ka. Up until 38 ka (Hasselo) the Neanderthals appear to have been present in low in numbers but increase considerably after this time. Although no definitive statements can be made relating to competition, Neanderthals held a stronger footing in northern Europe than the modern human counterparts who were certainly present in other parts of Europe at this time.

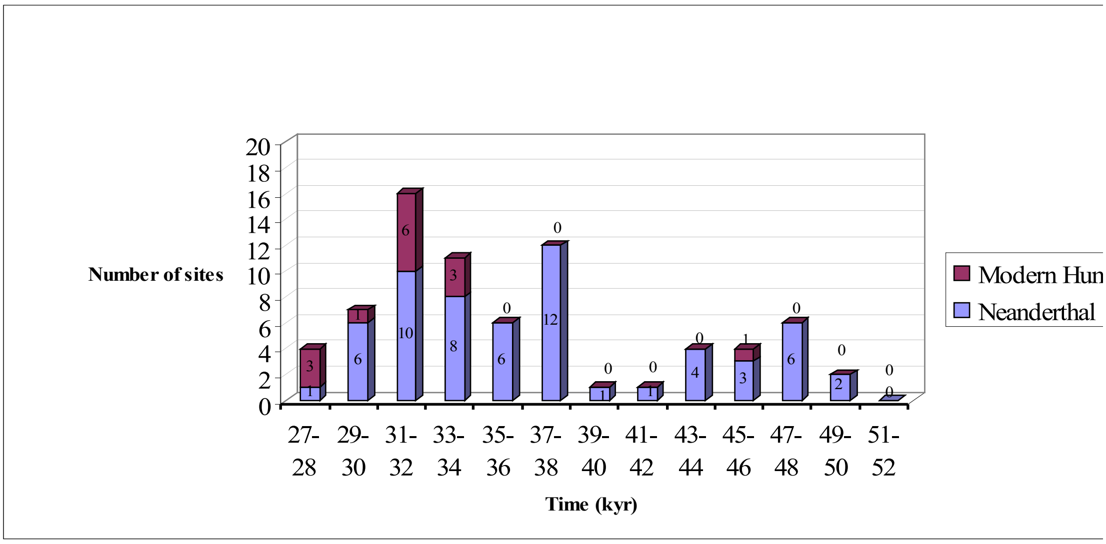


Figure 5.18 'Neanderthal' and 'Modern Human' archaeology in the northern province across the 52 ka - 27 ka timeframe

In contrast with the NP, where modern humans may have been marginalized by Neanderthals at the most preferred sites on a sub-regional scale, the Neanderthal/modern human demographic in the CP appears to have been quite different. Here, Neanderthals were essentially absent across the Middle Pleniglacial (fig. 5.18) while modern humans were strongly present between *ca.* 38 to *ca.* 35 ka across eastern Germany and Austria.

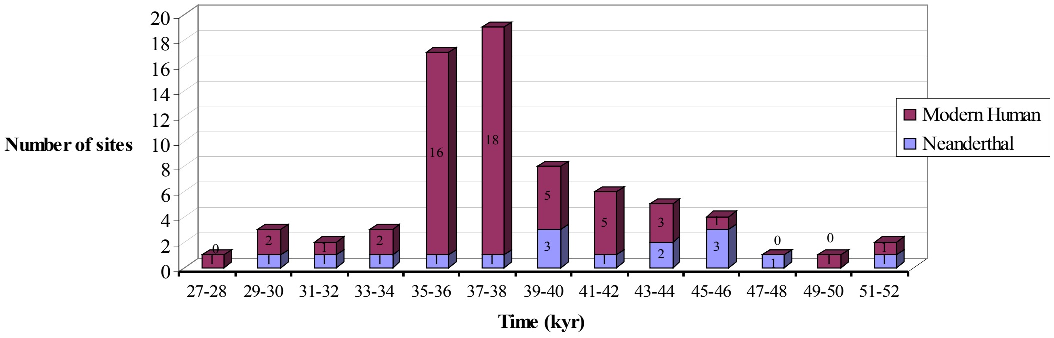


Figure 5.19 'Neanderthal' and 'Modern Human' archaeology in the central study region across the 52 ka - 27 ka timeframe

In the SP, particularly France, it was the Neanderthals, and not modern humans, who were present between *ca.* 52 to ca. 41 ka (fig. 5.20). By 40 ka some modern human presence becomes observable, before a strong increase during the Hasselo stadial at *ca.* 38 ka. Modern human presence seems to have declined after the Hasselo stadial in contrast to Neanderthal numbers which remain relatively constant up until the late Middle Pleniglacial (in conjunction with population increases in northern and Mediterranean Europe). It appears that modern humans established a foothold in France, only to be pushed back out by the Neanderthals. This 38-31 ka timeframe in the southern region may be indicative of a more complex pattern of regional interplay where some Neanderthal populations in a sense thrived, while in other regions e.g. central Europe, it was modern humans which enjoyed residence.

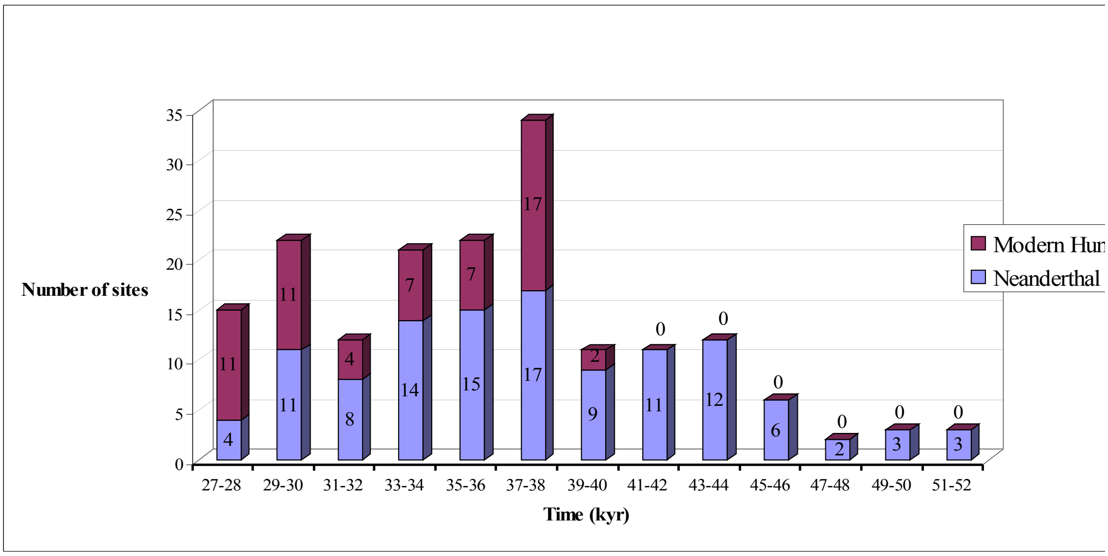


Figure 5.20 'Neanderthal' and 'Modern Human' archaeology in the southern province across the 52 ka - 27 ka timeframe

Modern humans appear to have entered the Mediterranean province earlier than in other regions, and maintained a more sustained presence relative to the northern, central and southern provinces (fig. 5.21). From *ca.* 48 ka to *ca.* 43 ka Neanderthals provided a stronger archaeological signature, but from *ca.* 42 to *ca.* 37 ka the Aurignacian culture seems to have been prevalent. Clearly, modern humans were present long before the Hengelo interstadial (*ca.* 38-36 kyr) so the notion favoured by Mellars (1998) that modern humans entered Europe during the temperate window of opportunity that was the Hengelo interstadial may require more consideration. Only in the southern province does the Hengelo, which resulted in semi-temperate/boreal steppe across France, appear to have played a role in facilitating the movement of modern humans. However, Neanderthal populations were still ascendant for the next *ca.* 7 kyr, from 36 ka to 28 ka. Neanderthal parity with the modern human populations up until these late dates makes their disappearance all the more surprising.

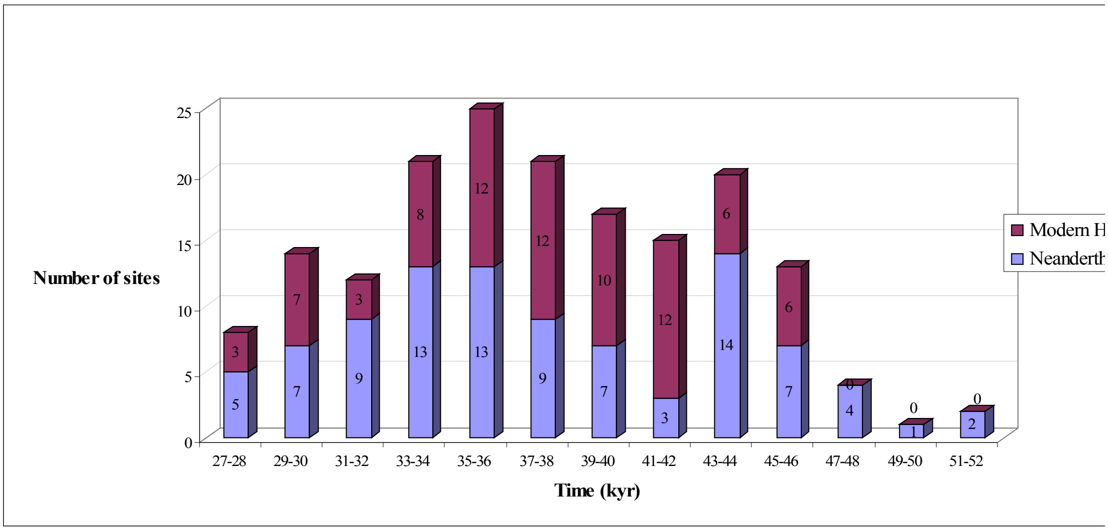


Figure 5.21 'Neanderthal' and 'Modern Human' archaeology in the Mediterranean province across the 52 ka - 27 ka timeframe

5.11 Neanderthal demographic responses to Heinrich Events

We have seen that a wide variety of marine, ice, and to a lesser extent, terrestrial records testify to a pattern of first-order, high-amplitude palaeoclimatic changes – the IG-G cycles - over the course of the Pleistocene. Superimposed upon these broad trends are a more enigmatic series of second-order fluctuations which were lower in magnitude but higher in frequency. These are referred to as Dansgaard-Oeschger (DO) events which in simple terms represent $\delta^{18}O$ climatic fluctuations midway between glacial and interglacial states, and Heinrich events (HE), episodic periods of cooling associated with large-scale ice-sheet collapse. Dansgaard *et al.* (1993) have reported that up to 23 DO events spanning the last 120,000 years or so are visible in the GISP2 ice core sequence. If, how, and in what ways such climate changes disrupted palaeoenvironments, or drove innovative human behaviour are but three themes which are currently the subject of much interest amongst archaeologists and climatologists. Some of these changes certainly appear to have disrupted terrestrial environments as Braüer *et al.* (2000) have shown, however they point out that correlations between marine, ice and certain terrestrial sequences are principally restricted to the larger events. This is a point acknowledged by van Andel (2003) who accepts that centennial- and millennial-scale correlations between Greenland and Europe cannot be securely substantiated. As I have argued earlier it seems that some of these climatic events may not have caused meaningful environmental change and in turn disrupted Neanderthal populations in all places and at all times (chapter 4.8-4.14). Moreover, even the absolute chronology of some of the larger events as recorded in proxies such as GISP2 is still rather uncertain. For instance Meese *et al.* (1997) suggested that some DO events have temporal uncertainties of up to ± 5-10%. A third facet compounds our approach even further and this is that many archaeological dates from the last glacial period are associated with broad standard deviations thus any attempts to tie-in a particular episode of human occupation with a particular climate event are inherently equivocal.

This is not to say that DO events did not disrupt faunal and floral configurations, as some pollen proxies particularly Lago Grande di Monticchio show that some abrupt and dramatic transformations between wooded and steppe landscapes occurred quite regularly during the Middle Pleniglacial. There is however an uncertainty particularly with regard to the magnitude and duration of such events, and in turn their differential contributions to environmental character. Dansgaard-Oeschger events do not appear to have been homogenous in terms of magnitude, frequency nor duration so it is unsafe to *a priori* infer that they *always* caused clear and meaningful palaeoenvironmental change throughout the course of the last glacial period. This has clear implications for those who argue DO events, the clearest trace of climate instability from marine- and ice-core proxies, are a secure and trustworthy piece of forensic evidence to implicate the Neanderthals in having failed to adapt to largely inferred *new* palaeoenvironmental circumstances and unusual selection pressures.

It may perhaps be profitable to examine the broad demographic response of Neanderthal populations in isolation against some of, if not the most strongly registered climatic changes of the last IG-G cycle – the Heinrich events (HE). Sachs and Anderson (2005:1118) have stated that,

> "[Heinrich events] coincided with the coldest periods of the last ice age".

Certainly, as any cursory glance at the reconstructed temperatures from Greenland ice core proxies shows that HE are readily conspicuous as some of the most significant $\delta^{18}O$ spikes, and arguably the most rapid and high magnitude climatic events of the last glacial period. It is suggested here that these may provide a more appropriate window than DO events from which to view Neanderthal response to rapid and high magnitude climatic change. Heinrich events are believed to have been caused by periodic collapse of the

Laurentide and Fennnoscandian ice-sheets every 5,000 to 10,000 years (Sachs and Anderson 2005). Such collapses resulted in vast flotillas of ice-bergs drifting out into the open ocean leading to the deposition of vast gravel fields, or ice-rafted debris (IRD) as well as the influx of huge volumes of fresh water which potentially disrupted North Atlantic thermohaline flow between 40° and 55°N. Charles *et al.* (1994) reported that two of the most prominent $\delta^{18}O$ shifts from the GRIP/GISP2 records were associated with ice-sheet discharge and melting at *ca.* 14,000 and 11,000 years ago. Six of these events occurred during the last glacial and are clearly observable in most marine and ice-core proxies as marked reversons in $\delta^{18}O/\delta^{16}O$ ratio. Four of these events are relevant to this discussion. For the purposes of chronology, the dates from the Chatham Rise core (MD 97-2120) will be used. The timing and visibility of these appear to be well-expressed in this proxy, certainly more discernible than in other proxies such as DSDP-609 (Bond and Lotti 1995) in which only H5 appears to have a more reliable chronology. While at first at glance the use of this proxy may at first seem unusual for establishing the chronological baseline for HE, however by using a proxy located in the southern hemisphere we can be sure that the events being considered were indeed globally significant climate phenomena, and were not simply restricted to the North Atlantic. HE were, by their very nature centennial/millennial in duration thus we can assume that their impact on terrestrial environments took place over a rather narrow timeframe and certainly less than stadial events for instance. Despite the short-lived nature (at least in geological terms) of these events a strong temporal correlation is apparent between northern and southern hemispheres and more recent research has confirmed the global impact of Heinrich events (Sachs and Anderson 2005).

The aim of this section is to explore the demographic structure of Neanderthals during specific temporal windows before, during and after HE 6, 5, 4 and 3 (table 5.2). Because of the uncertainties relating to the duration of HE themselves and the relatively broad standard deviations associated with many archaeological dates of this phase, it was decided that it was more profitable to adopt a less-restrictive approach than one in which the HE themselves were the principal phases of interest. Rather it was deemed more interesting to examine Neanderthal demographic structuring during three phases: *pre-*, *during* and *post-*HE. This was deemed necessary for two main reasons: because of the rather narrow, in geological terms, temporal durations of HE; and because of the inherent chronological uncertainty of the timing of the events themselves. The durations of the HE phases are uncertain and estimates on the timing and duration vary from one researcher to another depending on what proxy is dated or preferred (e.g. ice-rafted debris, algal productivity, radioisotope tracers of sedimentation etc. These problems are compounded further by the earlier HE events which are too old to be dated by radiocarbon, which is further complicated by stratigraphic uncertainty and lead and lag times, especially with regard to biomarkers and HE. Therefore it was deemed necessary to 'widen' the HE windows in this study. Following an analysis of Rahmstorf, 2002 Fig. 3, 2003 Fig. 1; Sachs and Anderson 2005 Fig. 1) the H6 event was viewed over 61.6-59 ka, H5 from 45 ka, H4 from 37.9-36.9 ka and H3 from 31.6-29 ka.

Table 5.9: Heinrich events of the Middle Pleniglacial

	Heinrich event (Ka)			
	H6	**H5**	**H4**	**H3**
MD-97-2120[8]	60-59	46	40-38	31-29
This study	61.6-59	45-44	37.9-36.9	31.6-29

A series of data was collected (appendix A) and subsequently grouped together in relevant temporal episodes. To gain insights into Neanderthal demographic structure it was decided to map archaeological data pertaining to a pre- and post- HE time phase, so as to examine the relative difference between these phases as well as to reflect any differences in structure with the HE themselves more clearly. The archaeological data were extracted from the Stage 3 archaeological database[9] and mapped onto the study provinces using the PanMap[10] software. The following discussion will show a series of maps illustrating Neanderthal sites and dates pertaining to a temporal phase before, during and after HE 6 to 3.

5.11.1 Pre-H6 (ca. 66-62 ka)

---

[8] After Sachs & Anderson (2005)

[9] Stage 3 Project. 2003. The Stage 3 Project Archaeological database. (online). Available: http://www.esc.cam.ac.uk/oistage3/secure/OIS-3i. html#maplot (2004, September 1).

[10] The PanMap programme is available at the website http://www.pangaea.de/Software/PanMap

Fig. 5.22 shows that we have only a limited amount of dated archaeological material thus restricting the scope of our ideas with regard to Neanderthal distribution, demography and habitat preference over the pre-H6 timeframe.

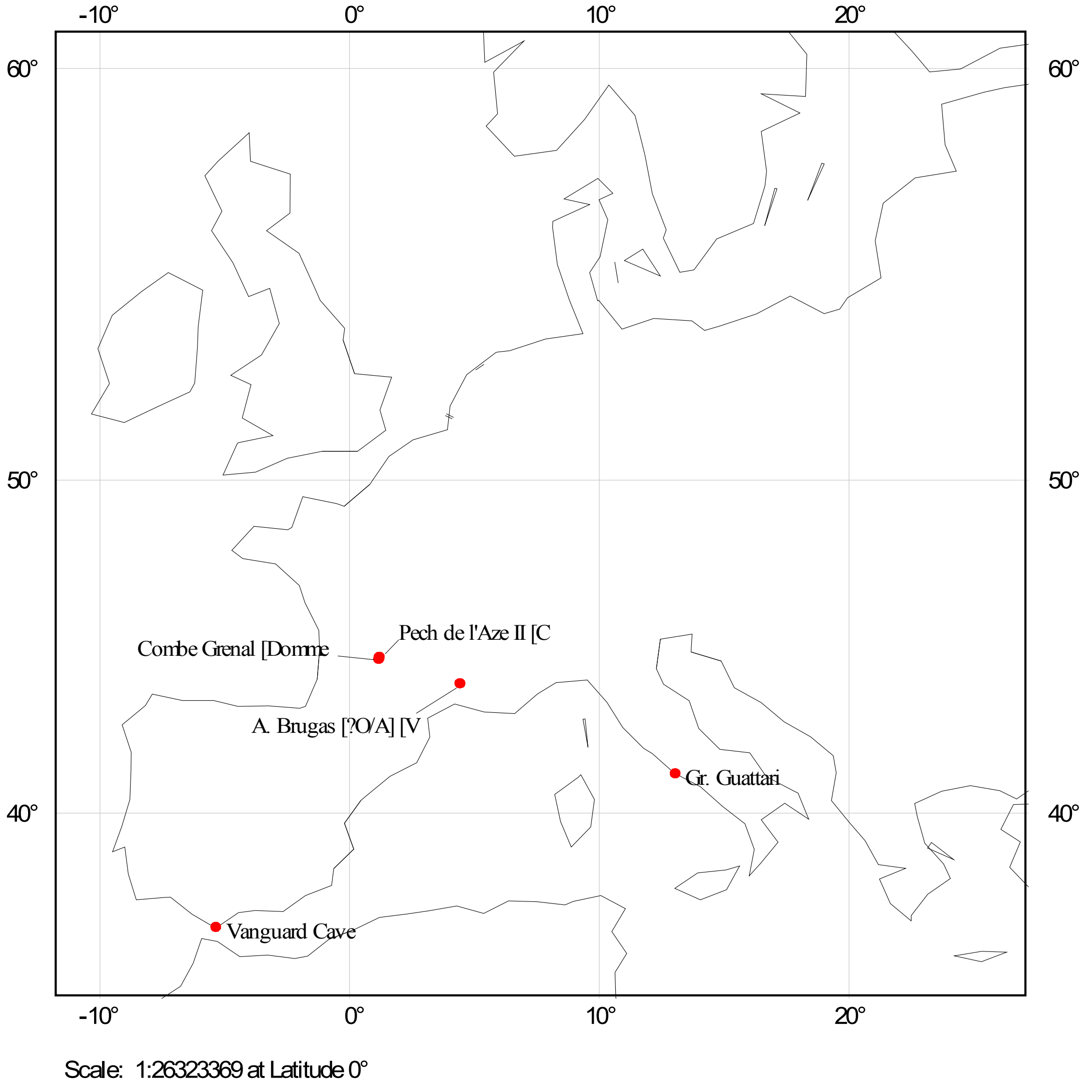


Figure 5.22 Neanderthal sites across the study provinces prior to H6

Only a few scattered cave sites situated in the SP and MP attest to Neanderthal presence during this phase (fig. 5.22). It appears that all of these sites were caves. We see that the dates fall at and around the transition between the classic MIS 4 to 3 (fig. 5.23). One possible interpretation is that most of the study provinces were abandoned several thousand years earlier, perhaps during the onset of the Early Glacial period (MIS 4). Another explanation is that there are more sites which as of yet are undated, or that suitable dating methods cannot be applied to the data in question. We can at least put forward the notion that Neanderthals were present across some of the study provinces and that they appear to have maintained a presence in the river valleys of modern day southern France as well as along the Mediterranean coastline.

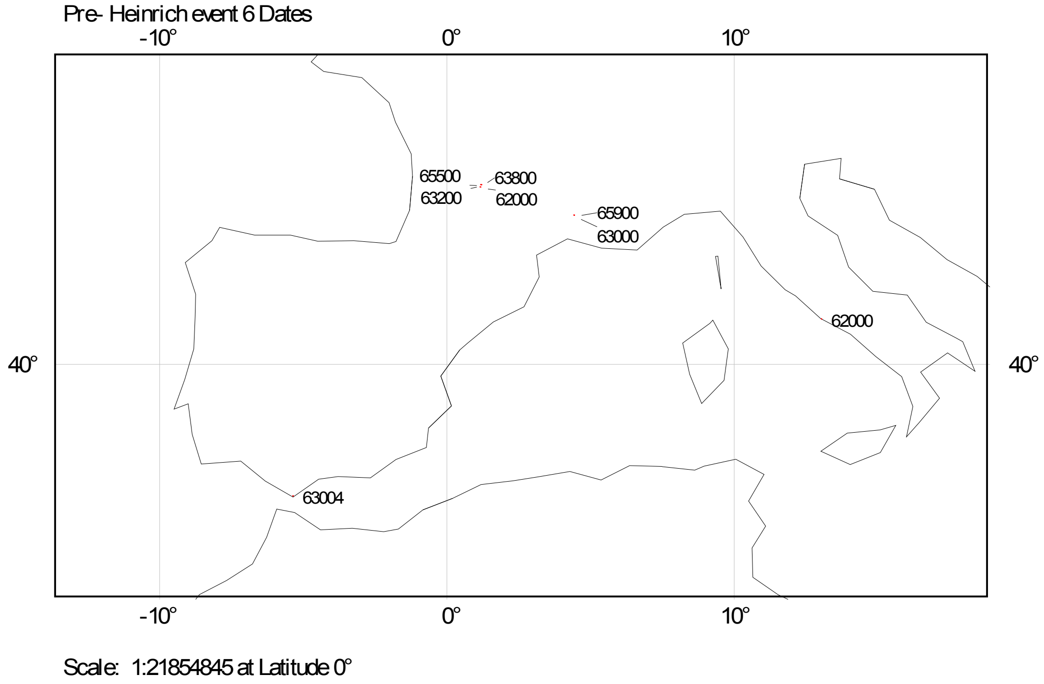


Figure 5.23 Dated Neanderthal sites across the study provinces prior to H6

5.11.2 H6 (ca. 59-60 ka)

According to Rahmstorf (2002 fig. 5.24), H6 was in climate terms a globally significant event that resulted in sea-surface temperatures falling to about 16°C in the subtropical Atlantic which compares to modern values of 22°-23°C. In terms of sea-surface temperature this would place H6 as the 4th coldest HE of the last glaciation, and the 3rd coldest of the four of interest to this study (fig. 5.24).

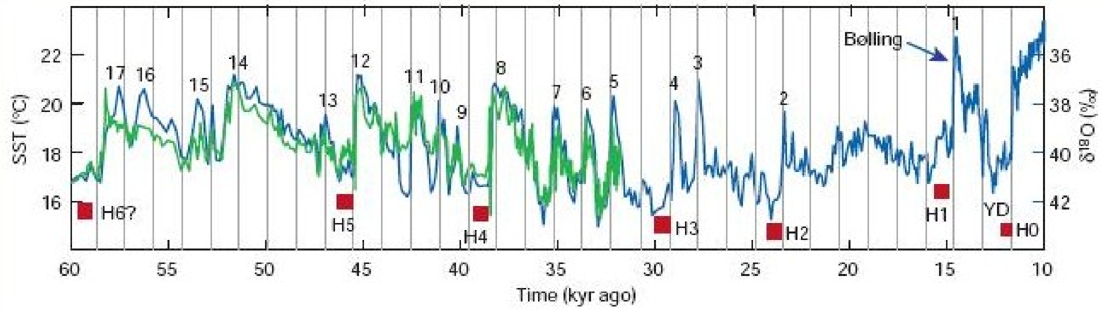


Figure 5.24 Selected DO and HE events of the last glacial. After Rahmstorf (2002)

Neanderthal distribution during the H6 phase appears to have been almost identical to that of the pre-H6 phase, with most sites distributed in the valleys of southern France and along the Mediterranean coast (fig. 5.25).

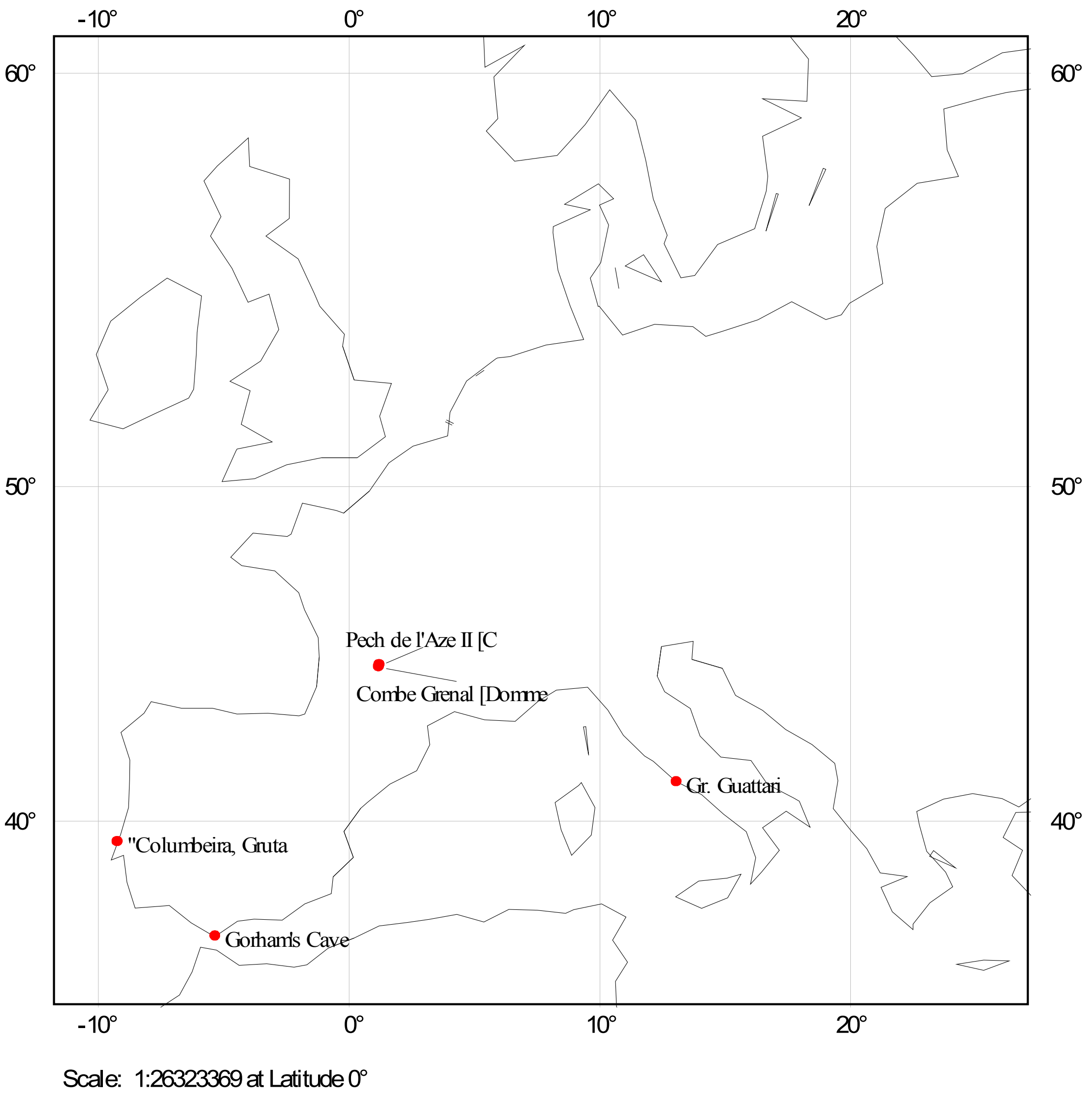


Figure 5.25 Neanderthal distribution during H6

Despite only having a few data at hand and notwithstanding the fact that some of these dates have rather broad calibration ranges, we can at least suggest that Neanderthals were present in these regions prior and during H6, thus by implication we can make an inference, while accepting the limitations in such a claim, that some Neanderthals present between the 35° and 45° parallels do indeed appear to have coped with the H6 event and any resultant environmental changes that ensued. As we have seen in chapter 3, major palaeoclimatic changes are viewed as significant factors in Neanderthal extinction. Despite the clear climatic impact of H6 it cannot be simply assumed that it resulted in clear and widespread environmental change which in turn resulted in disruption of these

Neanderthal populations. Thus two exclusive hypotheses exist: firstly, that the palaeoenvironmental disruptions of H6 do not appear to have affected parts of the SP and MP between 35° and 45°N, and secondly that palaeoenvironmental disruptions did indeed alter Neanderthal habitats between 35° and 45°N but the Neanderthals coped and adapted to these changes. Fig. 5.26 shows the available dates for this phase. Perhaps these limited amounts of data attest to local populations of specialized Neanderthals capable of subsisting in the late Early Pleniglacial habitats of northern Europe. At this stage it is too early to discuss these hypotheses further however I will return to this theme later.

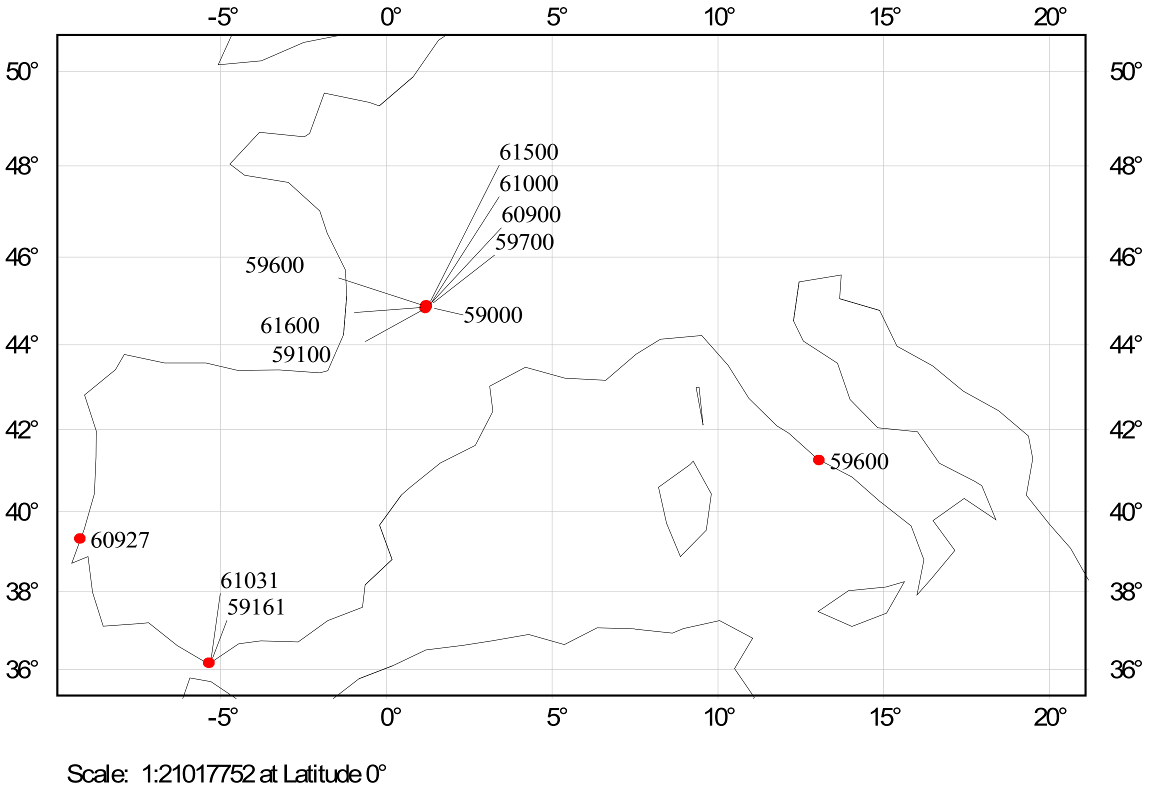


Figure 5.26 Dated Neanderthal sites ca. H6

5.11.3 Post-H6 (ca. 59-55 ka)

The several thousand years following the H6 event correspond to the early stage of the Middle Pleniglacial. This phase appears to have witnessed a clear blossoming of the western European Neanderthal population in general. Yet it cannot be claimed that these expansions occurred as a result of a perceived climatic improvement following the H6 event because population densities across Europe in general were clearly already low during the preceding MIS 4 glaciation. Thus H6 does not represent a sufficiently well placed climatic event in time from which to analyse the nature of a major climate change on Neanderthal populations or to develop ideas further about how such populations responded during and after such changes. With this caveat in mind Europe at this time shows a clear increase in dated sites particularly in the SP (fig. 5.27).

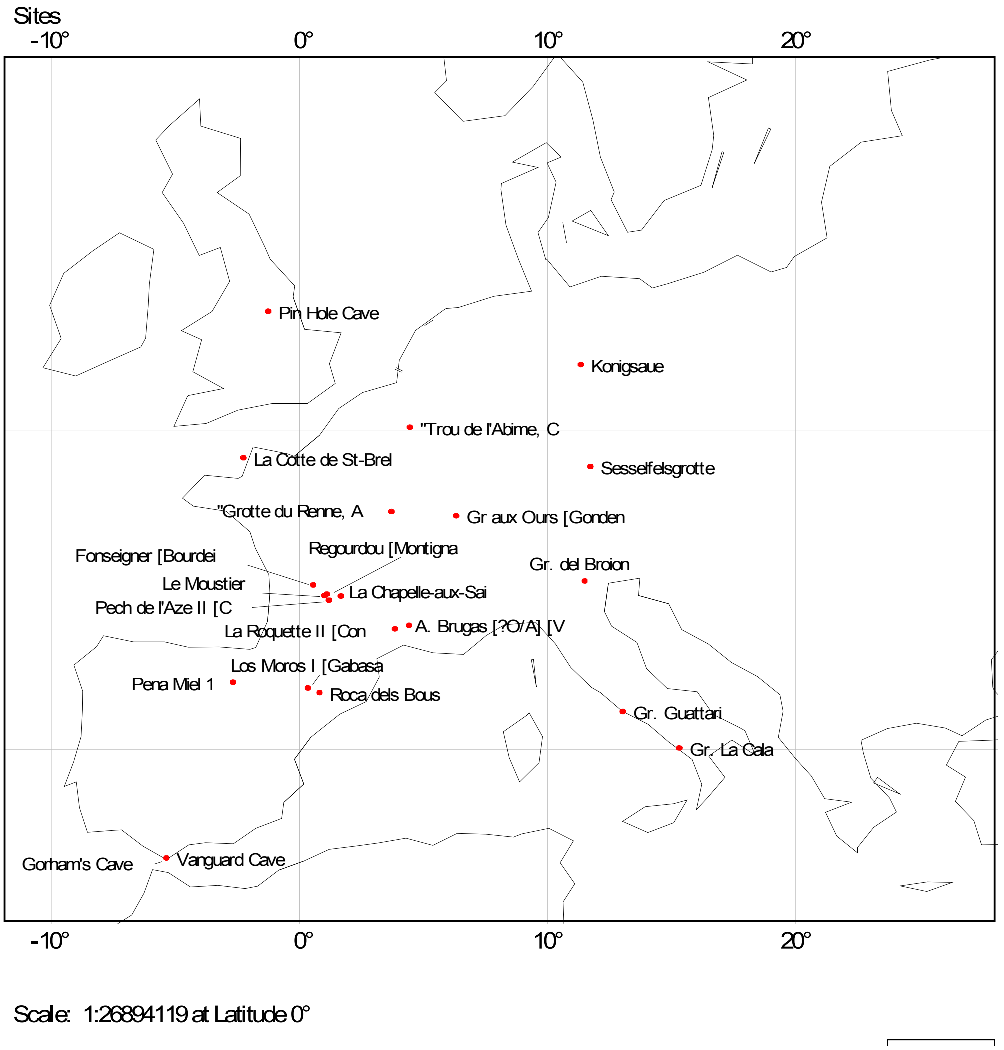


Figure 5.27 Neanderthal sites across the study provinces post- H6

Perhaps the most impressive feature is that Neanderthals appear to have ventured north and to the east, and it is at this time that we see some clear evidence for occupation of the NP and CP. It would be interesting to determine whether archaeological evidence can shed any light on where the focal point for this expansion to the north and east was initially situated. Intuitively perhaps it would seem a sensible hypothesis to envisage that the initial source for this migration was situated in the valleys of southern France which seems to have functioned as a focal point of occupation during the post-Eemian and Early Pleniglacial. The Post-H6 timeframe also appears to have been marked by two significant DO events, the first at *ca.* 59 and the second at *ca.* 56 ka (GISP2 17 & 16, *cf.* fig. 5.24) as well as two sharp 'stadial' events at *ca.* 57 and 55 ka. Nonetheless, Neanderthal populations appear to have coped with both the H6, as well as the four short, sharp oscillations that succeeded H6. One important conclusion that we can draw from the Neanderthal site distribution and demographic pattern as inferred here is that Neanderthals do not appear to have been perturbed nor disrupted by these early MIS 3 oscillations. The archaeological data instead point to a phase of expansion and local population growth at the regional level.

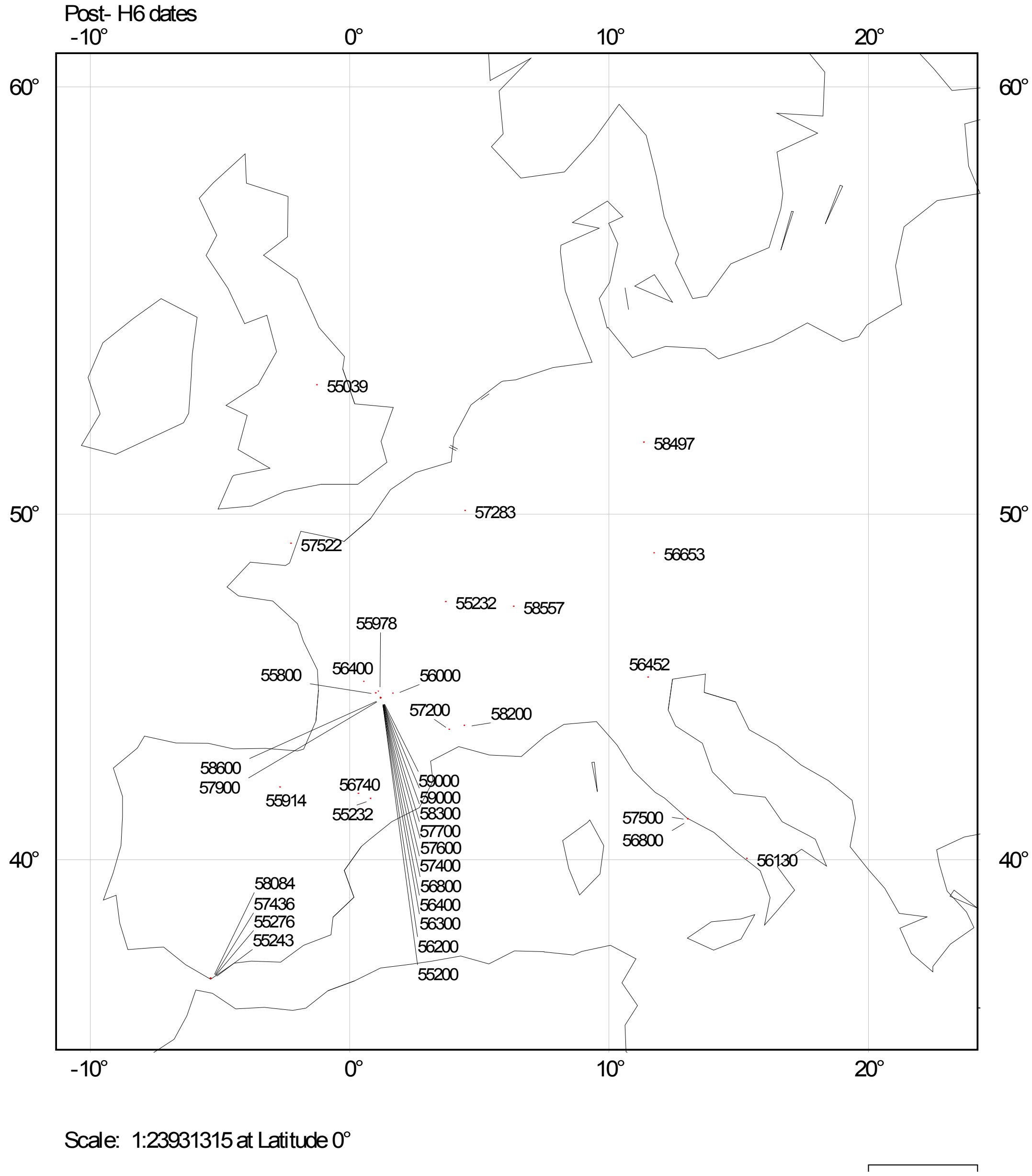
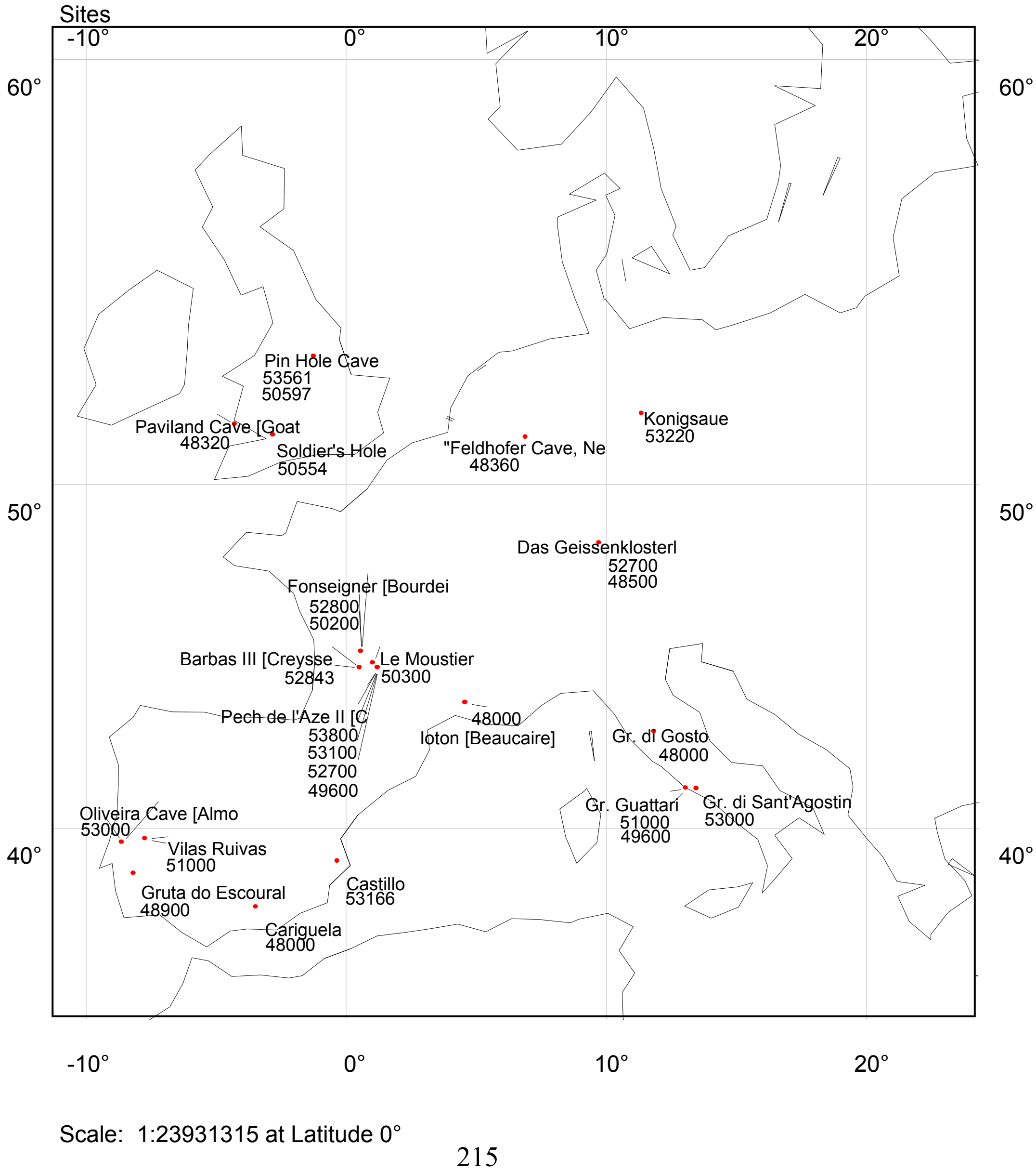


Figure 5.28 Neanderthal dates across the study provinces during post H6

5.11.4 Pre-H5 (ca. 53-48 ka)

According to fig. 5.24 this phase of climate saw a steady 3° or 4°C decline in sea surface temperature. It is important to point out that this temperature decline took place gradually over some 5,000 years and not during a distinct climatic or temporal phase. Fig. 5.29 illustrates the broad demographic pattern in terms of archaeological sites over this timeframe.


Sites
-10°
0°
10°
20°
60°
50°
40°
Pin Hole Cave
53561
50597
Paviland Cave [Goat
48320
Soldier's Hole
50554
"Feldhofer Cave, Ne
48360
Konigsaue
53220
Das Geissenklosterl
52700
48500
Fonseigner [Bourdei
52800
50200
Barbas III [Creysse
52843
Le Moustier
50300
Pech de l'Aze II [C
53800
53100
52700
49600
48000
loton [Beaucaire]
Gr. di Gosto
48000
Gr. Guattari
51000
49600
Gr. di Sant'Agostin
53000
Oliveira Cave [Almo
53000
Vilas Ruivas
51000
Gruta do Escoural
48900
Castillo
53166
Cariguela
48000
Scale: 1:23931315 at Latitude 0°

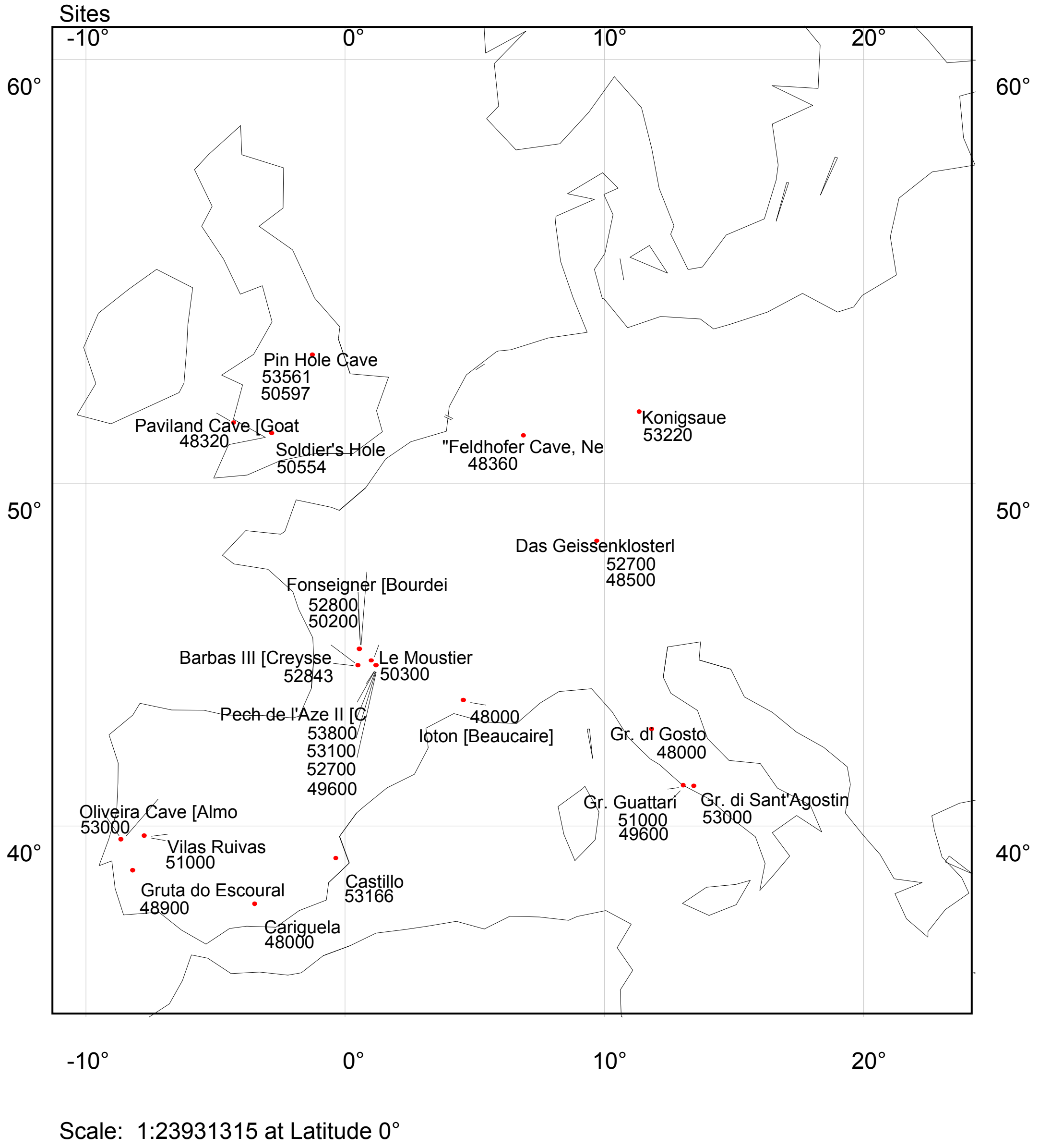


Figure 5.29 Pre-H5 Neanderthal distribution: dated sites (ka cal. BP)

The MP appears to have witnessed a broader occupation relative to earlier periods particularly in the SW and SE of Spain. Around this time there also appears to have been some human presence north of 52° at Pin Hole Cave. One issue is worth mentioning here, not just with regard to this particular site and its associated radiometric dates, but with many early MIS dates generally. Van Andel *et al.* (2003) have stated that with regard to the Aurignacian and the 'Early Upper Palaeolithic' any dates older than 50 ka should be disregarded as improbable, while those with SD_{cal} ranges of >±2,500 ka should be similarly dismissed as *too vague* (van Andel *et al.* 2003:40). This is an unusual decision to have taken however, as many dates from the Middle Pleniglacial which were utilised by the Stage 3 Project (2003:53 Appendix 4.1) are at or beyond the upper limits of ^{14}C and/or AMS and often come with large sigma (examples of which are summarised below in table 5.3). This highlights a slight methodological departure between the treatment or acceptance of dates which are Aurignacian and non-Aurignacian. With this in mind it is worth returning to the site of Pin Hole Cave which has two dates of 53,561 ± 8,234 and 50,597 ± 7,064 cal BP (Stage 3 Project archaeological database). Presumably these dates have been met with scepticism by archaeologists because these were too early and thus do not conform to current expectations regarding the timing of modern human entry into Europe. Similarly, they have been discounted as Neanderthal sites because they have been attributed an Early Upper Palaeolithic affiliation. So in this particular case we are left with two alternatives, either the dates or the cultural affiliation must be incorrect. In either case they do not appear to have attracted any interest in the Stage 3 Project publications. But for the purposes of this discussion, I will incorporate these sites under Neanderthal authorship for two reasons. Firstly, the dates themselves as well as the sigma do not represent significant departures from other Middle Palaeolithic dates utilised here and elsewhere (table 5.3). Secondly, if unequivocal modern human presence at or around *ca.* 50 ka in the NP could be substantiated this would no doubt raise problems for those workers favouring an early modern human influx from the east at *ca.* 45 ka (Mellars 2006a, b). Thus I believe that it is justifiable and more parsimonious to view these particular sites as evidence of Neanderthal settlement. That Neanderthals manufactured Upper Palaeolithic elements is generally accepted as a host of Châtelperronian sites situated in the SP and MP show. Moreover, there is an emerging willingness amongst some archaeologists to accept the idea that Neanderthals authored Upper Palaeolithic or Aurignacian industries at Trou de l'Abîme Vindija Cave and Bacho Kiro (van Andel *et al.* 2003).

Sigma (-)	6628	7420	6593	6934	7138	7079	7349	7225	8687	7849
Sigma (+)	6628	7420	6593	6934	7138	7079	7349	7225	8687	7849
Date	58557	58497	57436	56653	56452	56130	55978	55914	55232	52843
Method	C14	AMS C14	AMS C14	C14	C14	AMS C14	C14	C14	AMS C14	AMS C14
Lab No	GrN-4629	OxA-7125	OxA-6892		GrN-4637	OxA-7405	GrN-4308	GrN-12123	?	GifA-93050
Industry	Mousterian	Mousterian	Mousterian	Mousterian	final Mousterian	Mousterian	Mousterian	Mousterian	Mousterian	Mousterian
Site	Gr aux Ours	Konigsaue	Vanguard Cave	Sesselfelsgrotte	Gr. del Broion	Gr. La Cala	Regourdou	Pena Miel 1	Roca dels Bous	Barbas III
Country	France	Germany	Gibraltar	Germany	Italy	Italy	France	Spain	Spain	France
Longitude	47.4667	51.828	36.133	48.931	45.466	40.001	45.055	42.2089	41.866	44.866
Latitude	6.3833	11.409	-5.3	11.794	11.565	15.381	1.17	-2.619	0.8699	0.5584
S3P ID	570	1133	251	1143	1306	1293	541	206	177	732

Table 5.10 Selected Middle Pleniglacial radiocarbon determinations

5.11.5 H5 (ca. 45-44 ka)

The H5 event commenced at *ca.* 45 ka. We can see from fig. 5.24 that the H5 event coincides with the lowest point of what appears to have been a gradual decline in the δ^{18}O curve over the previous 8,000 years or so. Sea surface temperatures at this time in the sub-tropical Atlantic were at about 16°C. Fig. 5.30 illustrates the site distribution and general pattern of Neanderthal presence across the study provinces at this time.

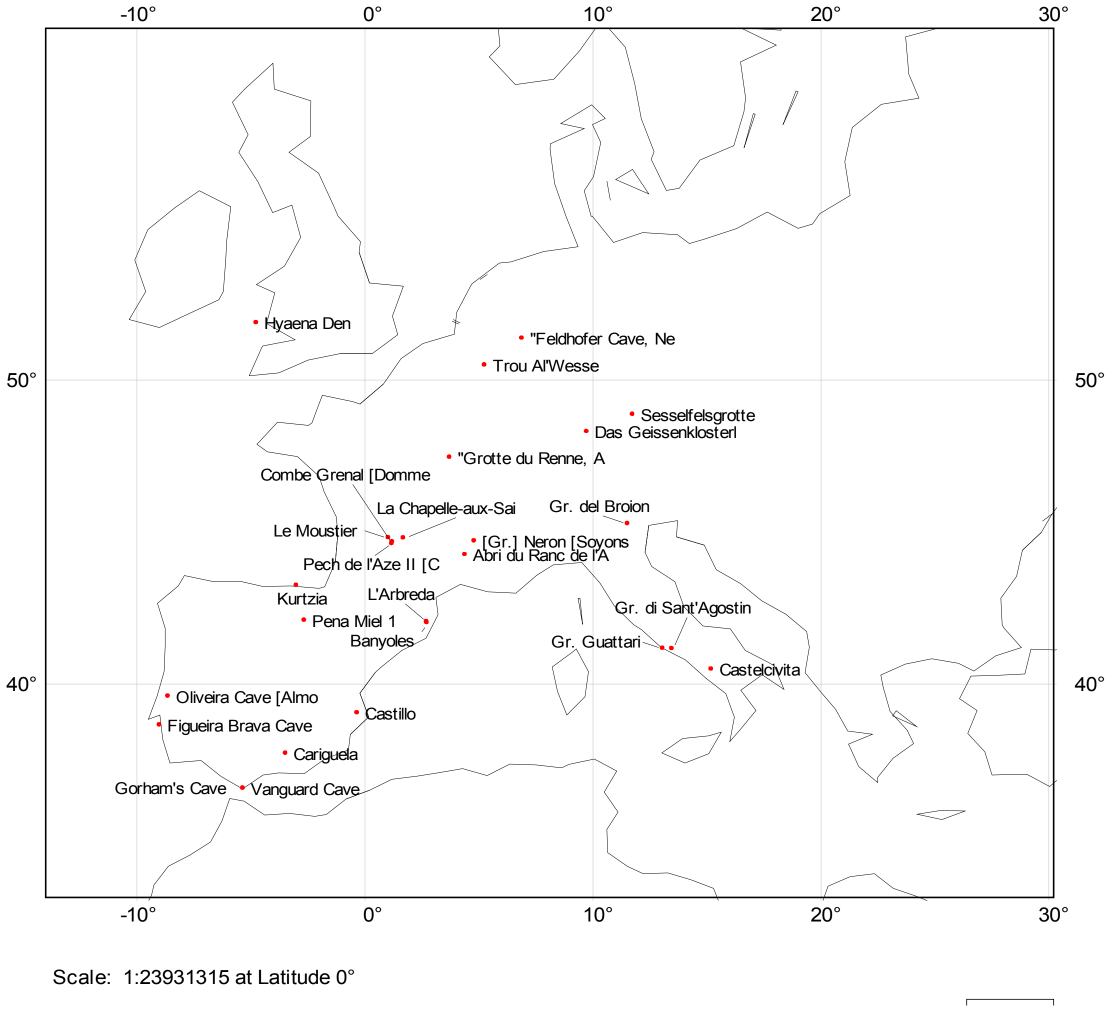


Figure 5.30 Neanderthal distribution during H5

We can see that in terms of the NP some differences between the pre-H5 and H5 do exist. For instance Paviland Cave, Soldiers Hole and Pin Hole Cave do not appear to have been occupied during H5. Similarly, the more eastern sites situated in the CP such as Willendorf II and Konigsaue appear to have been abandoned. This broad pattern gleaned it must be said from only a limited amount of data, is suggestive of a movement south or west perhaps as a result of the H5 event. Further support for this hypothesis comes from the apparent increase in sites located especially within the 0°E 10°E and 40°N 50°N section of the map. Several sites hitherto uninhabited during pre-H5 such as Grotte du Renne, Grotte del Brolon, Grotte Neron, Abri du Ranc de L'Arc, L'Arbreda, Banyoles and La Chapelle-aux-Saints appear to have been inhabited during the H5 event. Of course, it is extremely difficult to attempt to tie in particular dates to a particular climatic episode, but the archaeological data when viewed over a wider temporal window provide an indirect means to visualise the potential impact of a major climate change on Neanderthal populations. Thus it can be tentatively suggested that a pattern does exist, and that this indicates a regional abandonment of the NP and CP during H5. Dated sites applicable to the H5 event are shown below in fig. 5.31.

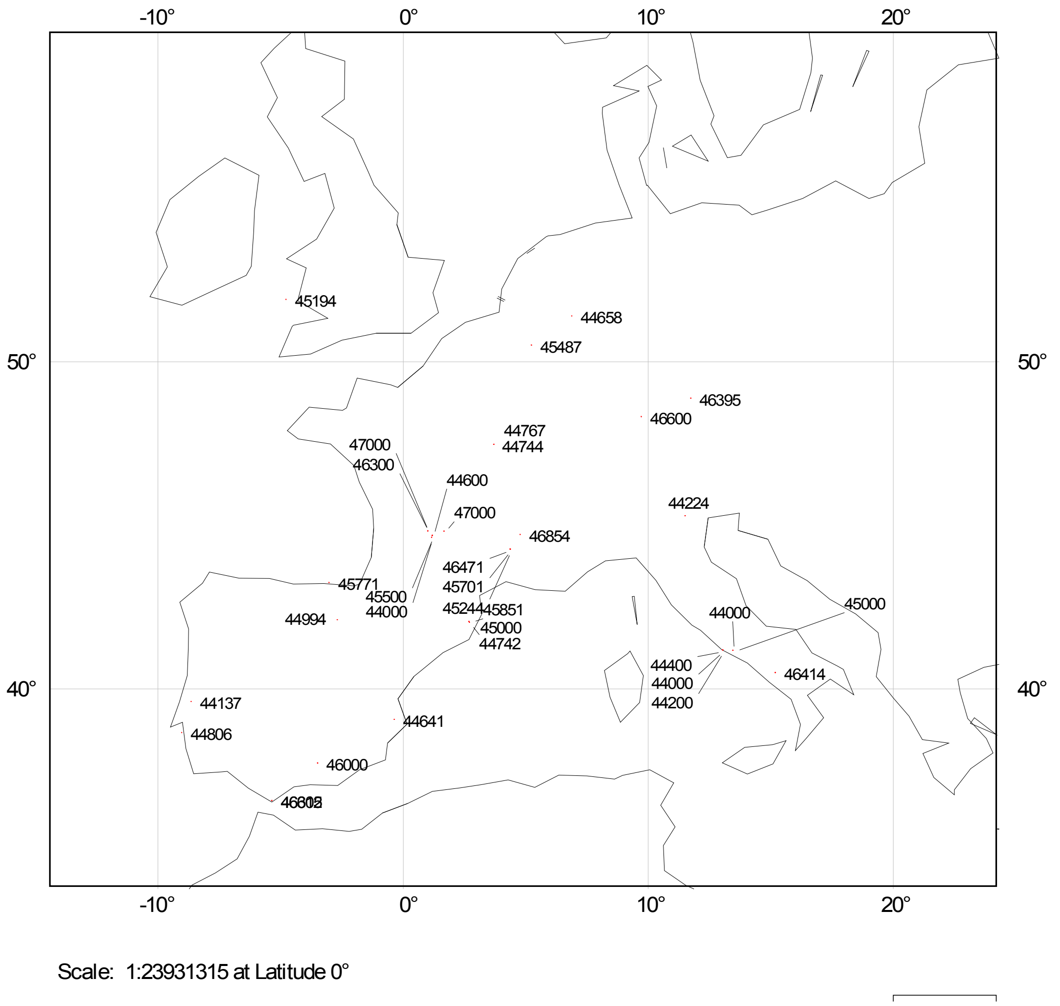


Figure 5.31 Dated sites H5

5.11.6 Post-H5 (ca. 43-40 ka)

For the purposes of this discussion post-H5 will corresponds to a *ca.* 3,000 yr period roughly between *ca.* 43,000 and 40,000 ka. Figs 5.32 and 5.33 illustrate the Neanderthal archaeological sites and dates respectively relevant to this period. According to GISP2 this phase witnessed three DO events. These are DO 11 (*ca.* 42.5 ka) DO 10 (*ca.* 41 ka) and DO 9 (*ca.* 40 ka). DO 12 at *ca.* 44 ka is a very visible signature in the GISP2 profile and appears to have occurred immediately after the H5 event. However as we have seen, it is impossible to accurately determine human presence during specific or narrow chronological windows so for the purposes of this study, the phase of time corresponding to DO 12 is subsumed within the timeframe given for the H5 event. These interstadials were all of different magnitude and duration (Fig. 5.24) thus appear to have had variable effects on global climate, for instance sea surface temperature varied between 18° and 21°C at the peak of these DO events. Presumably then, these DO events may also have exerted different controls on the palaeoenvironments, fauna and flora of Europe, and it is not inconceivable that they could have created different selection pressures on human populations, and that these pressures may have contrasted between the phases.

Based on the sites shown below it would appear Neanderthal settlement across the more northern areas seems to have occurred quite soon after the H5 event. We see that the same general areas of SW Britain which were occupied pre-H5 were again colonised. The SP appears to have witnessed an increase in population size, with more sites and dates available in the post-H5 phase than before. Population levels in the MP also appear to have increased over this period with greater numbers of sites situated across the Italian and Greek peninsulas. The CP, by contrast, did not witness any significant colonization ore re-settlement at this time.

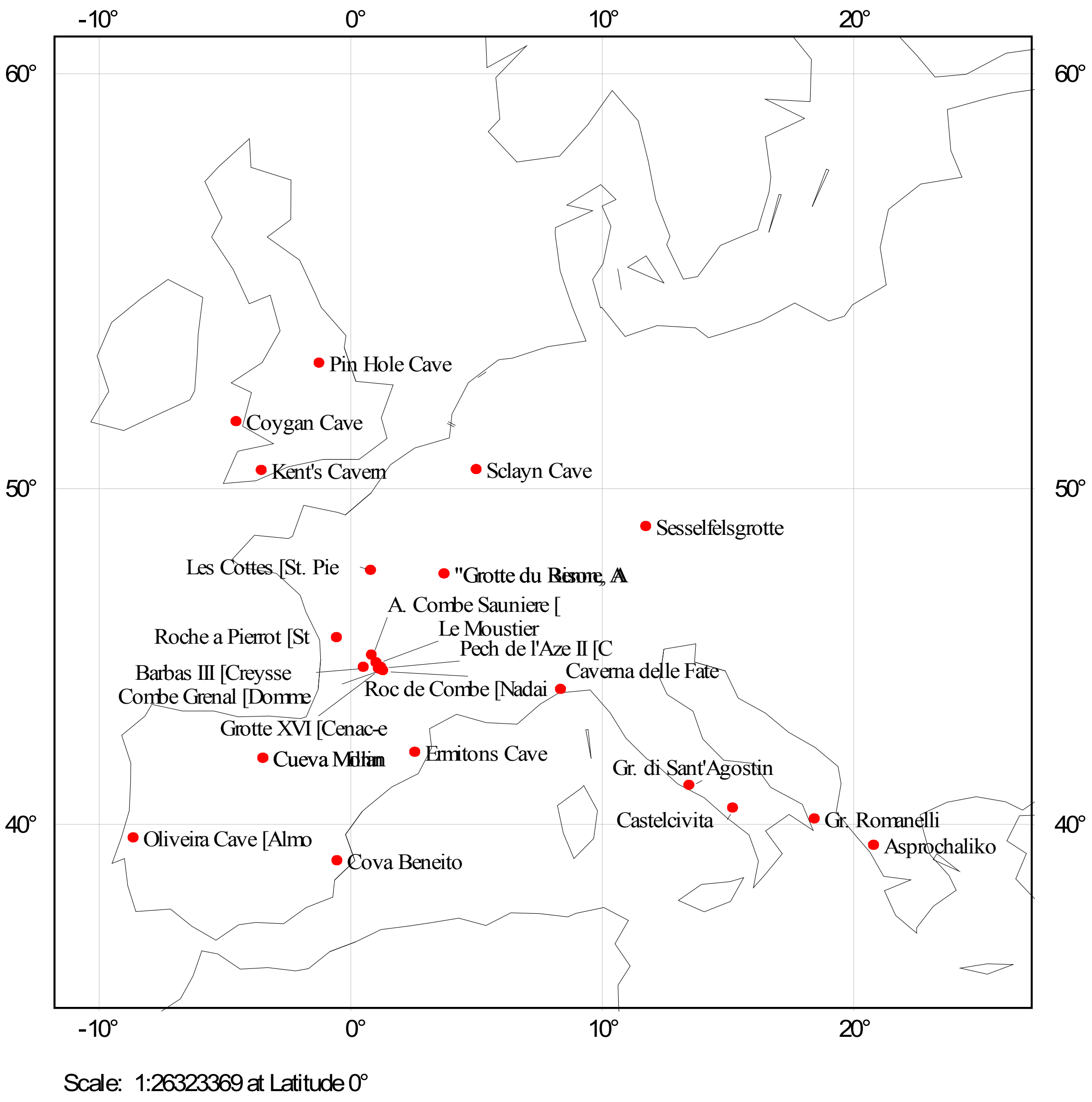


Figure 5.32 Neanderthal distribution post-H5

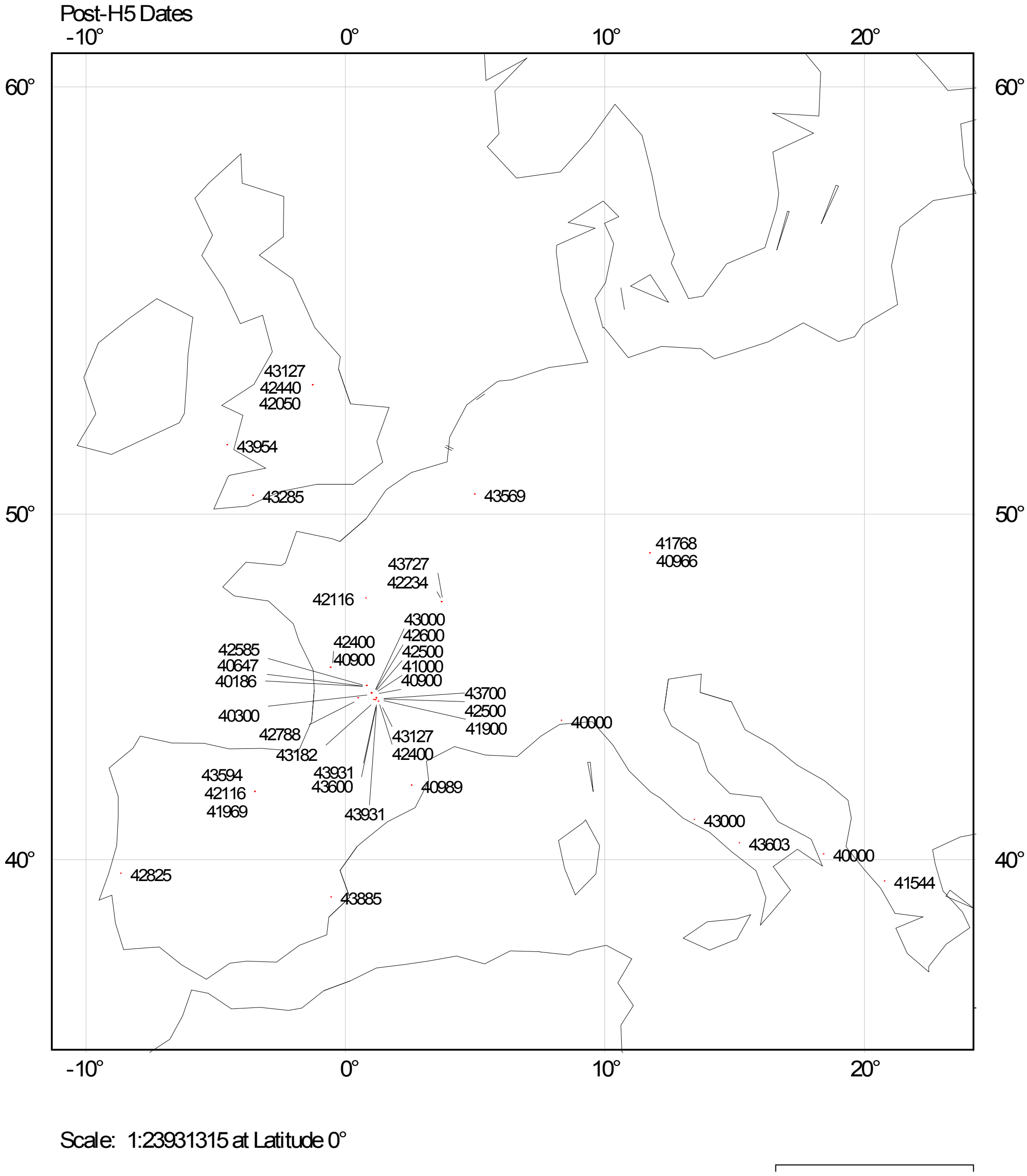


Figure 5.33 Dated sites post-H5

5.11.7 Pre-H4 (40-38 ka)

The pre-H4 phase corresponds to *ca.* 40-38 ka. Fig. 5.24 shows that temperature was very low after the GISP 2 DO 9 interstadial, however climate appears to have been very stable insofar as their does not appear to have been any sudden fluctuations over this period. Neanderthal site distribution is illustrated in fig. 5.34.

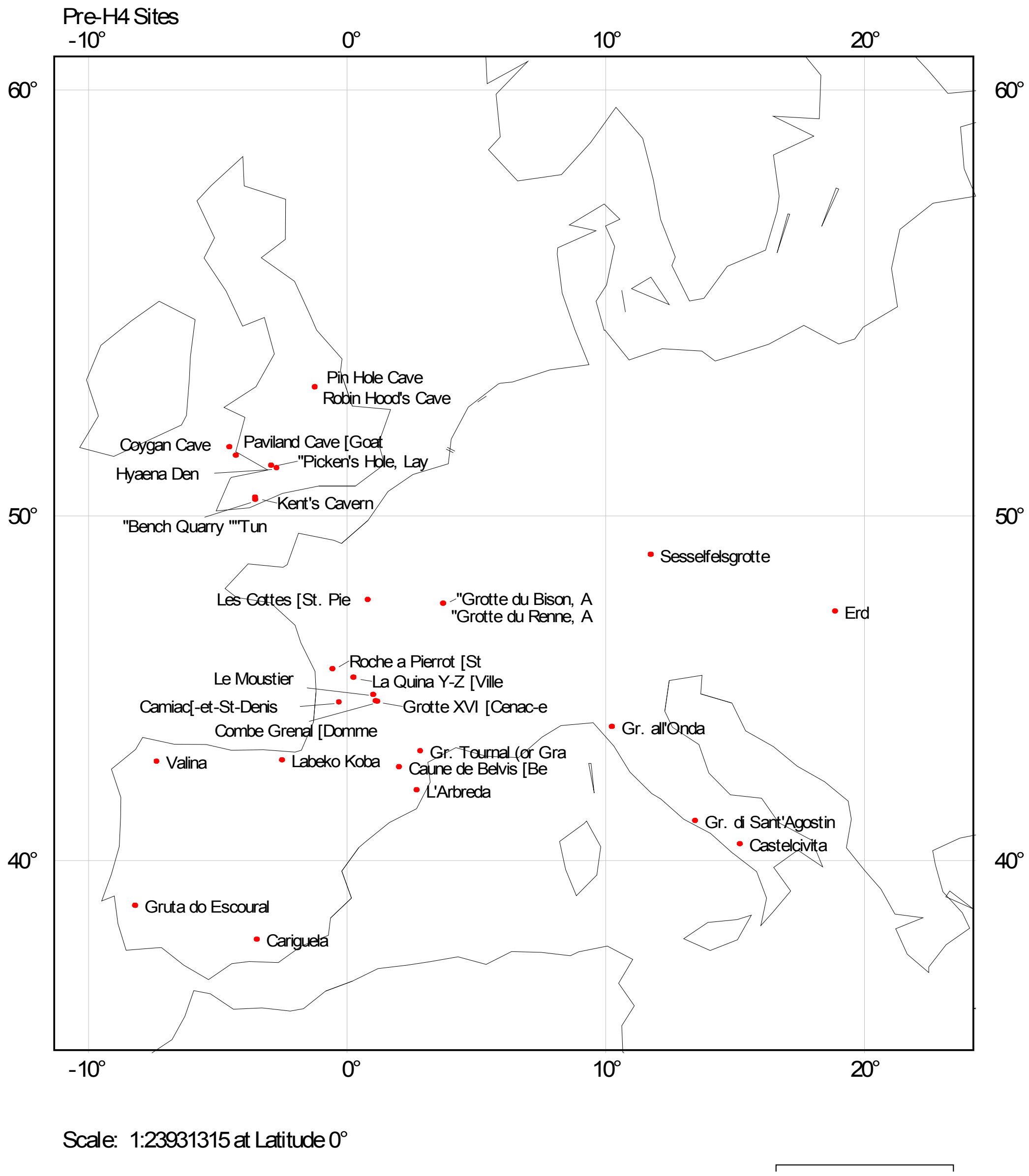


Figure 5.34 Neanderthal distribution pre-H4

The essential pattern of Neanderthal distribution, based on dates from this timeframe remains indistinguishable from the preceding post-H5 phase. While it is agreed that the actual duration of the pre-H4 phase is in fact less than the standard deviations associated with many of the 'relevant' archaeological dates this does not prevent us from at least suggesting that Neanderthal population levels appear to have remained relatively consistent between the H5 and H4 events. Added to this is the potential 'big if' insofar as if the Early Upper Palaeolithic sites located across the NP during this timeframe are indeed the work of the Neanderthals, then this would add further support to the idea that Neanderthals had perhaps, at least at a regional level adapted to the challenges of mid-glacial, high-latitude environments. This at the very least seems plausible, especially because five dates in particular (OxA-4782, BM-499, GrN-4400, OxA-3277 and OxA-4112) are all Mousterian and in close temporal proximity with the post-H5 phase. Alternatively it could also be argued that the sub-region north of 50° and west of 0° provided a more optimum combination of condition-resources than the adjacent areas of the NP north of 50° and east of 0° which does not appear to have been occupied by Neanderthals at any time during the IG-G. Fig. 5.35 shows the archaeological dates for this timeframe.

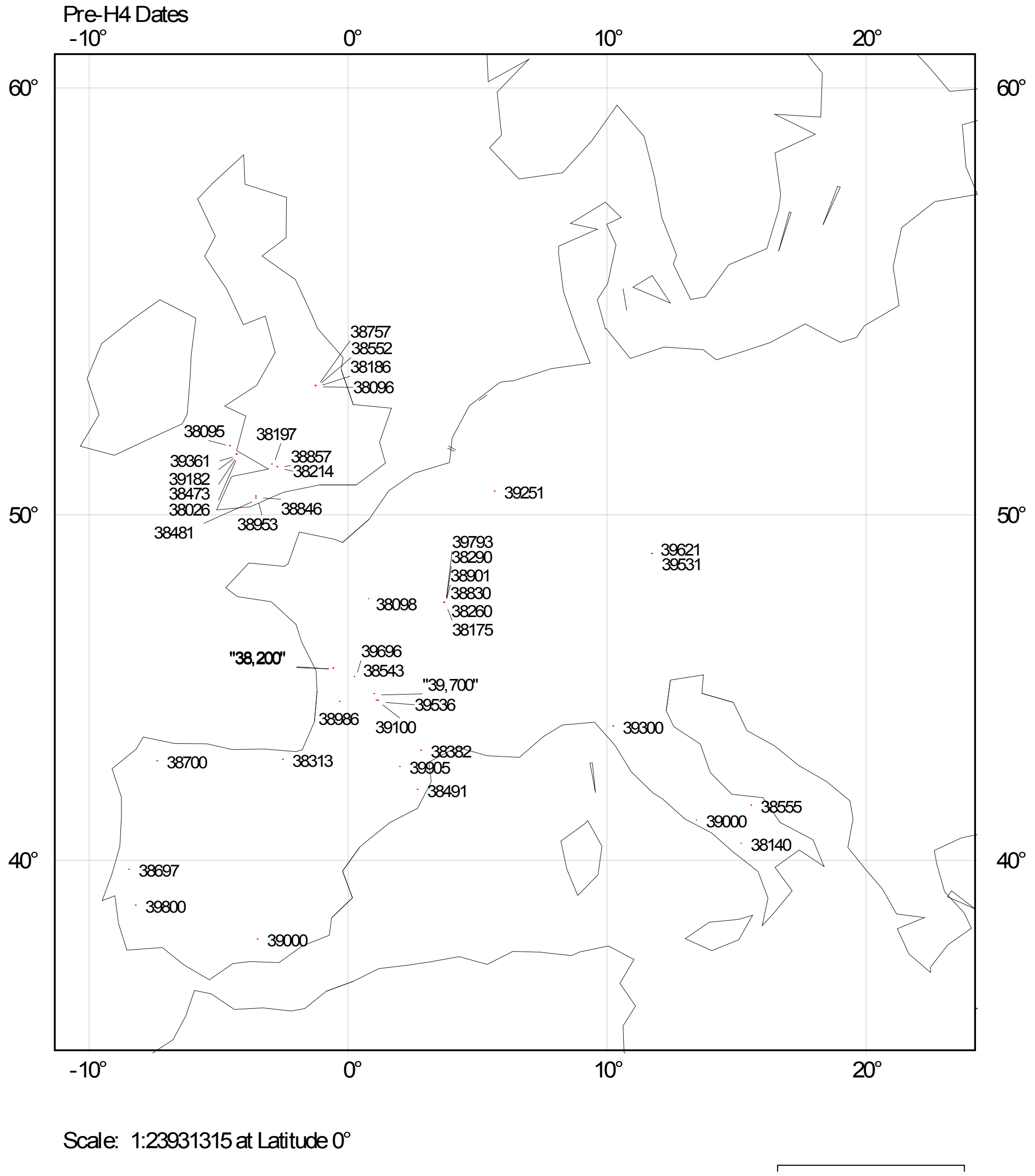


Figure 5.35 Dated sites pre-H4

5.11.8 H4 (*37,900-36,900 ka)*

The H4 event appears to have interrupted a period of stable but cold climate as suggested by the GISP2 $\delta^{18}O$ data. Proxy data from the subtropical Atlantic suggest that sea surface temperatures fell to around 15°C, representing perhaps the lowest temperature of the entire preceding Middle Pleniglacial. Fig. 5.36 shows that a clear shift in Neanderthal population appears to have occurred. All sites north of 50° appear to have been abandoned. Indeed Les Cottes in the SP represents the most northern site at this time. Previously there had been a clear preference for settlement in the SP at around 45° N and 0°E, but by now many of these sites such as Le Moustier, Camiac, Combe Grenal and La Quina were seemingly uninhabited. The sites of Tata and Salzofenhohle in the CP mirror this pattern of limited occupation of northern and eastern sites during H4. Fig. 5.37 shows the dated archaeological sites. The H4 event appears to have had a clear impact on Neanderthal settlement in western Europe. Abandonment of several key locales seems to have occurred.

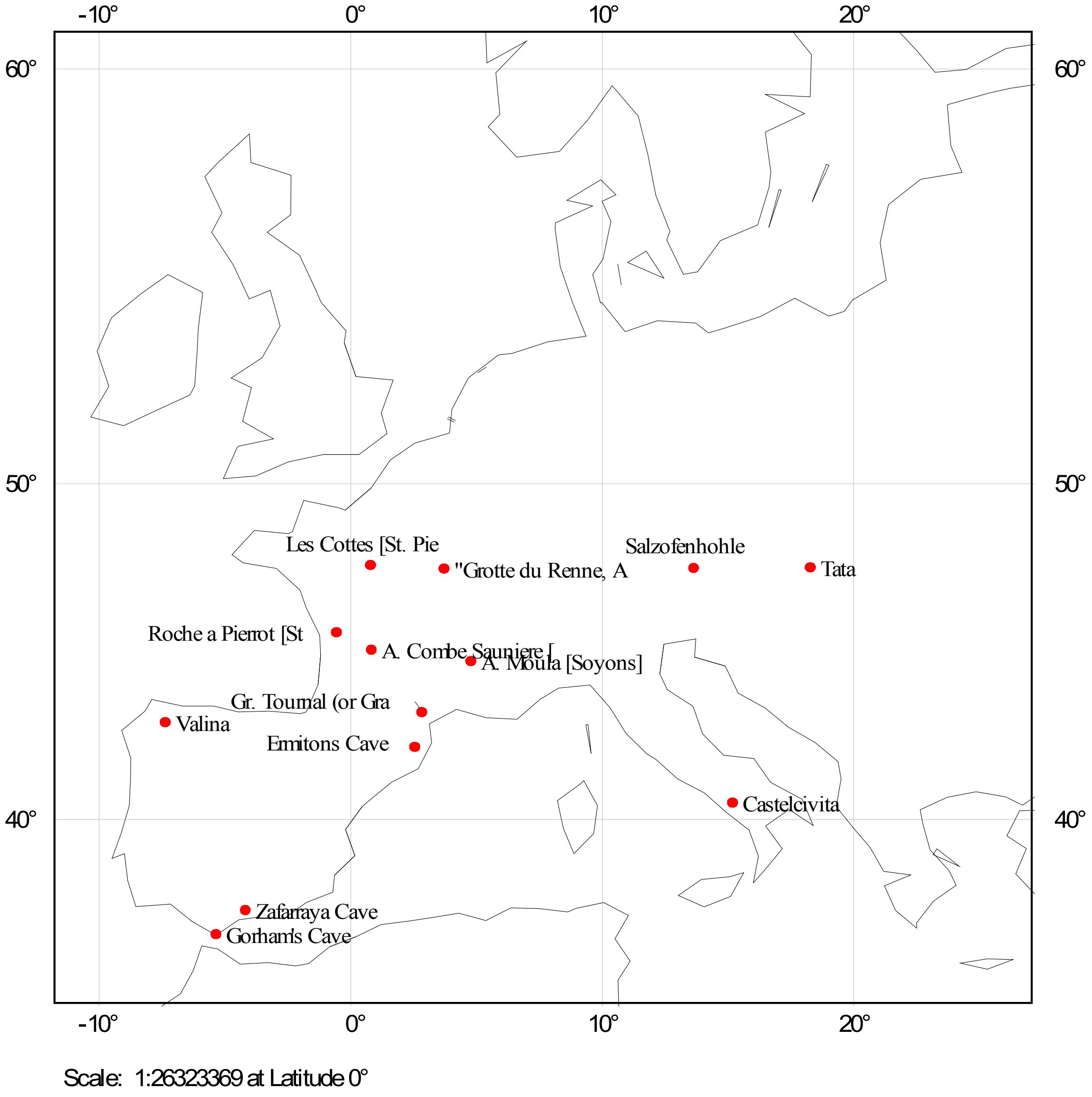


Figure 5.36 Neanderthal distribution during H4

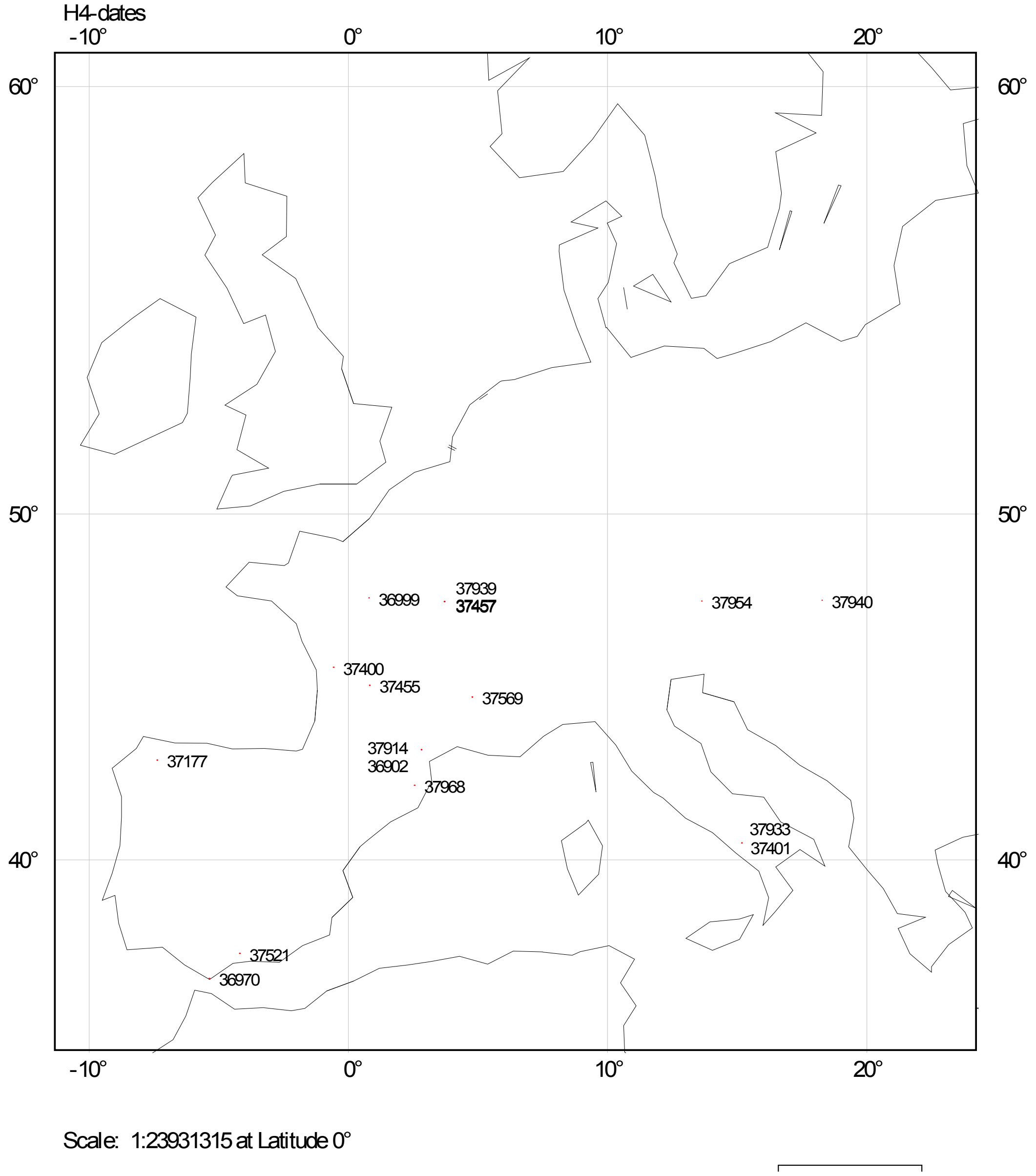


Figure 5.37 Dated Neanderthal sites at H4

5.11.9 Post-H4 *(ca. 37,000-34,800 ka)*

For the purposes of this discussion, the post-H4 phase is considered as a *ca.* 2,000 year period. We see from fig. 5.24 that both GISP2 and sea-surface temperature reconstructed from sub-tropical proxy data show that a strongly expressed DO event (GISP2 DO 8) occurred immediately after H4. These data suggest that sea-surface temperatures increased by as much as 6°C very rapidly indeed. Following the DO peak, climatic conditions as inferred from these proxies appear to have worsened considerably. Indeed the DO IS 8 cycle (from *ca.* 37-35 ka) appears to have been one of the most powerfully expressed of the so-called Bond cycles of the entire Middle Pleniglacial. So how did Neanderthal populations, already seemingly restricted to regions south of 50° latitude fare at this time? Fig. 5.38 below shows Neanderthal distribution patterns over this phase.

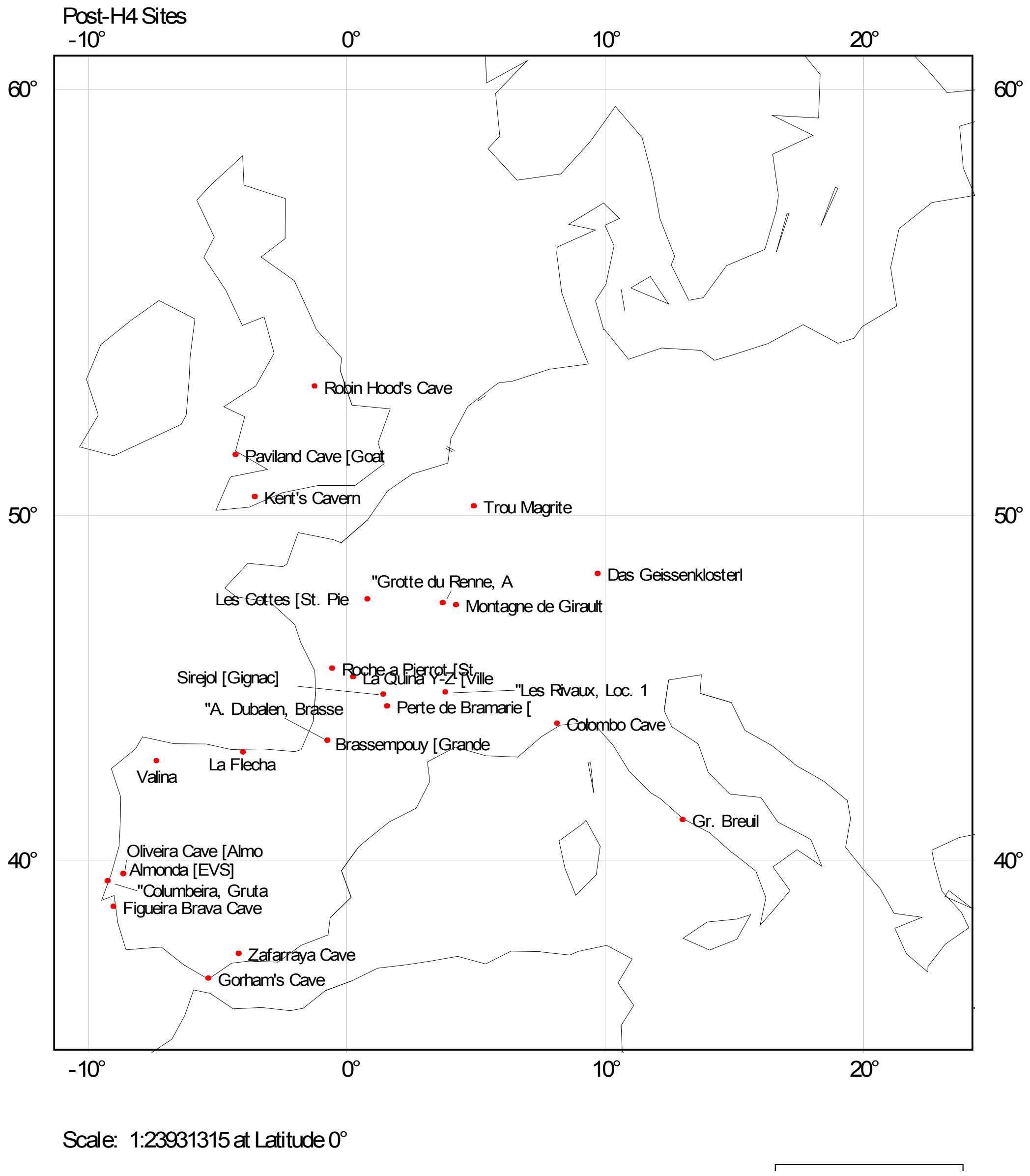


Figure 5.38 Post-H4 Neanderthal distribution

We see that the available data point to a further movement into the NP. We see that sites such as Robin Hood's Cave, Paviland Cave and Kent's Cavern, previously abandoned during the H4 event are occupied or re-occupied. One interesting observation is that

Neanderthals at this time do not appear to have occupied the more north-eastern part of Europe (north of 45° and east of 10°). Neanderthals also appear to have re-inhabited the SP, especially in the south-west of France, while the MP particularly along the northern, eastern and southern margins of Iberia appears to have witnessed perhaps its most strongly registered occupation since the pre-H5/H5 event. Perhaps this pattern is supportive of the so-called 'Neanderthal refugium' hypothesis, as proposed by several archaeologists (e.g. Stringer *et al.* 2003; Finlayson 2004). One cannot however argue that climatic deterioration or stress drove Neanderthals into this Iberian refuge *a priori*. As we have seen above, previous HE did not always result in the abandonment of higher latitudes or a Neanderthal retreat into the MP. On these grounds it cannot be argued that such a retreat, seen as inevitable by many workers owing to Neanderthal physiological or socio-behavioural deficiencies always took place following episodes of climate change. Rather, it appears that other contingent factors such as disease or local competition may have been at play, and these could equally have led to such a demographic outcome. It is even conceivable that the increased site numbers in the MP occurred as a function of local population increase and not as a result of immigration from other regions.

5.11.10 Pre-H3 *(ca. 34,700-32,000 ka)*

This phase of time was marked by at least three well-expressed interstadial events. They are recognised in the GISP2 sequence as GISP2 DO7 (*ca.* 35 ka), DO6 (*ca.* 33.5 ka) and DO5 (*ca.* 32.5 ka). Proxy data from the sub-tropical Atlantic indicate that sea surface temperatures were at a relatively constant 20° during these events. Fig. 5.24 also shows two well-expressed stadial events, both of which indicate that sea surface temperature dropped to around 16°C. In each of these three DO-cycles, warming appears to have occurred very rapidly, while cooling is clearly observed as a period of down-stepping, indeed, cooling phases throughout all DO cycles appear to have relatively protracted processes in comparison to phases of amelioration. One particularly interesting feature of these three DO cycles is that while they clearly qualify as abrupt oscillations, the magnitude of the DO IS 5, 6, 7 appears to have been considerably less than DO IS peaks 8, 10, 11, 12 and 3. Similarly, the two stadial events at *ca.* 34 ka and 32 ka appear to have some of the coldest of the entire glacial period. Thus in relative terms the temperature displacement appears to have been largely the same between the earlier and later phases of instability. Fig. 5.39 illustrates the distribution pattern of Neanderthal populations over this timeframe.

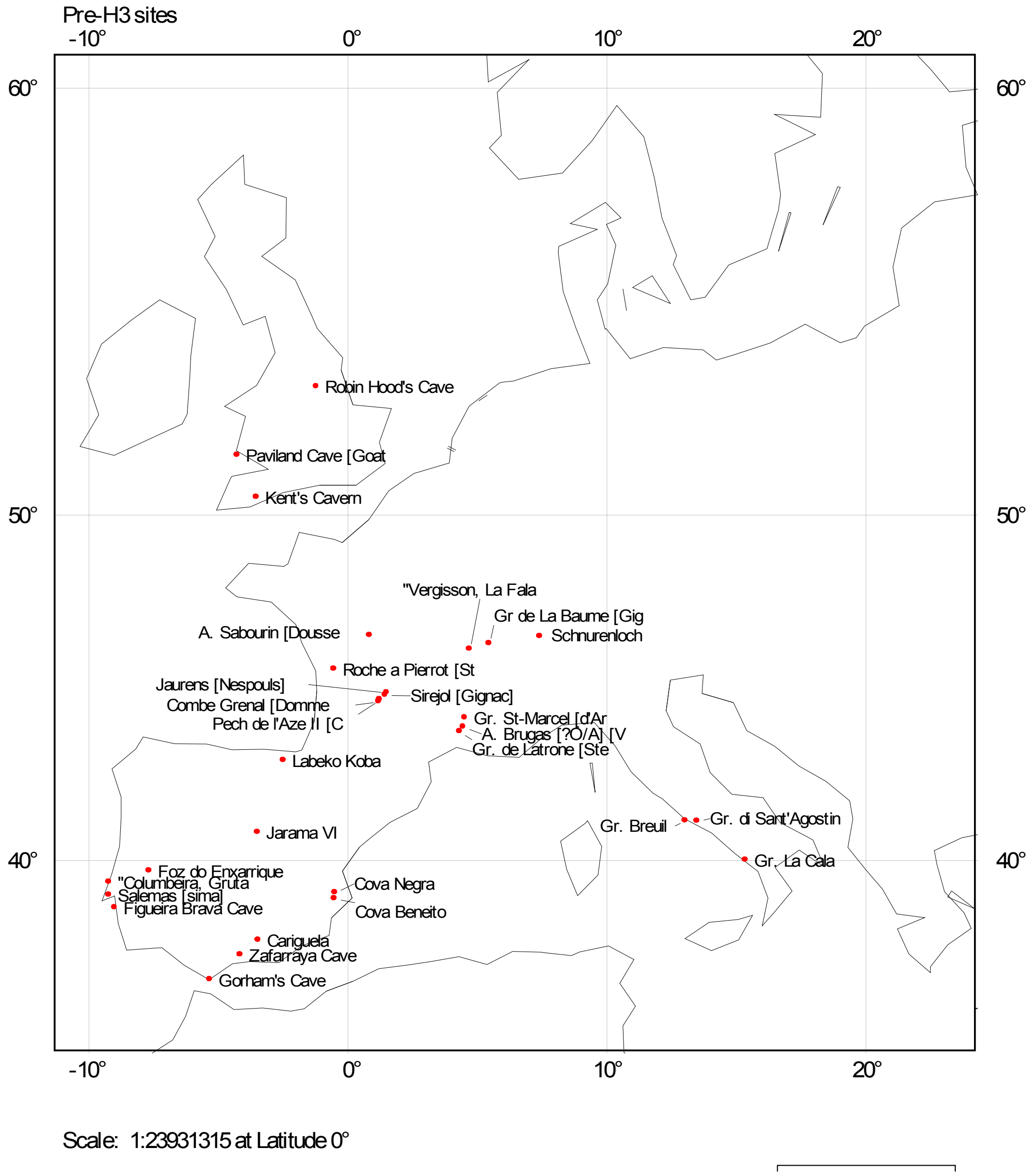


Figure 5.39 Pre-H3 Neanderthal distribution

It appears that Neanderthal distribution was largely centred, at least from the perspective of this study, around two major areas. These maintained clear pockets of sites and were situated east of 0° and 10°E and at 45°N in the SP and south of 40°N and west of 0° in the MP. There is also a suggestion that a third focal point existed in the Italian peninsula. Neanderthals do not appear to have been present in the CP with the same visibility as the SP and MP. Note that this more centralised pattern differs to the overall pattern observed for pre-H4, which was altogether more diffuse, lacking the concentration of sites which is evident for the pre-H3 phase. Looking at this overall pattern, coupled with the nature of changing climate which characterised this phase one may be tempted to infer that the nature of climate change over this period, characterised by three interstadials and two stadials, was the most probable factor in the geographic restriction of the Neanderthals. This is to say, climatic and environmental uncertainty ushered Neanderthal populations into regions that were more resilient to disruption. In doing so we can envisage that the regions or sub-regions displaying stronger or more visible settlement histories may have been more conducive to long-term habitation. To accept this one would be required to posit the existence of zones situated over vast areas of Europe, in this case across France and the Mediterranean that were in some way insensitive to the effects of climate change. While this may have been the case at the local level it seems highly unlikely that this would also have been the case at this scale. The more parsimonious explanation is that Neanderthals not only appear to have coped with rapid climatic change, but also high-magnitude climatic change akin to the events which took place during pre-H3. Fig. 5.40 shows dated sites from this phase.

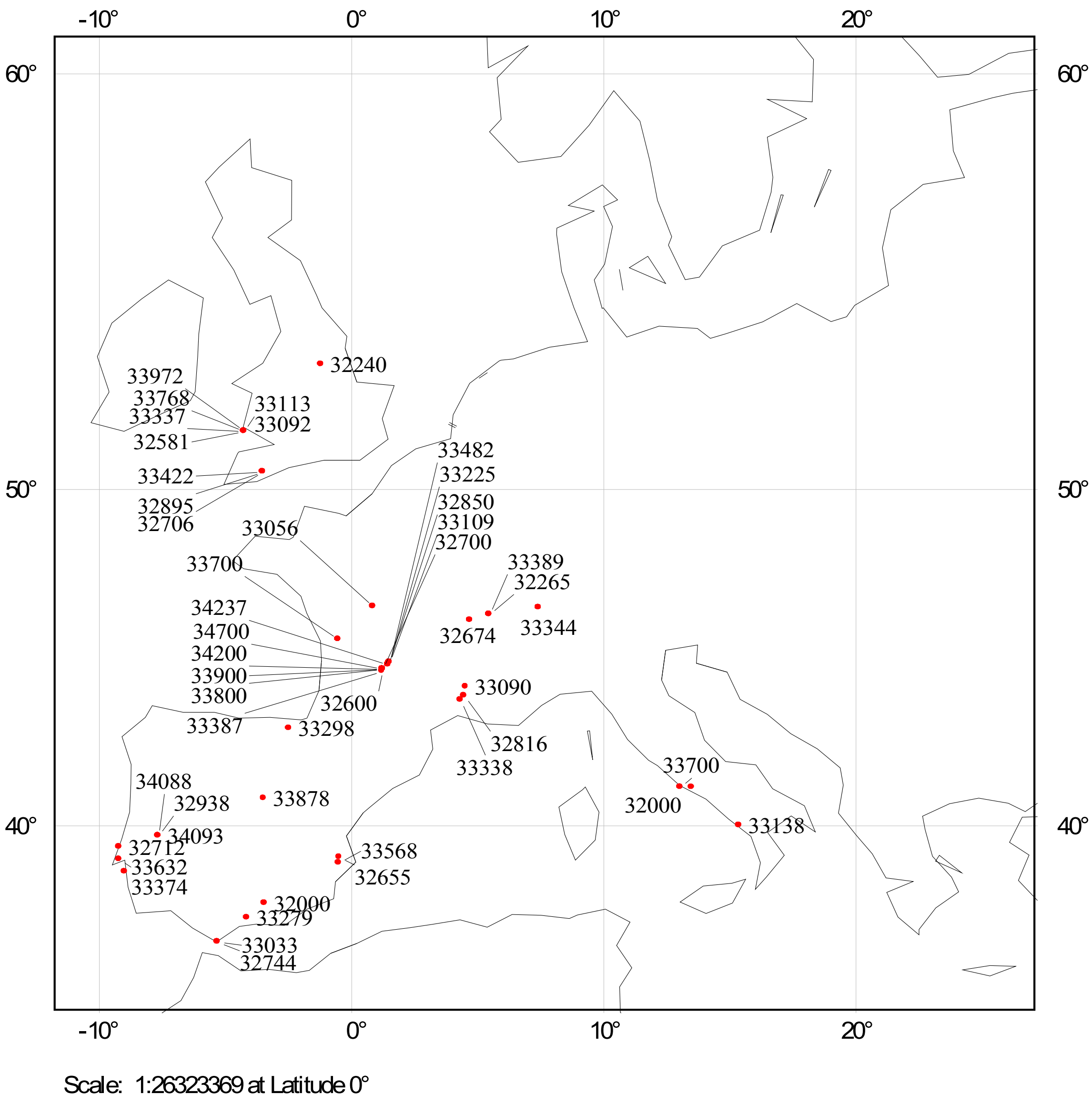


Figure 5.40 Dated Neanderthal sites at Pre-H3

5.11.11 H3 *(ca. 31.5-29 ka)*

By the end of GISP2 DO5 at *ca.* 32 ka sub-tropical sea surface temperatures had dropped to around 16°C as shown by the fall in $\delta^{18}O$ values. These values remained stable for the next 3,000 yr period suggesting that while this phase was no doubt one the coldest of the Middle Pleniglacial it also appears to have been one of the most stable. Fig. 5.24 shows $\delta^{18}O$ at this time was undoubtedly low and suggestive of colder conditions, but climate change was characterised by low-order fluctuations between the 42-41 ‰ values. Many of the stadial events which preceded H3 appear to have been marked by higher amplitude shifts in $\delta^{18}O$ values, for instance the stadials between DO events 8 and 6 saw variation between 38-42 ‰. The H3 event appears to have initiated at *ca*. 30 ka but it is arguably comparable to the other centennial-scale disruptions visible in the GISP2 $\delta^{18}O$ proxy.

Fig. 5.41 shows that Neanderthal distribution during the H3 phase appears to have been highly diffuse, with no real focal points (other than Iberian coastal cave sites) suggestive of strong, regional occupation.

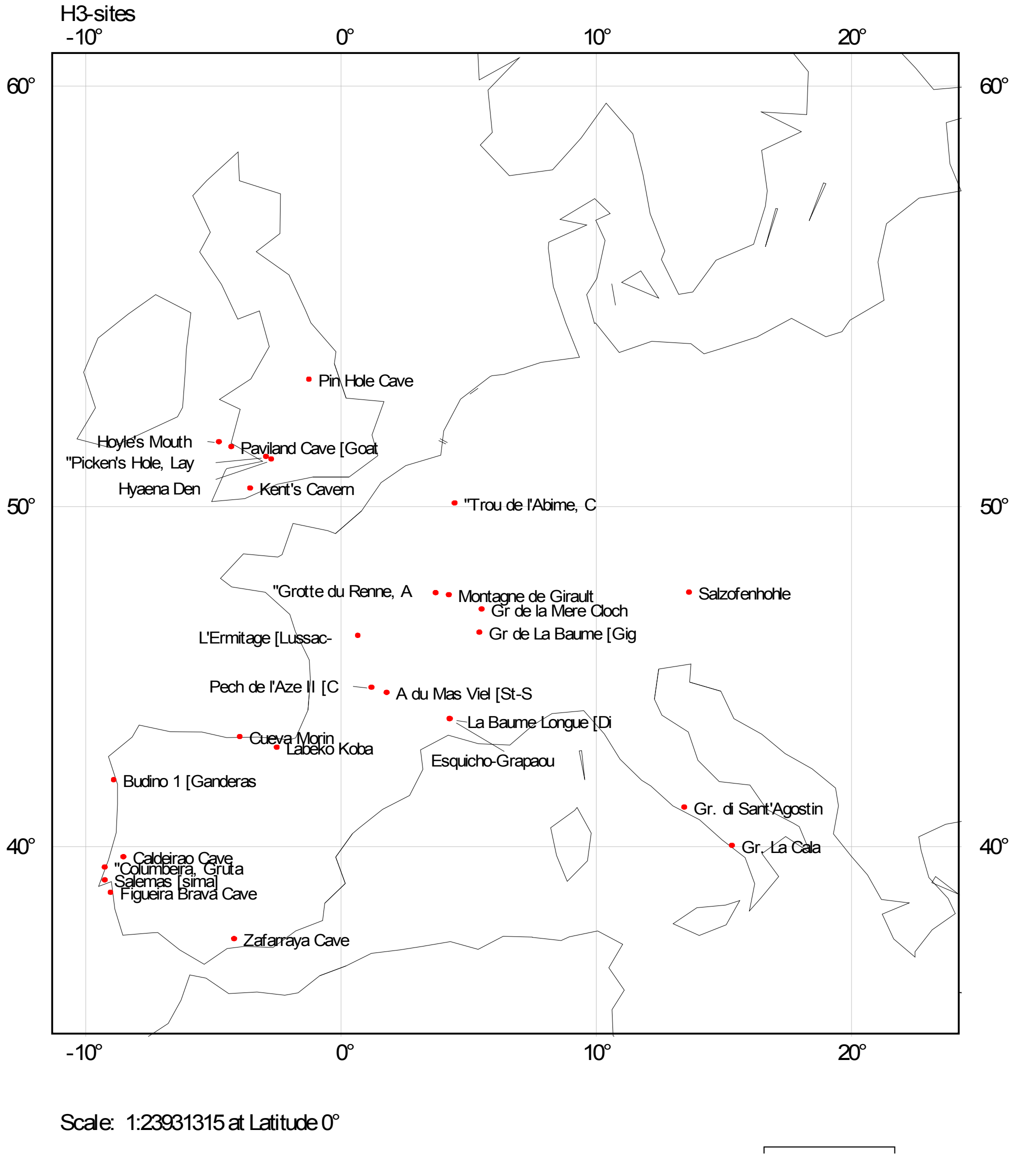


Figure 5.41 Neanderthal site distribution during H3

We see that the relatively dense occupation of the SP during the pre-H3 timeframe was superseded by abandonment of hinterland France and in its place a more diffuse occupation throughout the SP by a presumably smaller population. A relatively strong Neanderthal presence in the MP is also attested to by the fact that sites along the northern and western margins of the Iberian Peninsula were preferentially occupied to those of the hinterland.

5.12 Discussion

As with the preceding discussion in chapter three we have seen there is an emerging consensus that Middle Pleniglacial climatic changes were major factors in Neanderthal extinction. Some of those models discussed contended that the archaeological model of Neanderthal replacement could have been facilitated by the short and severe phases of climatic downturn such as DO and HE, and that these provide a powerful explanation for a process of major demographic change such as that envisaged during the Late Pleistocene. This study has provided an opportunity to test such an idea, and to examine in more detail the nature of the responses of geographically well-distributed Neanderthal populations to four major events which took place at *ca.* 60-59 ka, 46 ka, 40-38 ka and 31-29 ka. It has provided an opportunity to assess at least in qualitative terms Neanderthal presence before, during and after such events. Moreover it should at least shed some new light on the idea that climatic events and population expansion or decline were closely correlated in time or not. With this in mind it is pertinent to examine in more detail whether a decline in the number of radio- or chronometric dates and/or occupied sites can be phase-matched to HE. Fig. 5.42 below is a composite of the general trends in Neanderthal population variation over these phases. We can see that site numbers and the number of dates corresponding to each site are in close correspondence.

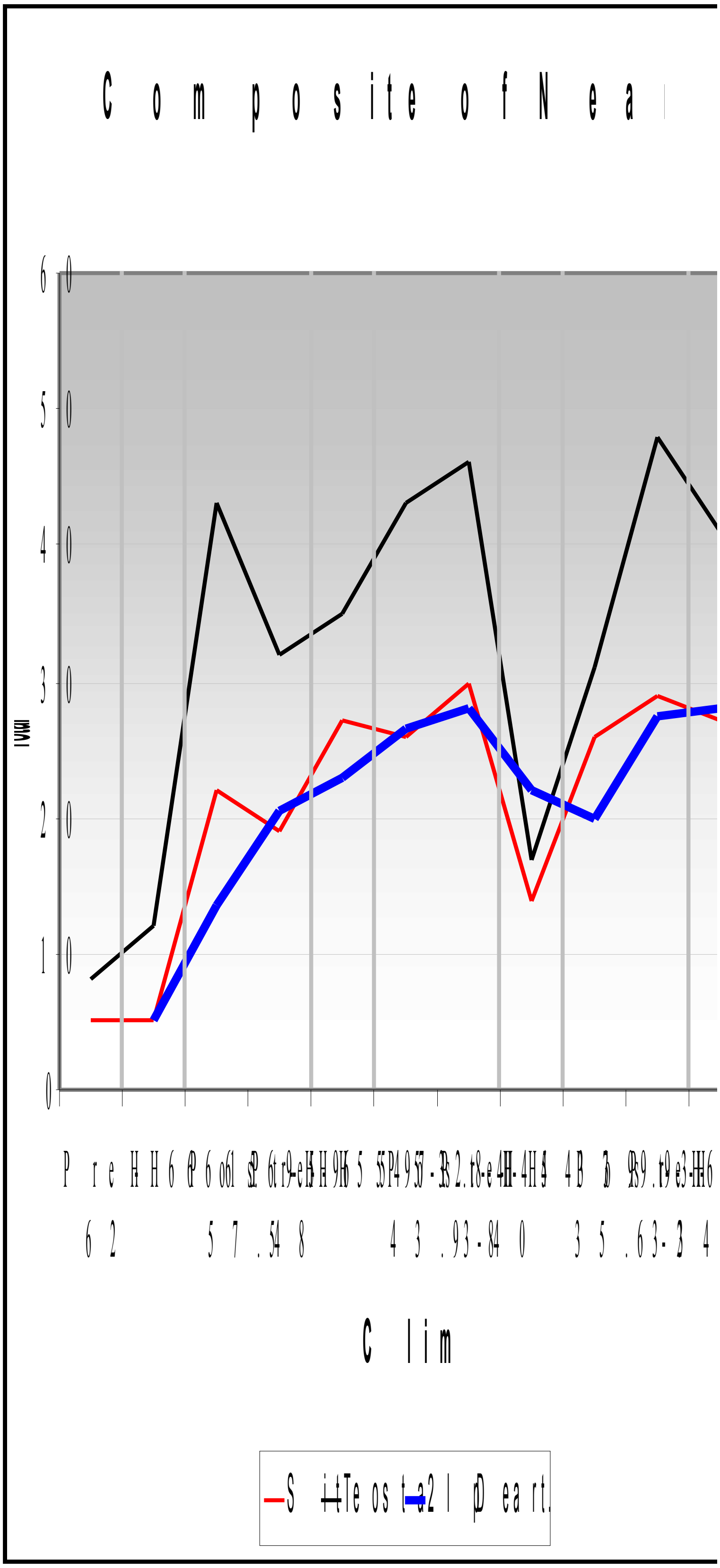


Figure 5.42

A total of 230 instances of Neanderthal occupation can be identified over this composite timeframe. This is to say, using pre-H6 as an example, that five separate sites were occupied during this timeframe.

Phase	<H6	H6	>H6	<H5	H5	>H5	<H4	H4	>H4	<H3	H3
Total	5	5	22	19	27	26	30	14	26	29	27

As we have seen the pre-H6 phase provides a total of 5 sites and only a handful of dates, each of which display a considerable standard deviation comparable in fact to the narrow 4,000 year period of interest. Three scenarios are envisaged (i) Neanderthals had abandoned the study provinces during the Early Pleniglacial or (ii) Neanderthal settlement was more expansive but we lack a suitable library of excavated sites or reliable chronometric data (iii) the available dates are wrong or date to an earlier/later period. A similar pattern characterises the H6 phase and the three scenarios can be equally applied. Nevertheless it is perhaps tempting to conclude that the relative dearth of Neanderthal presence was indeed due to the residual Early Pleniglacial environments exacerbated perhaps by the H6 event. Some support for this idea comes from the fact that more visible Neanderthal settlement appears to have taken place after the Early Pleniglacial and H6 event. A more interesting pattern occurs during the post-H6 phase and this is summarised in fig. 5.43 in more detail. At this time the first major increase in Neanderthal data can be observed. Phases 1-3 represent *Heinrich Cycle 1* (HC1), phases 4-6 *Heinrich Cycle 2* (HC2), phases 7-9 *Heinrich Cycle 3* (HC3) and phases 10-11 *Heinrich Cycle 4* (HC4). With the exception of HC4 each cycle is comprised of an HE as well as a pre- and post- HE phase. These pre- and post- phases are useful for comparative purposes as they clearly indicate a non-linear pattern (i.e. population growth during warm phases and population decline during cold phases) of human (Neanderthal) response to climatic change, a theme discussed in more detail below.

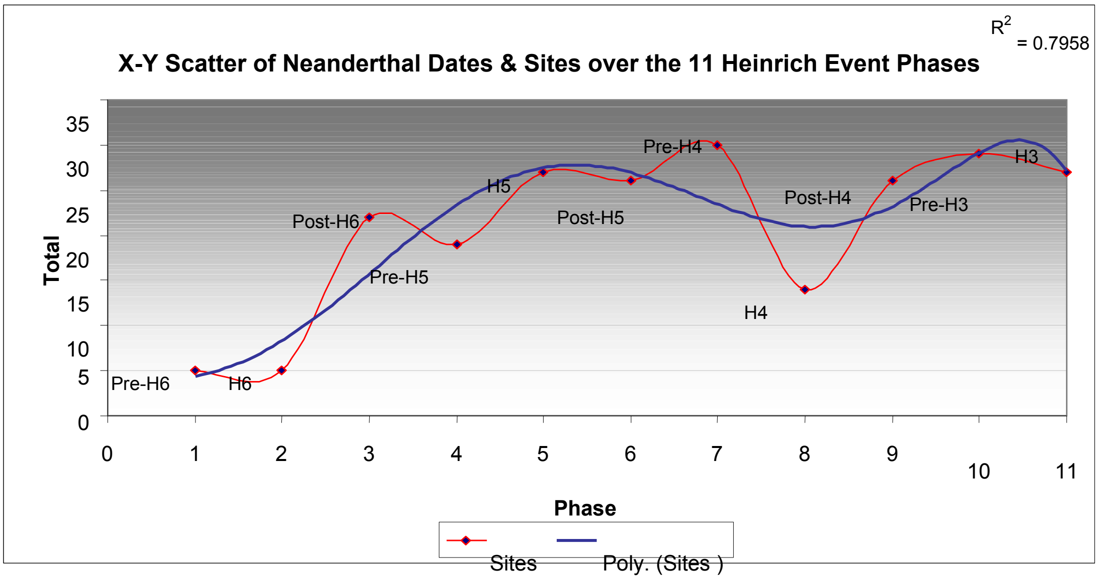


Figure 5.43 x-y scatter of Neanderthal dates and sites

The post-H6 and pre-H5 phases (late HC1 & early HC2) are separated by some 3,500 years which I have purposefully left to one side as this analysis is more concerned with the periods more proximal to HE. During late HC1 we witness a considerable increase not only in the scope of Neanderthal settlement, but also in the quantity of dates. The pattern suggests that post-H6 Neanderthal populations were widespread across the study provinces, a pattern which also appears to have continued into the pre-H5 phase. It seems that this period witnessed the resettlement and colonisation of new habitats. Interestingly the post-H6 and pre-H5 phases were both characterised by at least four sharp DO events (GRIP DO 17, 16, 14 and 13) which do not appear to have hindered the process of resettlement at least at this scale of analysis. It is interesting that Neanderthals appear to have settled across a well-defined 37°-53°N and -8°E 15°W 'macro-region' during Heinrich Cycle 1, which as we have seen, was marked by a relatively sharp increase in occupied sites over time.

HC2 was characterised by a period of continuing settlement in the core area along with some apparent colonisation of habitats in the NP and CP. The H5 event does not appear to have attenuated the process of resettlement nor restricted the scope of the colonisation. It is interesting that the H5 event, a marked period of climate downturn as GISP2 shows, was succeeded by GISP2 DO 12, a very strongly expressed interstadial event. That Neanderthals were present quite widely throughout western Europe during these changes and, moreover, apparently sustaining a meaningful demographic presence suggests that some proxy climate changes may be overstated i.e. they did not significantly disrupt Neanderthal distribution or that Neanderthals were adapting to the new environmental circumstances that such changes are thought to have created. Several major episodes of oscillatory climate occurred, yet these do not appear to have hindered or restricted the Early Pleniglacial colonisation. I argue that HC2 provides sufficient evidence to refute the idea that oscillatory climate (thus presumably environment) led to the extinction of Neanderthal populations in all places and at all times. While this of course cannot be ruled out, I feel that in this case it is more likely that the adaptive responses of a geographically widespread Neanderthal population to the demands of climatic variation was sufficiently advanced, and that this is a plausible alternative model to the notion that Neanderthals, in the face of uncertainty, retreated into more manageable, lower-latitude habitats.

The pre-H4 phase saw not only a well-expressed Neanderthal distribution throughout the 'core' area, but also perhaps a broader distribution in space which extended more to the north and the east (55°N and 20°E) than during earlier phases. There are some 30 sites associated with this phase, the highest number recorded in this study. But then something happened which appears to have reduced the Neanderthal population to near Early Pleniglacial levels. Fig. 5.42 shows that this population downturn occurred closely in time with the H4 event. We see a 50% reduction in total number of sites and those which remain are restricted principally to cave sites south of 50°N and largely located in the SP. On the face of this apparent association between population decline and climate change it would seem plausible to suggest that Neanderthal populations across Europe may have been critically disrupted as a result of H4. Yet this apparently straightforward interpretation is not as elegant as it at first seems. In a recent publication Roche *et al.* (2004) suggested that H4 was not as 'severe' as an uncritical acceptance of the term 'Heinrich event' would imply. They have suggested the H4 duration was far less than the traditional estimate of *ca.* 2 kyr (40-38 ka). They proposed that it was a tripartite phase comprised of a stadial, a 'small' interstadial followed by the H4 proper, which they say began at 36.25 ka and lasted approximately 250 ± 150 years resulting in only 2 ± 1 m sea-level change. These estimates of duration and magnitude are of course significantly different from the established view of *ca.* 2,000 yr duration with up to 15 m of sea-level change (Bond and Lotti 1995). Yet it is my feeling that they perhaps overstate this position. Roche *et al.* (2004: fig. 3) show H4 as the phase corresponding to a series of very fine δ^{18}O fluctuations occurring between 43-42‰. This is preceded by an 'interstadial', visible as a centennial series of almost imperceptible δ^{18}O 'fluctuations' with values between 42.5-41‰ between *ca.* 36.4 and 36.8 ka. This latter, purportedly warm phase in the eyes of Roche *et al.* (2004) demonstrates that H4 was less-substantial in terms of magnitude and duration. This is an interesting insight but one that is certainly problematic in its expectation: can sub-millennial fluctuations such as these low-order changes, 2 or 3 centuries in extent on single per-mille scales really be viewed as an amelioration and thus grounds to argue H4 was less severe than traditionally seen? Perhaps only detailed terrestrial palaeoenvironmental constructions will produce the detail necessary to answer such questions.

Nevertheless the apparent downturn in Neanderthal visibility at this time would appear to provide those workers who are in favour of the idea that a parallelism exists between Neanderthal movements and rapid climate changes good grounds to argue H4 is significant in this regard. However as perhaps is to be expected, the reality is not so straightforward. Human populations were not inert substances reacting in controlled and predictable ways to a series of climatological prompts in the sense of a chemistry experiment. We cannot simply conclude that *all* responses were the same at *all* times to the same stimuli. If Neanderthals reacted in one way during a particular climatic phase and differently in another i.e. population growth and decline took place during warm and cold phases respectively we should be able to use the archaeological data to investigate this hypothesis. Fig. 5.44 develops this idea by displaying Neanderthal site numbers across simplified cold (HE) and optimum warm (pre-HE) phases. For clarity, I have added an *expected trend* which in a sense is an arbitrary or 'common sense' baseline which should display a clear trend if the number of Neanderthal occupied sites increased during warm periods or declined during cold periods. It is not intended to convey any sense of the number of expected sites per se only to illustrate relative, qualitative contrasts in growth and decline during warm and cold respectively. Thus the null hypothesis, that Neanderthals were preferentially warm adapted and unsuited to periods of irregular, high-magnitude climate change can be examined.

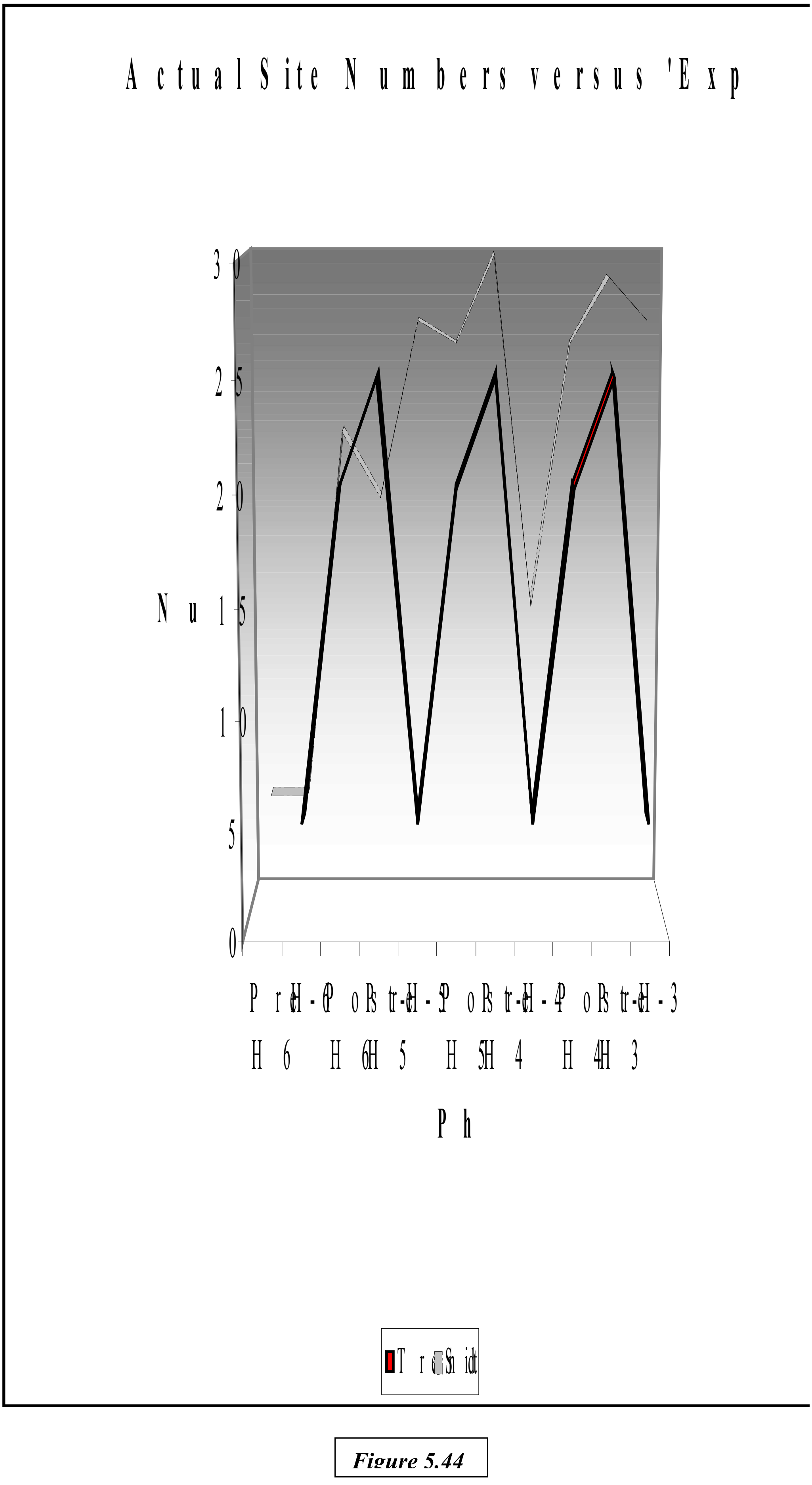

Actual Site Numbers versus 'Exp
30
25
20
15
10
5
0
Nu
Pre-H6
Post-H6
Pre-H5
Post-H5
Pre-H4
Post-H4
Pre-H3
Ph

Figure 5.44

With regard to the H6 phase and HC1 in general very little can be said about Neanderthal response to climatic change owing to the limited amount of data. Nevertheless it is clear that a major increase in site data occurred during the post-H6 phase. At this stage we cannot necessarily untangle whether such an increase was due to amelioration following the Early Pleniglacial or the H6 event. During the pre-H5 event, a reduction in site data may have taken place. But it is less certain whether this reduction was linked to oscillatory climate prior to GISP2 DO13, which is rather pronounced, or because of DO 13 itself. Alternatively the dates and sites presumed relevant to this period may not correspond with this phase.

It can be argued more forcefully that HC2 does not provide those who advocate a parallelism between Neanderthal decline and climatic deterioration much support whatsoever. H5 was followed by a pronounced interstadial (GISP2 DO 12) and increased levels of Neanderthal presence associated with this couplet clearly shows that Neanderthals at this time were not significantly disrupted by millennial/centennial scale disruptions. On the contrary; they appear to have coped admirably, reaching their most numerous levels at any point of the entire Middle Pleniglacial.

HC3, but especially the H4 event indicates a much closer fit between the 'expected trend' and Neanderthal site data. But as we have seen the interpretation of the key parameters of this episode, in terms of severity, duration and intra-phase frequency appear to be open to a variety of interpretations. After the H4 event we see that sites effectively double over this period. It is this pattern of an increase in sites particularly during the post-H4 which supports the idea that in *this particular phase* Neanderthal response to climatic amelioration and deterioration was linked. Such an argument cannot be made for Neanderthal demographic changes during the HC1 and HC2.

5.13 Final Remarks

The preceding discussion has hopefully illustrated two main points: (1) that there is something unsatisfactory about the notion that *Neanderthals* were unsuited to alternating stadial and interstadial climate states (2) that Neanderthal demographic structure can be essentially predicted based upon a particular climate state.

So does this mean that climatic and environmental change did not kill-off the Neanderthals? It appears that this question can be answered by yes and no. *No*, because we have emerging evidence that Neanderthals did indeed cope with the climatic oscillations and their effects on European environments over much of the Middle Pleniglacial, displaying evidence for a greater site distribution during putative episodes of oscillatory climate including an array of HE and DO. And *yes*, because it still remains plausible that a particular episode of climate change may have imparted a far greater impact on a much deeper range of inter-connected variables resulting in a condition-resource configuration that could have driven widespread Neanderthal population decline. This is not to say that Neanderthals were driven to extinction by 'oscillatory climate' in the sense in which it is typically implied. Rather they were unsuited to a specific instance of perturbations that took place *within* a climatic episode and not as a consequence of several phases of oscillatory climate.

A single phase of climate lasted at the very least many tens and even hundreds of Neanderthal generations. Therefore, '*a Neanderthal*' did not 'experience' the immense *variation* exerted by a series of DO and HE closely spaced in geologic time, nor the full remit of the possible ecologies resulting from these states. On the contrary, the individual experienced but a subset of the resultant condition-resources which characterised these cycles. It was these local condition-resources and their variations within the *lifetime* of any given Neanderthal that exerted the selective pressure on Neanderthal behaviour which was in turn propagated both genetically and socially. From this perspective it is surely unsound to make the claim of a readily identifiable 'behavioural potential' from a limited range of multi-scalar condition-resources that operated and varied in terms of frequency and magnitude within the lifetime of the individual and then contrast what Neanderthals experienced to the variation in condition-resources on geologic time-scales. Neanderthals (indeed any organism) with a life-span of only several tens of decades did not experience 'rapid climate change' in the sense that it is commonly insinuated. The typical Late Pleistocene family of Combe Grenal never faced mosaic habitats on Monday, tundra on Tuesday and warm interstadials on Wednesday. No Neanderthal or modern human for that matter could ever have experienced the resultant changes in parameters (e.g. faunal and floral variation, geographic modification, absolute temperature and precipitation change) associated with different climate regimes. It simply does not make sense to argue that the 'potential' of the Neanderthals or indeed any organism can be understood much less framed or defined at a point in time in this way. One cannot argue that a still-frame from a movie tells the complete story. Just as any movie can be visualised as a fusion of distinct and exclusive still-images, one can similarly envisage that the evolutionary chronicle of the Neanderthals was a similar union of characteristic snapshots, perhaps benign and uninteresting in themselves, but integral to the story of which they are apart.

The Neanderthals throughout the course of the Middle Pleniglacial inhabited regions which were characterised by different condition-resource configurations at different times of the DO and HE lifecycle. It seems safe to assert, based on the discussion in the preceding section, much of it sympathetic to the idea that Neanderthals managed to negotiate HE, and that Neanderthals were not restricted to, nor failed to successfully adapt to the resultant environmental circumstances associated with changing climatic circumstances. This would suggest that the Neanderthal lineage was imbued with the requisite physical and/or social and/or behavioural traits to see-out the MIS 3 climatic oscillations.

Chapter 6

Condition-Resource Variation

6.1 Introduction

Throughout chapter 5.0 it became clear that Neanderthal population response to climate change was complex. Some regional populations appear to have maintained a presence during fluctuating climate episodes while others appear to have abandoned areas or declined in number. In chapter 5.11 we saw that Neanderthal population levels did not simply reduce and expand as a function of cold and warm climate respectively, and that an underlying complexity appears to have governed the nature of Neanderthal demography. This alone presses one to conclude that an analysis conducted at the scale of the climate phase i.e. glacial, interglacial, stadial and interstadial, fails to provide the necessary detail from which to infer Neanderthal population response in time. Even higher-resolution 'meso-scale' models, which are versions of regional climate models nested within a global circulation models such as that adopted by Barron *et al.* (2003) cannot in themselves constitute a useful reconstruction of the European Neanderthal habitats during the last glacial (Huntley and Allen 2003). To understand these issues further requires a deeper investigation of the effects of climate not just on human populations, or our conceptions of human populations, but also into the range of fauna and flora that were part of the human food chain. One must also acknowledge that ecological variables were not fixed and predictable, but highly variable even during stable climate phases.

Climate is comprised of many parameters e.g. temperature, precipitation, wind, rain, snow and ocean currents which mesh together to influence ecological processes e.g. soil generation, faunal and floral distribution. Huntley and Allen (2003) noted that different climate states encouraged specific types of vegetation which in turn influence key terrain characteristics such as surface roughness and reflectivity which in turn influence seasonality, evaporation, precipitation. Faunal (and human) communities were no doubt influenced by the changes and fluctuations in these parameters throughout the Pleistocene. Long term changes in these parameters are of course difficult to model, and because they operate largely on geologic timescales any assessment or prediction of their effects on biotic systems is somewhat difficult to pin down. Nevertheless, it is the gross, long term changes in these parameters which we recognize today as climate change. And it is through the course grained units of analysis that are conventional nomenclature that we can develop first order hypotheses of the importance of climate in human bio-cultural evolution. Despite the fact that we presently live in a non-oscillatory climate regime (the Holocene) there are two major climate forcing systems that provide a succinct demonstration of the impact of low-order climate change on biotic systems: the El Niño southern oscillation (ENSO) and the North Atlantic oscillation (NAO). The El Niño is the name given to fluctuations in sea surface temperature in the tropical Pacific Ocean. It is characterised by considerable warming from the International Date Line to the west coast of South America. The closely related southern oscillation is a global-scale atmospheric mass balance transfer which takes place between the tropical and sub-tropical latitudes across the eastern and western hemispheres resulting in major variations in sea-level air pressure. These dynamic systems act to move tropical rainfall distribution patterns as well as creating anomalous cold and warm regions across the Earths surface. The NAO is name given to the mass balance that occurs between the high-pressure atmospheric center located over the Azores, and the subpolar low-pressure zone over Iceland. The pressure differential leads to changes in the direction and magnitude of westerly winds which in turn control winter temperature, precipitation and evaporation over the western European landmass. Stenseth *et al.* (2002) have shown how both phenomena have had well-documented effects on terrestrial ecosystems, and why they serve as useful indicators of how ecologies respond to low-order quasi-global climate change. The way in which climate acts on and influences terrestrial ecosystems is known as the *Moran Effect*. In the case of El Niño which leads to major rainfall variation in the arid/semi-arid regions of South America, the timing and scale of plant annuals, rodent outbreaks and vertebrate predator response varies considerably. El Niño has been directly implicated in massive population crashes in plankton, fish, marine mammals and seabirds, while the NAO also influences snow hare and lynx populations in the Canadian boreal forests. Similarly in Europe, the NAO influences the timing and expression of plant, amphibian and avian breeding. In all cases the Moran Effect is observed when climatic variations lead to quite different responses between populations of similar organisms in space. For example, increased rainfall in Scotland associated with the NAO is deleterious to ungulate populations. But in Norway, increased rainfall results in warmer winters especially at low elevation and thinner snow-cover overall. In contrast with the Scottish populations the ungulate populations in Norway are characterized by reduced mortality rates during increased NAO. These findings show how even during a stable climate regime how ecological responses to changes in conditions can be significantly different even at the regional scale (in this particular example, northern Europe). This point cannot be overstated because it has clear implications for how we interpret past human and faunal communities particularly during non-analogue climate regimes such as the Middle Pleniglacial. These themes will be elaborated on in more detail in the following discussion.

6.2 Conditions and resources

We can envision that climate phases are the combination and the expression of two broad categories of variables: *non-depletable* and *depletable*. The interaction of non-depletable and depletable conditions and resources both directly and indirectly influenced human behaviour across all scales – from the individual to the population. Non-depletable conditions include temperature, precipitation, seasonality and light (solar radiation). These are non-depletable in the sense that they were not directly utilised nor influenced by hominins. The second component, simply termed depletable resources consists of e.g. available living space, subsistence options and lithic resources. Resources (in contrast to conditions) were directly utilised by hominins. The balance and expression of *condition-resources* would vary on a range of temporal scales from the seasonal to the geological. Similarly, hominin responses to condition-resource change in turn would have varied in a hierarchical fashion starting with (i) the individual; (ii) the group/population-level; and eventually (iii) as part of the full biotic community at the regional scale. Multi-layered socio-behavioural response operating on a range of scales and tempos no doubt led to subtle and at times pronounced behavioural variations as hominins adopted new coping strategies to deal with conditions-resource change over time. The key point is that a climate stage is not comprised of a distinct subset of conditions and resources analogous in terms of temporal duration, frequency, variation and magnitude, replicated over time and space (which in turn facilitated a deterministic socio-behavioural response). For instance, stadial events, separated by several millennia are unlikely to have resulted in the same floral and faunal communities nor provided an analogous behavioural platform for Neanderthals (or any other hominin) to play out their survival strategies. We can envisage a series of factors, principally geological, such as tectonics and geomorphological processes which combined to reshape landforms, water courses and coast lines. These in turn influenced the way in which subsequent climatic events directed the distribution of fauna and flora and eventually hominin behaviour. Direct observation shows that equilibrium climate phases (modern interglacial) are comprised of at least four major regionally distinctive biomes (the Arctic/sub-Arctic zone, characterised by tundra; the sub-Arctic/boreal zone by taiga; the temperate-cold regions of Europe by broad-leaved/mixed forest and the temperate-warm area by broad-leaved forest and scrub) and this should caution us from viewing stadial-interstadial type climate phases (non-equilibrium) as harsh, uncertain and unpredictable phases at all times in all places. For these reasons the assertion and common belief that stadial/interstadial phases were comprised of distinct conditions such as 'representative temperature' or distinct resources such as 'representative taxa' is a restrictive position to adopt based on data from a narrow historical perspective. It is more accurate to say that palaeoclimatic phases such as stadials and interstadials can only be partially quantified. The 'reconstruction' of a particular episode is relevant only to that temporal phase. It is unsafe to generically apply the reconstruction of a particular episode and apply this as a *standard* for other episodes, which, in the absence of proxy data do not have primary reconstructions. For this reason Mellars (1998) argument that stadial and interstadial phases were mere mid-points between glacial and interglacial phases respectively should be regarded with caution. The approach that continues to adopt regional palaeotemperature catalogues, principally the Greenland ice cores which have limited value in reconstructing the intra- and inter-regional environmental character, has at best moderate worth indeed.

The question then is how do we quantify what I have termed *condition: resource variability* through time? One approach may be to assess the multidimensional niche space. We would need to reconstruct the conditions and resources of a range of faunal, floral and archaeological sites that pre- and post-date the episode of climate change forming the subject of interest. Notwithstanding the inherent difficulty in establishing reliable chronological proximity and relationships of these data, the goal would be to reconstruct a detailed ecological niche displaying a range of conditions and resources that characterised a given timeframe. This *n-dimensional* (where n= number of conditions and resources) approach may illustrate quantitative differences in condition-resource variability, and allow the packaging or formulation of distinctive spatial *domains* that were, or as the case may be, were not utilised by hominins. This approach would be particularly useful for understanding in real-terms those condition-resources preferred by the

Neanderthals prior and subsequent to the appearance of modern humans. This is to say it would provide a clearer opportunity to illustrate the *fundamental niche* (no competition) and a *realised niche* (effective competition), at least in those regions which saw constant condition-resource variability over time. This is a more attractive approach than assuming Neanderthals distribution became more limited as a function of more frequent stadial events during late MIS 3. This approach could also potentially contribute a more detailed appreciation of the conditions and resources prevailing in a study province during distinct episodes of the IG-G and in doing so illuminate what a given habitat could have supported in terms of population and group size.

Too often in the literature the notion of a population is taken for granted; hominin populations are generally inferred as healthy, or expansive during warm conditions and limited or restricted during colder phases. This is despite that fact that most discussions are ambiguous owing to the lack of a clear practical and theoretical understanding of the term, and only a passing consideration of the importance of climatic and environmental lag- and lead-times to this issue. In simple terms we can view a population as a group of organisms of the same species in a given area during a given time. Sometimes boundaries are easy to delineate (e.g. crocodiles in a lake) but in most cases population boundaries are diffuse and difficult to identify. So in simple terms population size can be broadly inferred from the number of individuals in a given area but this is not to say that increased levels of presence (in the case of the Palaeolithic, inferred from higher numbers of sites) is indicative of a balanced population because this is more accurately a function of relative age structure, a strong control on the viability and health of a population (fig. 6.1). This would no doubt have been highly variable between populations during different condition-resource configurations.

Population size and age-structure, while strongly influenced by carrying capacity (K), was also controlled by other variables (fig 6.1) such as variation in birth (B) and immigration (I) death (D) and emigration (E) all of which had various roles to play in growth and decline. It is too simplistic to draw broad inferences between population growth and size with broad climatic phases as too many population variables (i.e. B, I, D, E) do not simply correlate at this scale. Rather these factors are more likely to conform more closely to the changes in distribution, frequency and magnitude of condition-resources, as well as local, contingent factors including though not restricted to, disease. This suggests that we can only truly understand the mechanisms involved in these processes by developing a theoretical basis from which to infer condition-resource variability in time and space, and from this the nature of the population that could have been supported.

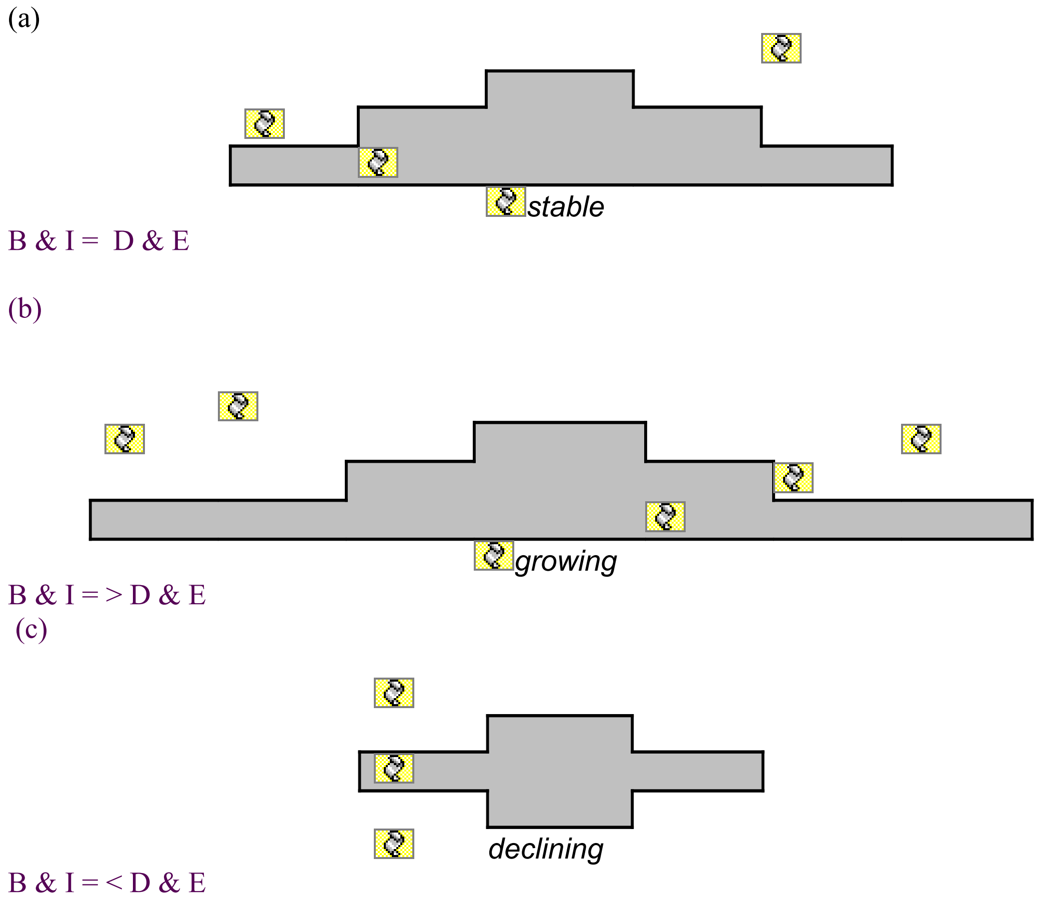


Figure 6.1 Three-stage population response to condition-resource variation over the Late Pleistocene B, birth; I, immigration; D, death; E, emigration. (a) stable population; (b) growing population; (c) declining population (modified from Mackenzie et al. 2001:75).

Palaeoenvironmental deterioration or the onset of new habitats which limited the scope for hominin settlement because of low-index condition-resources (i.e. low *K*, or because socio-behavioural attributes necessary to permit colonisation and exploitation of new settings were lacking) may have resulted in situations with increased-levels of competition between local, growing populations which in turn could have led to higher death rates and lower birth rates. Nevertheless the manner in which populations responded was dynamic and this would almost certainly been different between populations separated in time. We can hypothesise that some regions, as they became more densely populated witnessed >B & <D (fig. 6.1b) resulting in density dependent situations, while in others no change occurred at all hence they were density independent (fig. 6.1a). Added to this is the likelihood that palaeoenvironmental fluctuations may have caused populations to switch between density dependent and independent states with

variable birth and death rates. If a population was associated with a poor condition-resource index this would result in a negative *density-dependent* response, i.e. population decline would occur (fig. 6.1c). Yet population growth would not automatically take place in optimum condition-resource situations as growth would have been influenced by several other factors, chiefly: behaviour e.g. subsistence strategy, mate location/availability. Positive density dependence would only have occurred when suitable condition-resource domains were encountered by suitably structured populations. Yet even in such circumstances it cannot be assumed that population size would have steadily increased until K was reached. This is because maximum population levels may have occurred at intermediate density. This is known as the *Allee effect* and this could have been an important contributing factor that led to the decline of smaller or more localised Neanderthal (indeed all human) populations in Europe during the Middle Pleniglacial. The combination of oscillatory palaeoenvironments and variable birth and death rates means that K was a *range* rather than a single value. Therefore Stewart's (2004) assertion that Europe was "at carrying capacity" for much of the Pleniglacial seems perhaps too simplistic when the multilayered aspect of the problem is appreciated. So population size and structure were not passive entities responding in a predictable fashion to MIS 3 palaeoenvironmental change which in turn did *not* respond in a predictable manner to palaeoclimatic change. We cannot make claims that some regions were always 'at the brink of collapse' when we have no idea how populations of species within the region in question were structured, and this includes *all* of the community in which Neanderthals were part. Such considerations must be factored in to the emerging pattern of Late Pleistocene demographic change which appears to have been an extremely complex but no less fascinating phase in human evolution. The challenge is to develop more sophisticated and novel methodologies to explore these issues using bioarchaeological evidence.

If European populations were inconsistent in terms of size and structure particularly during the post-Eemian oscillations and Middle Pleniglacial, then delayed density dependence effects would have resulted in lead- and lag-times in birth and/or death rates thus populations would have been out of synchrony with condition-resources (or as other workers would prefer warm/stable climate phases). So it can be hypothesised that Neanderthal (and modern human) populations increased and decreased with no apparent *temporally consistent* cause and effect relationship between phases of amelioration (e.g. DO) and downturn (e.g. HE) this is to say that demographic changes were not necessarily phase-locked with episodes of palaeoclimatic change. We can envisage modern humans and Neanderthals as actors in complex, biotic meshes that were at times regionally distinctive, and not passive respondents to the interplay between rather normative descriptions of stadial and interstadial palaeoclimate (In this sense the discussion in chapter 5.11 supports this hypothesis). The important point to take from this discussion is that density dependence and stochastic palaeoenvironmental changes are complex and non-linear, thus population structure and viability cannot simply be seen as a simple function of a palaeoclimatic phase, or series of closely-spaced phases in time. Large-scale climatic fluctuations are but one of the non-linearities of a series of external and internal processes which structure population dynamics (Stenseth *et al.* 2002).

6.3 Inter and intra-specific competition

Protagonists of inter-specific competition between Neanderthals and modern humans argue that subsistence options or living space were the premium variables which essentially could not be shared 'between' populations. The outcome, competitive exclusion, is a popular idea that many believe could have led to Neanderthal extinction (chapter 3.0). However, competition would only have arisen if both Neanderthals and modern humans were exploiting the same *environmentally stable* condition-resources. If not, co-existence between Neanderthals and modern humans may have occurred if they were exploiting different condition-resource configurations. In both cases, but particularly during the former the backdrop for competition would no doubt have varied because of environmental fluctuations which disrupted or re-modelled the resources of a given region (particularly during the post-Eemian oscillations and MIS 3). Hence competition in the sense in which it is commonly applied was not a constant as such, but instead a discrete variable that fluctuated in its frequency and magnitude across time and space, only arising when condition-resources and hominin populations were suitably structured. When competition between modern humans and Neanderthals did occur it may never have reached a conclusion precisely because environmental fluctuations may have swayed the ecological circumstances in favour of one population over the other, and so on. That both Neanderthal populations and modern humans were present across large areas of Europe from perhaps as early as *ca.* 50 ka to 25 ka supports the notion that competitive exclusion, if it did operate, was not a significant factor in the demographic changes in Late Pleistocene Europe.

If Neanderthals were, in a sense, constrained to make their living in a certain ecological configuration then it seems reasonable to conclude that the contraction or decimation of such zones (via competition or environmental change) would also have led to intra-specific competition and intra-regional population decline. Intra-specific competition could have depressed the fitness of populations situated in the so-called refugia e.g. the Mediterranean unless of course this was mediated by strategies involving territoriality and dispersal. The former is difficult to assess and can only be hypothesised where evidence for high-density, long-term occupation is demonstrable. Other archaeological evidence may provide a clearer insight into dispersal. Perhaps we can tentatively suggest that the Mousterian, a heterogeneous technocomplex over space and time (table 6.3) serves as a proxy for internal differentiation as population centres responded to changing condition-resources and consolidated their positions over a range of spatial scales. Dispersal, then, was a key strategy adopted by Neanderthal populations to escape high density regions or unstable, low K habitats. Regional Mousterian variants may reflect this strategy. Of course, in order for dispersal to have been successful requires a capacity to seek out habitats comprised of suitable resources. Presumably Neanderthal populations would have identified areas that permitted relatively long-term occupation at the sub-regional scale, which afforded relatively constant and predictable resources. It is plausible that Neanderthal populations were intensely territorial and adopted aggressive means to defend these primary niches. In this context it is suggested that some of these primary niches include sites situated in NW Britain e.g. Pin Hole Cave, as well as much of the SW region of France.

6.4 Behavioural variation: a function of ecology?

Throughout the course the thesis the discussion has illustrated the complexities involved in attempting to reconstruct accurate palaeoenvironments from proxies such as $\delta^{18}O$, and highlighted the inherent assumptions behind the application of traditional climate nomenclature as 'standards' against which we can measure and explain hominin behaviour during the Middle and Upper Pleistocene. These combine to seriously undermine assertions which contend some hominins were pre-adapted to, or limited by a particular palaeoclimatic or environmental configuration and illustrate the need for different methodological approaches to the issue of adaptation, tolerance, competition, territoriality and behaviour in general. Some assessments of how different human socio-behavioural responses can be interpreted as the consequences of different ecological factors have been made, but these are principally gleaned from the study of modern hunter-gatherer groups. Dyson-Hudson and Smith (1978) made a notable attempt to understand how ecology influenced territoriality among modern hunter-gatherers and to a lesser extent, how competition was manifested amongst regional groups. They developed what they termed the *Economic Defendability Model*, which simply put states that if the energy lost in defending a resource is outweighed by the gains, then territoriality is a logical response irrespective of the population in question. In doing so they challenged the accepted paradigm of that time which saw humans as either territorial *or* not territorial, and argued instead that socio-territorial responses were flexible i.e. this particular behaviour was the functional response to mosaic patterns of resource distribution which varied in space and time. They examined the resource utilization of several hunter gatherer populations, two of which may be of relevance to this discussion (i) Intra-group variation among the Basin-Plateau Indian (ii) The spatial organisation of the Karimojong at one point in time. It is clear from these studies that closely-related modern human hunter-gatherer groups can display significant differences in subsistence, land-use patterns and territoriality. Of course, any discussion of anatomically modern human behavioural variation is never discussed in terms of reflecting a difference in *cognitive potential*. Potential is always deemed the same between groups, and difference is accommodated by the quite reasonable presumption, sometimes demonstration, that groups were behaving differently to meet the contingent ecological circumstances of the time. Other studies have reinforced this idea by showing that closely related hunter-gatherer groups can display significant differences in subsistence, settlement and socio-territorial organisation. For example Ambrose and Lorenz (1990) citing Harpending and Davis (1977:255) noted that !Kung San bands found in wetter, more stable environments are associated with more concentrated, abundant and stable resources which can be exploited within a largely sedentary/home-range system. Conversely, !Kung San bands which inhabit the arid southern Kalahari exploit more mobile and unpredictable resources therefore these latter groups are more broadly dispersed and range over thousands of square kilometres. These studies clearly indicate that inter- and intra-group behaviour, in this case socio-territorial organisation, can be highly varied. So in terms of human behaviour, Dyson-Hudson and Smith (1978) illustrated that one important aspect– territoriality – was not specific to any single group or population, and was but one of several means used to maximise resource capture. All of these studies demonstrate that certain behaviours will be practised whenever they offer an adaptive advantage and that the presence or absence of this trait can be explained purely in terms of cost-benefit analysis. For instance no-one would contend that a fundamental cognitive dichotomy separated the Basin-Plateau Indian from the !Kung San. I argue that a similar methodological approach could prove fruitful and perhaps provide a more informed insight into the *why* of human behaviour particularly over the last IG-G. It is for these reasons that I feel we can never truly understand the Late Pleistocene population dynamics in Europe by simply compartmentalising modern humans into one socio-behavioural category and Neanderthals in another, based on dubious premises such as cognitive differences or latent palaeoenvironmental preferences.

This having been said, it is much more difficult to reconstruct the ecological backdrop for the Neanderthals and to identify intra-group differences in socio-behavioural responses such as territoriality and resource capture more accurately for four main reasons: (i) we presently live in an interglacial phase hence there are no analogous habitats that we can approach with the principle of uniformitarianism (ii) Neanderthal populations cannot be directly observed (iii) many proxies for palaeoclimate/environment are beset by chronological problems e.g. placing a particular archaeological behaviour within a particular palaeoclimatic phase (iv) the imbalance between generality and specificity: i.e. the reconstruction of specific palaeoenvironmental reconstructions from general normative palaeoclimatic nomenclature. Despite these problems, Ambrose and Lorenz (1990) have sought to demonstrate that Late Pleistocene archaeological changes or 'innovations' can be explained as a function of local adaptation to palaeoenvironmental change instead of far-reaching cognitive changes or population replacement. They examined the Howieson's Poort (HP) tradition of Southern Africa which is characterised by typical MSA artefact classes such as flakes, side-scrapers, uni-facial and bi-facial points as well as features more akin with the LSA such as end-scrapers, thin-backed blades, trapezoidal, crescentic and triangular backed-blade segments. Many of these LSA-type artefact classes were made from raw materials that were obtained from more distant lithic resources than the typical MSA tools in adjacent levels. Despite a recent contribution by Lombard (2005) who argued that the behavioural hypotheses stemming from the HP are "far reaching", it is the combination of these MSA/LSA features with the apparent early anatomically modern human remains from sites such as Klasies River Mouth that has provided more support for the idea that modern behaviour and anatomy arose in Africa. Ambrose and Lorenz (1990) argued that there is an inverse relationship between the presence of 'exotic' lithic material and resource abundance and predictability. Therefore as groups are forced to abandon traditional means of resource exploitation, changes in other variables such as group size and habitat use will also occur. It is the new ecological circumstances which govern the socio-behavioural responses and *not* the external introduction or replacement of existing cultures, populations, species or ideas. This idea is simply put as follows:

> "Ecology may thus ultimately dictate the kind of lithic technology adopted".
>
> (Ambrose and Lorenz 1990:19)

This hypothesis contends that technological and typological changes provide an insight into landscape use and social co-operation. For example Ambrose and Lorenz (1990 citing Gould: 1978) have shown that the Aborigines of the Western Desert extracted most of their raw materials from sources within 32 km of their settlements, however some of their tools were obtained from sources several hundred km away, far outside their annual ranges. This observation, according to Ambrose and Lorenz points to a system where:

> "Information sharing and pooling of resources would thus be highly adaptive…exotic lithic raw material exchange along totemic affiliation lines functioned to maintain a broad-base of contacts and obligations with distant affines and relatives who could be relied on in times of stress…and may take the form of ritualised gift exchange, as among the Kalahari San…where resources are more predictable, territorial groups…like the Northern Kalahari San, would find lithic exchange unnecessary".
>
> (Ambrose and Lorenz 1990:20)

Ambrose and Lorenz (1990) argue that the HP should be largely if not entirely explained in the same terms as these modern examples, thus should be interpreted as a somewhat distinctive MSA industry because of its association with fine-grained, non-local resources. They believe that the HP groups represent some of the first MSA humans to have extended their foraging ranges and to have adopted inter-group networks. It does not appear that lithic procurement changed to suit the demands of producing the microlithic aspect of the HP because the former seems to have occurred before the latter (ibid.). Gamble (1978) has provided a further example of this pattern. He combined faunal data, lithic material and palaeoclimatic/environmental data to model the adaptive changes of Late Pleistocene/Early Holocene hunter-gatherers of southern Germany. It appears that the Late Pleistocene Magdalenian groups hunted horse and reindeer over broad territories, while the Mesolithic groups managed far-smaller ranges, were far-less specialised in their acquisition of prey, had a wide-range of local, idiosyncratic tool forms and a complete absence of any exotic raw materials.

Hopkinson's Ecological Geography

More recent work focussed specifically on the behaviour of European Neanderthals was presented by Terry Hopkinson in his *The Middle Palaeolithic Leaf Points of Europe* (BAR International Series 1663 2007). The work is a far ranging assessment of Neanderthal behaviour and ecological adaptation in central and eastern Europe. It is a detailed consideration of ecology, scale and hierarchy in an archaeological and environmental context. Although the locations of the archaeological sites which comprise the essence of his thesis are outside of the geographic scope of the work presented here, it is still useful to include a review this work owing to its specifically ecological approach to the issue of Neanderthal behaviour and climate adaptation. Moreover, it sheds new light on the process of adaptation and changes in behavioural expression at different social and ecological scales. The works centres on the spatiotemporal history of the central European leaf point phenomenon and provides insights into Neanderthal behaviour and response to climate change during MIS 4/3. Leaf points, or leaf point-like bifaces are frequently referred to under the Micoquian lithic industrial category and they extend from France and Belgium into central Europe and southern Russia, Crimea and the Balkans. Hopkinson considers specifically the leaf point sites situated predominantly in the Altmühl Valley (Bavaria) and a cluster of other sites located in the adjacent upper Danube.

The central premise of the research is that leaf points represent indicators of changing social response to environmental change; specifically, short episodes of cyclical environmental change. In a movement away from Gamble's orders of sociality model (intimate, effective and extended networks), Hopkinson argues that the archaeological material diversity can be understood only when one incorporates the notions of scale domain. He argues for two key elements in this regard: *knowledgeable action* (behavioural acts performed by the individual alongside the acts of other individuals) and *socially transmitted knowledge* (acts operating on trans-individual scale domains). The theory contends that these differing scales of knowledge outlined above are inextricably bound in with ecology and the observable result is behavioural (archaeological) variation. One must expect to see observable behavioural variation as normal because human environments are always heterogeneous in space and time, while human action varies over different spatio-temporal scales (the individual to the population).

Chapter 2 of the thesis emphasises the importance of flux and disequilibrium in ecological systems. The 'environment' in this sense, is actually an array of interconnected parameters both biotic and abiotic, operating on and changing over different spatio-temporal scales. The thrust of the message is that we cannot talk about 'a temperature' or 'an ecosystem' in the sense that they were discernible objects with tangible fixed properties. One can extend this argument to argue against the position that stadials or interstadials were, in a similar manner, replicable systems over space and time comprised of a distinct and predictable range of biotic and abiotic resources, conditions and resources in time.

In chapter 3 Hopkinson begins to flesh out the idea that a stark, major change in human ecology was first observable after 200 ka. By now, it is argued that European populations were systematically occupying climatically continental regions of Europe (e.g. broken karst environments and more seasonal eastern regions) and displaying a tolerance of high amplitude intra annual cyclicity. Similarly, lithic practises now begin to display more structured change.

Chapters 4 and 5 review the structured change in more detail. It is argued that the leaf point phenomenon of the Altmühl Valley archaeological sites represents a major socio-behavioural change in Neanderthal survival strategy both in terms of how the landscape was used, and more importantly, an emerging success in forecasting landscape change. Hopkinson argues that one can recognise specific lithic patterning in this central European region. It is argued that two basis patterns can be identified: firstly, large assemblages of foliate bifaces are found most frequently in well stratified shelter and cave sites and these occur alongside other archaeological indicators including hearths and discarded animal bone. Such sites represent, in Hopkinson's eyes, extended occupations (i.e. residential sites or home bases). Secondly, Middle Palaeolithic leaf points which are typically small to medium sized assemblages that are indicative of more task specific/non-residential occupation.

Hopkinson argues that these apparently divergent 'cultures' are in fact nothing of the sort and are better interpreted as functional behaviour appropriate to one particular ecological comportment. In other words, some behaviour (in the case of the leaf point phenomenon) demonstrates that Neanderthals were displaying increased ability to socially transmit knowledge in the face of environmental transformation which in turn underwrote the regionalisation of lithic industries. Returning to some of the key sites cited in the study will reinforce this argument. The Altmühl Valley site of Mauern, layers F/F_1, $G^1/F_2/G$ which are leaf point rich contrast with that of Sesselfelsgrotte, G-Komplex which is leaf point poor. Hopkinson argues that there are many shared qualitative traits between these sites and the leaf point concentration difference remains indicative of a shared body of socially transmitted knowledge but which was employed differently in the landscape. In other words, there is no meaningful requirement to suggest distinct Micoquian (leaf point poor) and Altmühlian (leaf point rich) cultures. This archaeological patterning reflects, instead, "*a shared mode of engaging with the world*" (Hopkinson, 2007:110). Sesselfelsgrotte reflects a site of intense occupation whereas Mauern was probably a leaf point cache positioned to afford Neanderthal groups behavioural flexibility in more uncertain ecological settings.

Hopkinson concludes that *knowledge* and *knowledgeable action* are two different, but linked themes that can explain archaeological behaviour (Hopkinson 2007: chapter 7). The former is viewed as trans-generational (whether progressed over time biologically or culturally) while the latter is a contextually appropriate approach or response to sensed and lived-in experience. It is argued that it was not until after 200 ka that change in the spatio-temporal reach of knowledgeable action resulted in a greater Neanderthal population extent across a range of new environments in Europe. This resulted in what we now see in the archaeological record: structured change in lithic stone working practises of ecological scales of tens of millennia. The most dramatic of which is the leaf point phenomenon which Hopkinson argues is found most strongly expressed in habitats that witnessed alternating steppe/woodland episodes on timescales of 1-3 kyr. In this model we can see home bases such as Sesselfelsgrotte as the home base – the here and now; while Mauern represented contingency – the there and then. Leaf points emerged from pre-existing capability and were employed as part of a survival strategy in new contexts. In this regard they can be viewed as significant behavioural departures and conform to the T2 model (discussed below). One of the most interesting and important claims is that such behavioural departures from preceding behaviour may or may not have been fixed in local and regional projects for living. It was not enough for emerging behaviours to occur, they had to become institutionalised. Hence socio-behavioural change should be viewed as an event but a process. The ongoing and as yet unresolved question is what mechanisms were the most important in articulating socio-behavioural innovation and how this was passed through generations and between groups.

Behavioural variation as a function of ecology is also observed in other species. In an important paper by Martin (2000) in this respect it was shown how a variety of different variables including but not restricted to population size and density, home range, mobility and social organisation all varied between populations of a single species in accordance with environmental structure.

> "Different species in a similar environment can have more similar behavioural characteristics than the same species in varying habitats. A behavioural ecological approach is a more fruitful way of predicting wild animal behaviour for past environments. It is particularly appropriate for non-analogue palaeoenvironments since the need to 'match' with a modern analogue is eliminated".
>
> (Martin 2000:14)

While Martin (2000) acknowledges that by investigating the ethology of extant populations one can proceed to infer behaviour/population structure of archaeological remains, she acknowledges the limitations of the approach insofar as the behavioural ecology of past populations was no doubt different during other climatic regimes to that of today. Thus we cannot simply presume that we fully understand the range of behaviour of a single-species based on modern data alone. Similar cautions were voiced by the Stage 3 Project because the distribution patterns of extinct mammal populations during MIS 3 were shown to be quite different to that of modern populations (*cf.* Stewart 2005).

Even during stable climate phases modern-day observations have shown that animal behavioural ecology is highly complex. Martin (2000 citing Collier and White 1976) examined several types of herd ungulates and concluded that the population structure of each was essentially unpredictable; that the notion of a 'normal herd' was unsound and that similar ideas based on reconstructions of archaeological bone assemblages must necessarily also be suspect. Martin (2000) summarised *behavioural ecology* as the interplay of five variables:

- Reproductive cycle
- Group size
- Density
- Composition
- Movement

These fluctuate in accordance with four constraining parameters, chiefly:

- Food and water
- Predators
- Commensurate fauna
- Tolerances

The key point is that behavioural variation is a function of the environment so to understand the reasons behind behavioural variation one is required to first elucidate the underlying ecological backdrop. To explore these ideas Martin (2000) investigated eighteen modern gazelle populations in an attempt to tie-in how the ecological parameters influenced and constrained the five variables listed above. It was found that while general increases in precipitation result in generally larger population numbers there are some notable exceptions at the regional scale. Two populations of gazelles inhabiting the Negev desert (Israel) exhibit contrasting patterns in terms of population density and size. Population 'a' inhabiting the low rainfall zone is a larger and more dense that population 'b' in the high rainfall zone. The high rainfall zone is characterised by a much larger range of shrub species than the low rainfall zone which is almost exclusively *Zizphyus lotus*. The *Z. lotus* shrub provides much better shelter from the sun and predators than the mixed shrub zones and it is this that largely explains the much greater population size. We see then that generalised inferences about population size based almost exclusively on broad parameter controls such as precipitation or temperature do not always reflect reality. This realisation carries clear implications for archaeologists who infer that given regions of Europe during the Early and Middle Pleniglacial were easier to settle and extract resources from than others especially when such inferences are made from rather coarse palaeoclimate catalogues. Such claims it seems could quite simply be wrong, or obscure an underlying sensitivity.

Martin (2000) also reported that home range and mobility varied across gazelle populations and that three broad land-use categories were recognised: sedentary, nomadic and seasonal migrators. One population of Arabian gazelles was found to have small home ranges and that their habitats contained sufficient forage while a second population was observed to have migrated seasonally between low elevations in the winter and spring and the grasslands of higher elevations in the summer. One Levantine population of *G. dorcas* was observed exploiting vegetation patches in the wadi beds over a small home range of 1-2 km^2 while a second population of the same species exploited less-predictable and sparser vegetation over a much broader home range of 25 km^2.

This brief digression into gazelle behavioural ecology is nonetheless relevant to some of the issues discussed previously, perhaps the most important of which is the idea that socio-behavioural differences between closely related populations (as reflected in the archaeological record or by ethnographic study) can ultimately be understood in terms of ecology (Dyson-Hudson and Smith 1978; Ambrose and Lorenz 1990). That we can observe broad departures in socio-behavioural responses between closely related gazelle populations adds further direct support to the idea that the ecological domain is the principal control on adaptation on all scales. Central to this argument is the theme that animal behavioural ecology would have influenced human behaviour and vice versa. We can envision situations where animal distribution in the landscape, particularly with regard to its relationship with sites of human occupation would have varied in terms of density, structure, movements as well as in terms of migration routes etc. Similarly human socio-behavioural responses would have been modulated to suit such variations in animal behavioural ecology.

This brief review of intra- and inter-group socio-behavioural group variability has clear implications relating to how we interpret similar differences within Neanderthal populations as well as between Neanderthals and modern humans. As we have seen, archaeologists have relied heavily on traditional palaeoclimatic nomenclature, however we are as yet to understand how the ecological fabric of these climate phases influenced or determined Neanderthal behaviours at a truly meaningful scale. The following section will outline an approach to this issue and suggest a means by which we can understand socio-behaviour as a function of the environment.

6.5 Current climatological conventions are not facts but hypothesis that can be tested

Climate phases are of fundamental importance as they form a major backdrop against which demographic and socio-behavioural changes may be understood. Traditional climate terminology in the eyes of many archaeologists is comprised of predictable parameters and ecological configurations, and any alternative discussion is rarely considered or applied to existing archaeological problems. This is to say that current climate phases are comprised of a range of variables such as temperature and precipitation that can be predicted to combine to form distinct environmental circumstances. Idealised outcomes such as these are discussed by archaeologists as corroborated – facts even - and transferred across time and space as the basis to interpret other archaeological changes. Such an approach is no doubt sufficient for end-member climate regimes such as glacials and interglacials which in terms of strong climatic controls such as sea-level and ice-cover are at opposite ends of the spectrum, but it is less-so for the more closely related climate phases such as stadials and interstadials. In using terminology such as stadial and interstadial one implicitly operates on the understanding that the differences between such entities are clear and demonstrable. Not only this but that they were manifested as consistent entities across space and time. By contrast if stadials resulted in some quite different environmental outcomes say for instance across northern Europe we must acknowledge that such climate terms are misleading and that it is more accurate to view stadials instead as processes with sliding, irregular and inconsistent variable packages. To my knowledge no real considerations have been made in the literature regarding how sub-interglacial/glacial climate stages such as e.g. stadials have differed over time, thus how the generic application of such a term may be misleading (themes discussed in chapter 4.0). This is clearly an important factor relevant to the Neanderthal debate. A related theme is that large scale demographic and/or cultural events have also been associated with key climatological circumstances seen as unique over the course of previous geologic time. Indeed this prevailing view largely ignores the fact that fauna and flora do not behave like inert substances reacting in regular and predictable ways to climatological stimuli. We can never be sure that the application of well-constructed stadial and interstadial events (if this is even possible for broad spatial areas) can be discussed in anything other than probabilistic terms for other temporal phases. This has resulted in an archaeological conservatism that ultimately fails to account for or explain Neanderthal disappearance and precludes new thinking. Climatological and ecological reconstructions have become essentially typological. But climate stages are not like stone tools that offer distinct units of analysis that allow some insights into inter-assemblage variation. We are unlikely ever to have the resolution in time and space of key features that allow us to characterise climatological phases. This uncritical application harms the true understanding of what these Palaeolithic populations were facing.

What follows are in outline three important hypotheses which I view as central tests relevant not only to the Neanderthal debate, but as contributory factors, which, if substantiated may be relevant toward any discussion of the causes of socio-behavioural change.

Hypothesis A: Temperature change (as determined from $\delta^{18}O$ records) directly influenced palaeoenvironment therefore a given temperature configuration should result in an identifiable or unique palaeoenvironment distinguishable from other palaeoenvironment/temperature configurations. This is to say stadials and interstadials were each distinct, replicable systems over geological time.

Hypothesis B: Specialized fauna (?Neanderthals) will only be associated with a limited range of conditions and resources i.e. a definable subset of the range typical of an IG-G.

6.6 Testing the hypotheses

Hypothesis A: It should be possible to show that $\delta^{18}O$ change in Greenland ice records can be indexed against palaeoenvironmental change. Temperature change would initially affect more sensitive condition-resource configurations (e.g. I have argued that the NP and CP were more susceptible to disruption during the post-Eemian than the SP and MP which experienced greater changes during the Middle Pleniglacial) hence these cannot be used to argue a broad spatial effect. Further temperature change would reach a threshold after which the effects would be more marked spatially, **or**: The condition-resource attributes (i.e. faunal/floral attributes) do not associate within the expected range of a given climate phase thus other contingent factors operating in conjunction with a broad palaeoclimatological control are at play. Therefore a standardized norm that separates climate labels such as stadial and interstadial does not exist.

Hypothesis B: On the basis of the distribution patterns of archaeological materials it should be possible to identify the palaeoenvironmental limitations of Neanderthal populations, **or**: Claims that Neanderthals and modern humans displayed different inert socio-behavioural responses to palaeoclimatic and environmental change may be without grounds.

6.7 Condition-resource model

My aim is to develop a methodology which can assess some of these issues using the theme of condition-resource variation. The hypothesis can be outlined as follows: We can begin with the notion that the study provinces at any given time were characterised by condition-resources which meshed together to form the behavioural domain. As condition-resource configurations changed, a new domain was imposed and socio-behavioural responses were adjusted accordingly. Increasing ecological complexity or change can be visualised as a set of concentric spheres each representing a domain, the perimeters of which delimit the range in which socio-behavioural responses can be utilised and up to which demographic success is possible. As broader ranges of domains were experienced, populations in turn became more socially and behaviourally flexible. Consequently the lineages fitness increased and the spheres of tolerance are broadened; however, they still include all former domains which are now inherently part of the behavioural capacity. The archaeological record will reflect the lineages capacity to exist within a broader range of ecological circumstances (where suitable palaeoenvironmental reconstructions can be made). This is not a deterministic scheme but one which attempts to reconcile the emergence of new behaviours within an environmental context, and allow us to discuss what these may have done to enhance the adaptability and fitness of the lineage in question. The hypothesis contends that socio-behavioural innovations emerged largely at the edges during the transition between domains. This is to say that socio-behavioural innovations may have been more likely to have been adopted in instances where human populations encountered unusual biotic configurations or in other words discrete 'non-analogue' communities.

It is becoming more evident that the climate parameters of the Middle Pleniglacial resulted in environmental configurations which appear not only to have been highly sensitive to change in certain parts of Europe, but also characterised by faunal and floral communities without modern analogue. Following the analysis of the Stage 3 Project mammalian database (Stewart *et al.* 2003b) this theme was discussed at greater length in Stewart's (2005) publication which explored the phenomenon of mammal communities that were in sympatry during MIS 3 but not today. It was found that Europe could be split into three latitudinal zones. The first of which is the *Northern province* which lay broadly to the north of 46°-47°N; a *Southern province* which lay broadly to the south of 43°-44°N; and finally an *Overlap province* which was sandwiched by the Northern and Southern provinces (fig. 6.2).

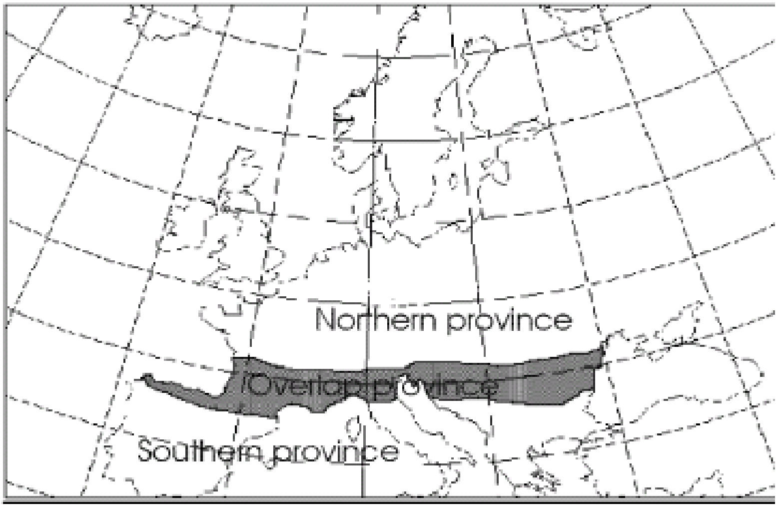


Figure 6.2 **The faunal zones of Europe during MIS 3 (after Stewart 2005)**

The northern and overlap zones are associated with the classic cold-adapted megafauna (e.g. mammoth and wooly rhino) as well as a range of mammals now found in the boreal regions of Europe, while in the southern zone the so-called interglacial survivors were living alongside southern endemic taxa. The overlap zone was inhabited by faunas from both the northern and southern zones while many other mammals were found across all three zones (ibid.). It was reported that a range of fauna such as wood mice (*Apodemus* sp.) and moles (*Talpa* sp.) today found in temperate parts of Europe reached as far north as 50°N during MIS 3 while the souslik (*Spermophilus* sp.) and the saiga (*Saiga tartarica*) which are today located in more eastern parts of Europe were inhabiting more western parts of Europe such as France during MIS 3. One of the most striking findings to emerge from the analysis of the Stage 3 Project mammalian database is that the geographical range or the *tolerance* of many taxa is much broader than modern day observations of fauna would indicate. It appears that many taxa have a greater tolerance to a wider array of climatic and environmental factors than is currently accepted. For example it appears that boreal mammalian taxa extended as far south as Cantabria (Spain) while temperate mammals were found as far north as the Ardennes (Belgium).

The following discussion will elaborate on the scenario above and illustrate in a very rudimentary way the process to show the ways resources were manifested and their tolerances to parameters, in this case (but not exclusive to) temperature (T) and precipitation (P). It is only for the purposes of clarity that two controlling parameters (P) and (T) will be used however it is wholeheartedly acknowledged that other parameters were no doubt important. The following figures illustrate the hypothesis qualitatively by demonstrating how the tolerance of a selection of hypothetical faunal resources are deemed to cross-cut and transcend traditional climatic nomenclature i.e. interglacial, stadial and interstadial conditions. Fig. 6.3 shows increasing mean annual temperature on the X axis and increasing precipitation on the Y axis. For the purposes of clarity and simplicity the basic terminology of the interglacial-glacial cycle is employed (IG, interglacial; G, glacial; S, stadial; IS, interstadial). The detail in fig. 6.3 shows a hypothesised subset of condition-resources associated with interglacial type climate. We can see that the mean values as well as the general tolerances are indeed generally associated with the interglacial phase of the cycle, but a significant proportion of these also overlap with interstadial type climate and thus have much broader tolerances and can be associated with temperature and precipitation values more akin with cooler and more arid phases.

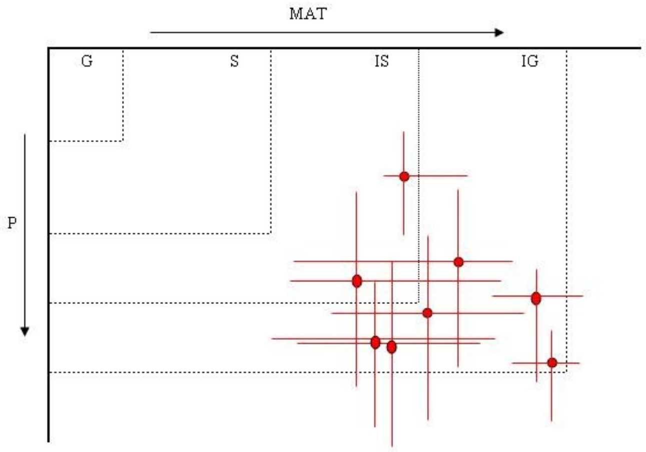


Figure 6.3 **Condition-resource variation: IG-G & IS**

It is hypothesised that onset of temperature and/or precipitation decline will result in the interplay of up to three scenarios: either the emergence of new condition-resources and/or the continuation of condition-resources at levels and frequencies of the preceding phase and/or the disappearance of condition-resources with narrower ranges of tolerances. In fig. 6.4 we see the emergence of new condition-resources (blue detail) and note also the decline and disappearance of some condition-resources associated with higher P or T. At the same tim,e we note the development of an overlap between condition-resources leading to ecology with a much less prescriptive subset of condition-resource options. The key point to be stressed is that these situations would lead to non-analogue condition-resource amalgams. In other words, unusual combinations of fauna and/or flora would be expected to have occurred and it is predicted that these should be observable within discrete time-space episodes in the archaeological record. Furthermore, these zones perhaps drive and/or require new socio-behavioural responses.

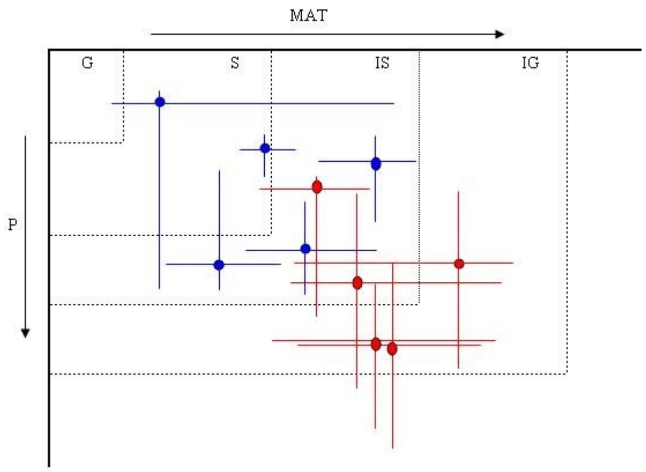


Figure 6.4 **Condition-resource resource configuration at interstadial phase**

It is hypothesised that during interstadial- and stadial-type climate the scope for condition-resource heterogeneity was far greater, and this could have resulted in more pronounced non-analogue aggregates of fauna and flora with broader tolerances and adaptations. This would have led to discrete sub-regional zones of potentially challenging or beneficial habitats which provided hominin groups with greater opportunity to innovate new socio-behavioural traits. Those groups which managed to adapt a greater range of innovative behaviours to tackle the problems inherent in such a non-uniform biome would surely be better placed to meet not only general, directional trends in palaeoenvironment, but also those which were subject to fluctuating communities, between non-analogue and analogue states. Those groups that lack the required means to consolidate their presence in such zones are forced to track their equilibrium habitats and are unlikely to produce new, innovative socio-behavioural traits. Fig. 6.5 illustrates a faunal range (see detail) which have P and/or T tolerances that are far broader than a single climate phase such as a stadial would otherwise indicate.

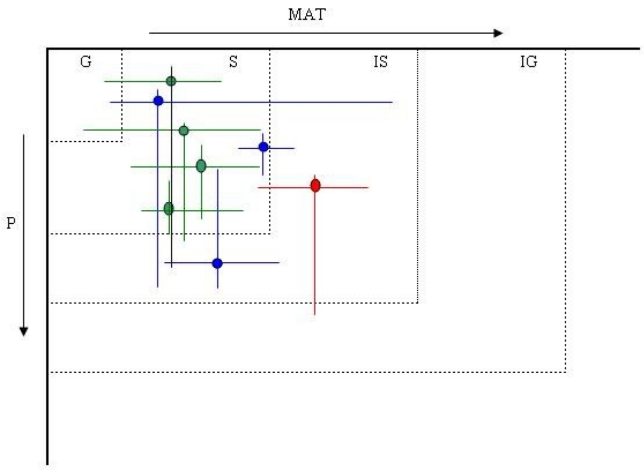


Figure 6.5 **Full stadial, early glacial configuration**

In fig. 6.6 we see that a more homogenous set of condition-resources with a narrower range of parameter tolerance prevails. Here we would expect (for instance during end-member regimes) that faunal and floral groupings would adopt a more uniform, analogue character. Such zones, it is envisaged did not provide populations or groups the basis to generate socio-behavioural skills that have a wider application, and were instead more specialized domains.

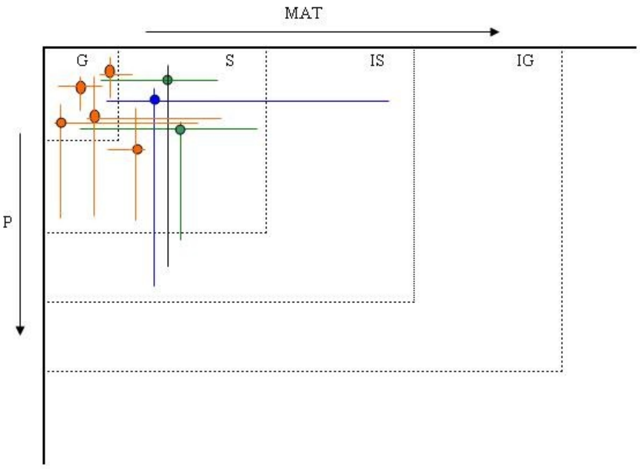


Figure 6.6 **Condition-resources during a full glacial configuration**

6.8 Socio-behavioural change

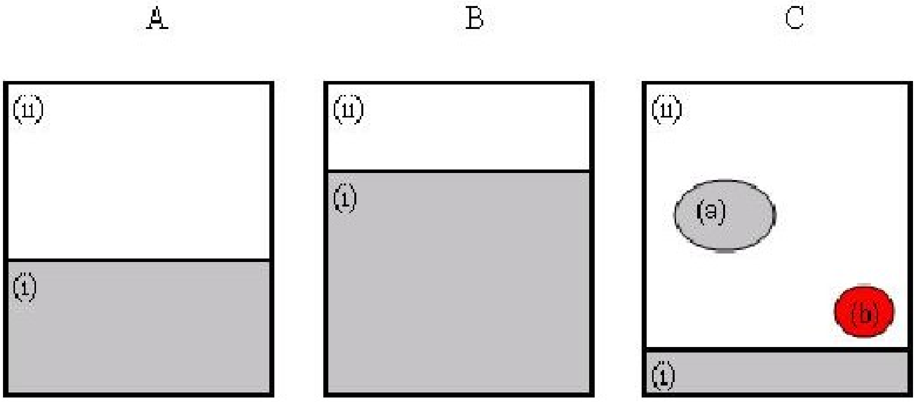
The following section will elaborate on the idea that socio-behavioural variation at all levels, from the simple to the complex, may be a function of condition-resource dynamics. It is suggested here that socio-behavioural responses can be broadly grouped into two essential developmental stages and that these in turn can each be associated with a given condition-resource context. The first of these developmental stages is what I will refer to as *type I* (tI) responses and the second as *type II* (tII).

tI socio-behavioural responses are associated with more stable ecological configurations, that is to say a domains which are not characterised by condition-resource fluctuation to any real degree. tI socio-behavioural responses can be sub-divided into two types: the first of which is tIa. This is where condition-resources are essentially stable in spatial terms. This is to say that over seasonal as well as longer timeframes the basic components of the environment especially in terms of exploited resources are predictable. The second aspect is referred to as tIb. This is where socio-behavioural responses are maintained because the given population tracks a limited range of condition-resources both in time and space. Because the preferred configuration is unstable in space, hominins are forced to undertake spatial movements in order to maintain behavioural equilibrium.

The socio-behavioural responses in tIa and tIb systems are uniform and consistent because no meaningful changes in existing condition-resources (such as temperature and precipitation) occur, nor are any aspects of the domain (for example other human populations or major faunal changes) introduced into the system. Whatever the case tIa and tIb responses should be visualised as essentially stable behavioural strategies selected for in contexts that do not require what can be termed *immediacy* – or a socio-behavioural package that is flexible and adaptable to a much broader array of circumstances. Of course, with regard to tIb systems only a finite degree of spatial movement would occur before new condition-resources disrupt or change the existing domain. This scheme is not necessarily so restrictive that we will observe only a limited range of archaeological variation in the record, or that we should not expect to see any significant departures in technology or typology in stone tools, for instance. Condition-resource differences between one domain and another would predictably result in observable archaeological variation leading to nuances of the tI system discussed above. However, hominins exploiting tI domains respond to and behave within certain, defined stimuli. Some domains would require certain adaptations or characteristic behaviours yet the socio-behavioural category should be seen as a finite cultural output from a finite range of condition-resources.

In any domain we posit that some condition-resources are neutral, that is to say, they are unimportant in socio-behavioural terms and do not influence the resultant hominin behaviour in question. Similarly, we can also operate on the understanding that local fluctuations in abundance, availability and frequency of occurrence will also influence behaviour to a greater or lesser degree over time. Thus condition-resource variation *sensu lato* does not necessarily result in meaningful, observable socio-behavioural change and similarly structured (in ecological terms) but geographically separated domains may well display a degree of convergence in cultural output.

If a cause and effect relationship between climate change and socio-behavioural change exists, then we can hypothesise that this relationship should appear strongest at the transitions between major climate regimes such as for example, the transition between glacial and interglacial episodes. During these transitions we can envision two major outcomes. On the one hand, we can hypothesise that some populations were forced to undertake major demographic restructuring in order to maintain socio-behavioural equilibrium, while on the other hand populations maintained a demographic structure at the regional scale because they adapted and modulated their behaviours to suit the introduction of new condition-resources. But before adopting the "*social context as all*" (Soffer 1994:114) explanation as to why *H. sapiens sapiens* succeeded during what can be termed domain fluidity (i.e. inhabited areas that required more sophisticated socio-behaviour – to be discussed below) it is crucial to identify the emergence in time of these key behaviours that are believed to have formed the basis for successful colonization. Did these behaviours appear coeval with the appearance of *H. sapiens sapiens* in Eurasia, or did they appear in a diachronic fashion over different spatial and temporal scales, yet linked to a specific domain state comprised of condition-resources that in some way required the development of new behaviours? Fig. 6.7 cartoons the process of socio-behavioural change outlined here.



(i) Stable t1a population situated adjacent to more unstable, t2 settings (ii)

(i) Broadening in spatial extent of t1a conditions resulting in a population increase

(i) Large-scale change in condition-resources resulting in a broad demographic and spatial restructuring. Hominin associations with t2 conditions caused by (a) socio-behavioural innovation (b) *pseudo-adaptation* : presence is determined by pressure from preferred t1 habitats

Figure 6.7 Condition-resource variation and socio behavioural change

Fig. 6.7a shows two domains (i) and (ii). Domain (i) can be taken as a more stable setting utilised by tI society. Domain (ii) however, is characterised by more unstable condition-resources (domain fluidity) and requires more specialised or sophisticated behaviour. Fig. 6.7b shows that the context in which tI behaviour can be utilised has changed, and in this case, the socio-behavioural response in now visible over a wider spatial area. Fig. 6.7c shows that a further change in condition-resources has led to a reduction in domain (i) and a concomitant increase in domain (ii). We observe that hominin success in domain (ii) is predicated by one of two possibilities: the first of which is that they are *sink* populations, that is to say, populations using tI responses unsuited to long term occupation in the new domain and which will eventually die-out. The second possibility is that the inhabitants have adjusted their socio-behavioural responses accordingly to deal with the new circumstances thus conforming to type II (tII) behaviour. We can visualise tII socio-behaviour as a coping mechanism well-suited to dealing with unpredictable and/or challenging domains. Rapidly changing, unpredictable or fluctuating condition-resources would require a different socio-behavioural package to that of tI.

If it can be shown that some populations of Neanderthals endured the transitions between condition-resource changes this would provide a different perspective from which to infer that the emergence of pioneering behaviours is grounded in purely ecological terms as oppose to the more traditional explanations of trade, emulation or scavenging. To be sure, socio-behavioural innovation – or tII society – in the sense in which it is implied here does indeed demonstrate a degree of demographic resistivity to domain change. However, it is less-certain that local examples of tII socio-behavioural change are demonstrative of an ability to manage all domain configurations of an IG-G. If over broader timeframes only a subset of domains were experienced by a given population (or lineage) this could have still resulted in a situation where the population in question was over-specialised and ill-suited to cope with the emergence of altogether more challenging domains (comprised of other human populations, for example). It is interesting that we could also hypothesise that those populations that were in a sense overspecialised and suited to a narrow range condition-resources may also been more susceptible to increased levels of gene flow as they encountered other groups moving across the landscape in search of domains in keeping with their behavioural potential. In contrast, those groups socio-behaviourally more flexible to domain change (tII) were by definition probably more sedentary which in demographic terms means they were prohibited in terms of meeting other groups (or ideas) had they ranged across broader areas more frequently in time.

Some workers believe that the Neanderthals were specialized humans, well-adapted to the cold of the Pleniglacial, but only to a narrow range of the palaeoenvironmental settings which characterised an IG-G (Holliday 1997a). This viewpoint contends that the Neanderthals were bound to a narrow range of condition-resources. In this light Neanderthal social systems conform to the t1 socio-behavioural structure. While the claim for Neanderthal over-specialization may be overstated, it is not that surprising, for at any given point in time, regional populations, whether Eurasian Neanderthals; Asian *H. erectus*, or African *H. sapiens* were exposed to only a limited range of condition-resources. Throughout the course of time, Palaeolithic people, irrespective of species were displaying or were capable of expressing complex socio-behavioural traits as functions of given condition-resource contexts. This is an important point because the variation in cultural outputs between different human populations (or the perceived lack of it) should not simply be interpreted as a consequence of some inherent cognitive differences between human populations or species. It was largely the outcome of their given environmental circumstances. Perhaps 'modern' i.e an integrated socio-behavioural system owes less to species-specific innovative event than to population pressure which combined to articulate tI social systems into a broader synthesized dynamic – the tII system. This begs the question: did socio-behavioural complexity amongst Late Pleistocene humans arise as part of an adaptive process to a greater range of new habitats and contexts?

At one end of the spectrum, a movement between similar condition-resource configurations requires the maintenance of existing socio-behavioural responses, or only slight modifications (tI). This pattern would indicate, at least in archaeological terms, a broadly consistent behavioural repertoire between domain (i) and domain (ii). Owing to the nature of the archaeological record, only limited media, principally lithic information is generally available; but this may not be the most revealing evidence for demographic, cultural or biologic change. Indeed, where movements into new domains do not require significant cultural change it is unlikely that a clear indication of demographic change will be identifiable based on lithic information alone. This problem is compounded further by fossil evidence which is often equivocally dated or classified. The apparent lack of cultural change during the Lower and Middle Palaeolithic would reinforce notions of population stasis, clouding for instance our basis to infer the likelihood of gene flow between regional populations, obscuring the potential to theorize on micro- and macro-population movements throughout the Lower to Upper Pleistocene within Europe and between wider areas.

At the other end of the spectrum we can hypothesise two further situations, both ecologically driven, out of which socio-behavioural change may have emerged. In the first of these the condition resources of the existing domain change. This may have occurred on a variety of scales. For example, the frequency of occurrence of certain taxa may have changed or reduced to levels that were unexploitable. In the second instance migrations from one domain into another would by default require modification of existing socio-behavioural strategies or the innovation of new behaviours altogether. Implicit in this scenario is the notion that socio-behavioural innovation could lead to major demographic changes and the colonisation of new palaeoenvironmental circumstances. A similar suggestion was made by Lahr and Foley (1998) who argued that the emergence of blade tools was an innovation that facilitated the colonisation of a wider range of environments. The sequence at Boker Tachtit (Marks 1990) appears to show an independent transition from Levallois to prismatic core flake/blade production independent of any changes in condition-resources. No new condition-resources arose alongside, nor pre-empted this technological transition. This reason alone suggests that cultural change, at least in terms of this particular example was not palaeoclimatically or palaeoenvironmentally linked. Blade technology was not some fundamentally new adaptation required to succeed in new ecological circumstances. Laminar technology appeared tens of thousands of years prior to the Upper Palaeolithic (Hawks and Wolpoff 2001) within temporally and spatially discrete human populations, thereby pointing to a degree of technological convergence over wide temporal spans (see also Straus 2001 who reaches a similar conclusion for typo-technological change in Iberia and North Africa). For this reason the idea that large-scale migrations can account for the emergence of discrete behavioural traits such as blade technology must also fail. Other behavioural changes have been used as a proxy to infer the movement of (principally) modern humans into new habitats. Many workers are keen to emphasise that many behavioural changes are intrinsically linked in space and time, and from this they argue that they arose within a single population within a discrete geographical location. Table 6.1 lists some of the behaviours which it is argued were the innovations of modern humans during the Late Pleistocene (after Stringer and Gamble 1993). But it is clear that many of these innovations were temporally and spatially discrete and in no way are associated with a one-off revolutionary event within a discrete human population (*cf.* McBrearty and Brooks 2000).

Table 6.1 UP behavioural elements and their emergence in time (after Stringer and Gamble 1993)

Behaviour	*Known occurence (ca. ka)*
Art	40
Bone tools	40
Body ornament	40
Artefact style	60
Hearths	50
Structured living space	70
Cave burials	80
Open burials	40
Storage pits	40
Huts	50
Microliths	70
Quarries	40
Regional art	40
Long distance raw material	60
Long-term occupation of harsh habitats	40
Language	?80
Forward planning	60

The European Mousterian is conventionally viewed as the behavioural legacy of the Neanderthals. Its apparent technological and typological conservatism has been interpreted as a function of isolation from external (presumably African) cultural innovations (e.g. Gamble 1999). However this is but one possible interpretation. We have seen that under the tI society model, a perceived lack of industrial variation does not in any way limit one to conclude that the Mousterians were at the periphery of innovation (going on elsewhere), nor small, restricted societies drifting on a biological trajectory away from modernity. Cultural conservatism, then, does not *a priori* demonstrate population isolation and stasis. Perhaps even the notion that the Mousterian is a mundane, repetitive behaviour is inaccurate. Table 6.2 shows that the Mousterian was technologically and typologically highly differentiated and this fact is accommodated by either the tI or the tII approach outlined above. In order to elucidate which one of course would require a more systematic understanding of the environments that these industries were associated with. If tI systems can be identified in time and space, then the resultant ‘cultural conservatism’, can actually accommodate the idea of demographic movements and gene flow. Alternatively, if the Mousterian does indeed reflect an adaptation to broad range of condition-resource configurations therein conforming to tII systems, this has clear implications for those models which contend Neanderthals were socio-behaviourally incapable of inhabiting more complex and challenging environments. It is finally worth mentioning that the overall nature of the Mousterian, which points to some technological and typological distinction at the regional level may support the idea populations were conforming to both tI and tII scales.

(summarised from F.C. Howell 1998)

Table 6.2 *The spatio-temporal variants of the Mousterian technocomplex*	*Location*	*Neanderthal Association*
Charentian Mousterian complex, with Ferrassie and Quina groups	Pan-Europe	Yes
Typical Mousterian complex including (European)	Pan-Europe	Yes
Levalloiso-Mousterian: strong laminar components at mostly open air sites	Northwest, central, eastern Europe and the Crimea	
Typical Mousterian/Crvena Stijena type	Balkans	Yes
Levantine Mousterian	West Asian Levant	Yes
Mousterian/Vasconian type	Northern Iberia	
Denticulate Mousterian	Pan-Europe	Yes
Mousterian/Acheulean tradition	SW Europe	Yes
Mousterian/Châtelperronian type	SW Europe	Yes
Mousterian/Cambresian type	NW Europe	
Mousterian/Pontinian type	Greater Latium	Yes
Mousterian/Kartstein type	Central Europe	Yes
Mousterian/Tata type	Bükk Mountains	
Mousterian/Staroselje type	Crimea	
Mousterian/Tsutskhvatskaya type	Crimea, western Caucasus	
Mousterian/Khostinskaya type	Western Caucasus	
Mousterian/Kudaro type	Western Caucasus, Georgia	
Mousterian/Zagros type	Greater Zagros Mountains	Yes
European Micoquian, including subgroups (see next)	Pan-Europe	Yes
Micoquian/Bocksteinian	Central Europe	Yes
Micoquian/Altmühlian	Upper Danube	Yes
Micoquian/Jankovician	Trans/lower Danube	Yes
Micoquian/Babonyian	Bükk Mountains	Yes
Micoquian/Kiik-Koban	Crimea	Yes
Micoquian/Ak-Kayan	Crimea	Yes
Acheuleo-Yabrudian or Levantine Mugharan	Levant	Yes

Some of the early and late Aurignacian behaviour of the Périgord region (France) may also reflect this pattern. Blades (1999) reported that the Aurignacian industry in this region was highly variable. Behaviour such as settlement pattern and faunal exploitation all varied according to the different palaeoclimatic/environmental settings throughout the Middle Pleniglacial. In this case certain socio-behavioural traits were moderated to suit a particular condition-resource context. The chapter has outlined the condition-resource hypothesis which deals with three main socio-behavioural themes:

i) how human populations tracked preferred condition-resource configurations and maintained cultural continuity.
ii) how socio-behavioural responses and initiatives were maintained, co-opted or changed as a function of condition-resource variability.
iii) how cultural stability or 'stasis' is compatible with notions of demographic flux or population change.

The central issue is whether or not late Middle/Late Stone Age/Upper Palaeolithic behaviours were the product of a true *revolution* (where revolution refers to a suite of new characteristics that emerged closely in time and space) or were the product of a far-less dramatic explanation in the sense that all socio-behaviour can be accounted for by a more sustained exposure to broader arrays of condition-resources over geological time. Considering the latter proposition, the spread of socio-behavioural change may be inextricably linked to demographic pressure (and not some 'special' explanation unique to African populations). If population numbers were maintained at sufficient levels during phases of uncertainty, uniqueness or fluctuation, behavioural capacity could have reached 'potential' as new behaviours emerged or were co-opted from existing behaviours to suit the needs of the new behavioural domain(s). Demographic flux would have resulted in a positive feedback situation, where in a sense, surplus behaviours, some more pertinent than others to a given situation were at hand and others maintained via tradition perhaps to be employed as and when new condition-resource domains emerged or where encountered. This scenario, combining the changing balance of condition-resources coupled with finely balanced demographic patterns, may have combined in hitherto unpredicted ways, resulting in new and novel approaches to survival being phased-in across key regions. The means by which behaviours were transferred between populations may not have required the influx of new people, but were instead regulated by the climatic and environmental controls that acted on *existing* populations. The pressure caused by climatic change would have in turn affected condition-resources and these in turn would have regulated subsequent behavioural expressions.

Chapter 7

Neanderthal Biogeographical Scope and Scale: Summary of Findings

7.1 Introduction

This thesis was designed to hopefully better understand the evolutionary history of the Neanderthals in Europe and to further explore the possible causes of their extinction. This ambition in itself is not new. Indeed, archaeologists and anthropologists have grappled with these issues since the late 19th century. More recent work, the sum of important contributions from the disciplines of geochronology, genetics, palaeoclimatology and archaeology, has advanced our understanding of the evolutionary history of our species. It is an indelible fact that our species as we recognise it today evolved in the late Middle Pleistocene; and it is also true that the dominion of the planet by a single member of our genus – *Homo sapiens sapiens*, is clearly the exception, not the rule. This is a point worth re-emphasising: for the great majority of the Pleistocene period our genus was polytypic; regional populations diverged into new species, which in turn evolved or died-out. That one of their number, *Homo sapiens sapiens*, achieved global dominance is quite clear, but the reasons why are less so, and still the focus of intense scientific interest. To understand why our species came to dominate the planet requires an understanding of why other species did not. And with that aim in mind the ongoing endeavour to understand the Neanderthal evolutionary path and eventual disappearance sometime in the Late Pleistocene remains an open question, which, when answered decisively will surely broaden our own understanding of ourselves and our place in nature.

The relationship of the Neanderthals with modern humans has been studied in great detail over the course of the 20th century. And despite the co-ordinated efforts of several disciplines it has been not been possible to establish a consensus on the relationship of Neanderthals with modern humans on purely morphological grounds alone. Accordingly, researchers have turned to genetics, and it is hoped that the Neanderthal Genome Project and related work[11] may clarify one way or the other this longstanding issue. The appearance of modern humans in Europe was and still is the traditional implied explanation of Neanderthal extinction; however, recent models appear distanced from purely competition-based scenarios and are instead grounded more in climatic and environmental terms. These approaches, as sound as they are, are limited because they view what was clearly a complex process through narrow temporal or geographic windows leaving the broader perspective largely unexplored. In this work a wider perspective was adopted, and Neanderthal population history within a climatic and environmental framework was presented and discussed in detail.

7.2 Limitations

The manner in which the chronometric and radiometric determinations were used in this study as well as the resultant discussion and conclusions drawn will no doubt be open to criticism. For instance, the decision taken not to combine multiple dates from single sites (to determine a mean value) was based on the grounds that it simply cannot be assumed that just because several determinations were garnered from materials purportedly in close temporal and spatial proximity, that they can also be attributed essentially to the same occupation episode. In cases where, for example, several fragmented charcoal samples were each dated and shown to fall within a range of say, between 35 ka and 37 ka, one could infer that a site was occupied at different times over a 2,000 year period. But it also cannot be ruled out that some dated samples pertain to the same incipient occupation episode and that contamination and/or uncertainties in the accuracy of each dated sample can contribute to divergent interpretation over the nature of occupation i.e., long-term residency, or long-term seasonal use over a 2,000 year period. It was principally because of these reasons, and the restriction involving the use of a mean determination, that multiple age determinations were used in this study. By doing so it was hoped that the large numbers of dates over a broad geological timeframe would smooth out any irregularities in terms of sites that had received inordinately high treatment in terms of excavation and/or emphasis on dating.

---

[11] "Neanderthal DNA" Accessed 26 January 2007 <http://www.nature.com/nature/focus/neanderthaldna/index.html>

As the work progressed it became increasingly clear that some archaeological sites with relatively long occupation histories and multiple age determinations could have been referenced against climatological records especially in the southern and Mediterranean provinces. It was felt that chapter 5 in general and 5.12 in particular would have benefited from a case study considering the effects of a specific Heinrich event or D-O event at a more local scale (site or closely spaced multiple site) to complement the regional demographic studies which formed the basis of this chapter. However, this realisation was formed too late in the day and would have involved a major return to the literature. Other limitations include the real uncertanties relating to the chronological precision of archaeological determinations (refer to 5.2), phases and periods of seasonal, habitual and all-year round occupation, as well as the timing and duration of relatively short-lived (on geological timescales) climate reversions such as Heinrich events, and critically, their tie-in with terrestrial environmental change i.e. the tangible and direct changes in fauna and flora and the concomitant effects on Neanderthal and early modern human populations. It cannot be overstated here that until a more rigorous chronological framework can be put firmly in place these findings presented here must be viewed tentatively.

7.3 Research in context

In line with d'Errico and Sánchez Goñi (2003) and Finlayson *et al.* (2004) it was recognised that the archaeological record for MIS 3 is ambiguous, and that serious obstacles stand in the way of archaeologists trying to establish a more accurate chronological record for this particular timeframe. This issue is made all the more difficult as many materials dated radiometrically may be simply wrong because of the differential production of upper atmospheric ^{14}C throughout the glacial period and contamination effects with much younger carbon. Quickly it was realised that to treat isolated age determinations or even single sites in isolation and to try and match these to the finer-grained climate records would provide no gain. Similarly it was realised that direct inter-regional comparisons between regional archaeological signatures, and the GISP2 ice-core, for example, would not do, precisely because some regions appear to have experienced greater levels of environmental change than others. This was compounded further by the difficulty in establishing accurate chronological controls with individual sites and/or dates, coupled with asynchronous relationships between palaeoclimate change (driver) and palaeoenvironmental change (response) in space and time. On present evidence the best that could be achieved was to try and investigate the large-scale or population histories of the four study provinces. By exploring these issues from the broader perspective, in this case over an interglacial-glacial cycle, it was possible to view how Neanderthal demography fared and fluctuated during 100,000 years or so of their existence.

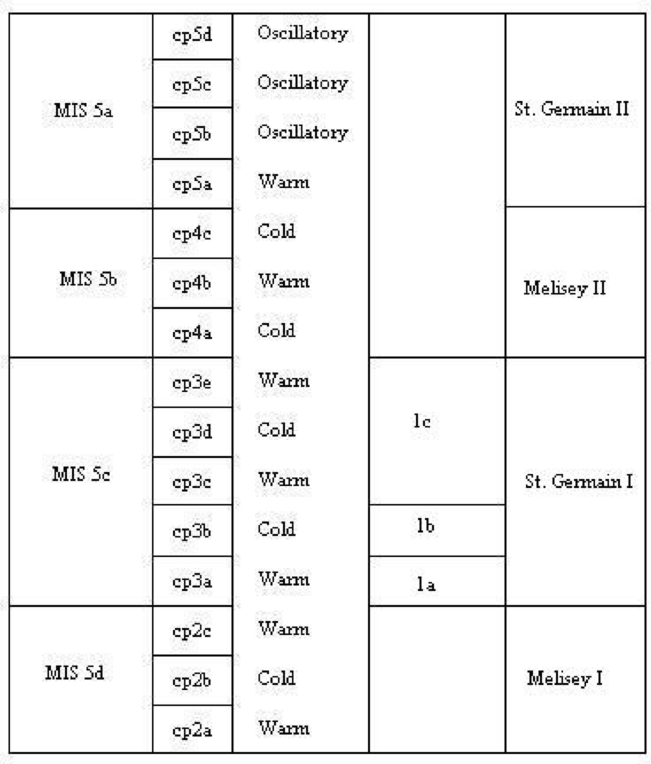
The underlying current of this investigation has been to better understand the diversity of climatic and environmental conditions that prevailed across but one flank of the Neanderthal's European range, and how the Neanderthals fared in these environments over the course of an interglacial-glacial cycle. More specific questions concerned the role of those resultant environmental changes during MIS 3 in Neanderthal extinction. These themes, as well as several recent studies which approach the issue of Neanderthal disappearance couched in purely climatic or environmental terms were discussed in chapters 2.0 and 3.0. Of those reviewed, all approached the issue of Neanderthal adaptation with one assumption in common, that MIS 3 posed the Neanderthal lineage with almost unique demands hitherto only rarely (or if at all) encountered previously in Europe. What these models lacked was an appreciation of the variation, both in space and time of those conditions and resources and the dynamic ways in which these were linked throughout the course of the interglacial-glacial cycle.

We have seen how some recent discussions have invoked climate and environmental change to a greater or lesser degree in Neanderthal extinction. We saw how d'Errico and Sanchez Goñi (2003) argued that European Neanderthal populations across Spain and Portugal were greatly reduced during H4. They argued that the Franco-Cantabrian region was comprised of rich heath and grassland that was capable of supporting a much larger biomass than the less-supportive *Artemisia* type steppe that prevailed in the south. d'Errico and Sanchez Goñi (2003) claimed, somewhat paradoxically, that Aurignacian subsistence strategies were, in contrast to those of the Neanderthals, ill-suited to exploiting arid and poor environments and that it was only during the *climatic improvement* following H4, that modern humans were able to venture into the inhospitable southern Iberian zone to outcompete Neanderthal populations. This hypothesis differs somewhat to the work of Finlayson *et al.* (2000 a, b, 2006; Finlayson 2004 a, b) who claim that the Neanderthals were a mid-latitude, warm-loving species, seriously disrupted by the Early Pleniglacial and unable to adapt to increasing environmental uncertainty during MIS 3. In the end, the Neanderthals were restricted to environmentally stable, resource rich zones that suited the Neanderthals' opportunistic 'Middle Palaeolithic' socio-behavioural abilities, with the extreme south of the Iberian margin being but one example of such a zone (other examples include Crimea e.g. Burke 2006). Mellars (1996, 1998) argued that climate change in a sense sounded the death knell for Neanderthal populations but in a less direct way. Instead he claimed that major periods of MIS 3 warming facilitated the entry of African-derived modern human populations into Europe, and, following a short-lived phase of co-existence, the Neanderthals were replaced principally through the effects of competitive exclusion by modern humans (Mellars 2006). Stringer *et al's* (2003) analysis was in contrast to d'Errico and Sanchez Goñi's (2003) study insofar as it made explicit predictions regarding when Neanderthal populations expanded and declined across the course of the glacial period. If chapter 3 was a review of current ideas and conventions of Neanderthal disappearance within a climatic and environmental context, then chapter 5 represents an assessment of these hypotheses as well as the co-ordination of the first three aims of the thesis.

7.4 Did climate change drive Neanderthal extinction?

From the outset the intention was to recreate as best as possible the demographic structure of Neanderthal populations and view any resultant trends through four study provinces over the last interglacial-glacial cycle. But as figs. 5.1 and 5.2 made clear, there are disproportionately larger numbers of determinations available for the Middle Pleniglacial (MIS 3) than for any other phase. The earlier optimism, born out of the clarity with which Eemian environments could be visualized, was short-lived when it was realised the corresponding archaeological data was rare, and that only a general consideration of Neanderthal demographic structure could be made for this phase. Further restrictions, which became clear in chapter 4.0, showed that proxies such as marine or ice palaeotemperature curves are largely general in nature, regionally specific and are difficult to correlate with perceived environmental change with any confidence. Proxies such as these must be accepted with caution when inferring terrestrial environments. Traditional estimates for the duration of the Eemian of 10 kyr appear to be grossly underestimated, while evidence for intra-phase instability recorded in regional climate catalogues (GRIP) appears to have been overstated. Terrestrial evidence instead suggests that mixed boreal/deciduous forests i.e. the Eemian environments proper persisted across some parts of Europe well into the purported stadial (MIS 5d) phase of the marine sequences. Here, then, we have clear evidence for an asynchrony at work between regional terrestrial records and broader palaeoclimatic catalogues. Over reliance on one proxy, or the exclusion of others can obfuscate an already patchy record and could have potentially deleterious effects on the reconstruction of past hominin demography at all scales.

Based on the age determinations used in this study, Neanderthal occupation of Europe corresponding to the earliest phase of the cycle at the Saale-Eemian transition as well as the earliest stages of the Eemian itself appears to have been limited to the SP. However, we saw a range of evidence discussed in section 5.8 which supports the view that Neanderthals were present across wider areas of Europe including parts of Germany and the Mediterranean during the Eemian thermal optimum. Indeed the thermal optimum as well as the terminal Eemian emerged as potentially some of the most interesting phases of time examined across the interglacial-glacial cycle. If, as it appears likely, Kukla *et al*'s (2002) Eemian framework is adopted more widely in the literature, then the termination boundary of the interglacial will be pushed forward to *ca.* 107 ka and this will enlarge the scope to investigate Neanderthal response to what increasingly appears to have been a more protracted period of climatic deterioriation during which forested conditions persisted across southern and Mediterranean Europe at a range of different tempos. We saw how the conventional IG-G chronology portrays MIS 5 as a *ca.* 50 kyr phase lasting between 125-75 ka, of which the first *ca.* 13 kyr corresponds to the Eemian proper. The MIS 5d and 5b stadials and 5c and 5a interstadials are portrayed as *ca.* 37 kyr of rather stable, high-amplitude events – signifying gradual climatic and environmental change played-out over the scale of geological time – not human lifetime. But it became clear in chapter 4.0 that the palaeoenvironmental records of Europe during the post-Eemian phase reflected a far more complex picture than the broad trends shown by fig. 4.5. This discussion developed from the observation that in purely climatic terms the transition between MIS 5a-MIS 4 and MIS 3-MIS 2 were similar because in both cases they represent interstadial/full glacial boundaries. But according to the current conception in the literature this is where the similarity ended, for as we have seen, MIS 3 was singled out as having been marked by several high-frequency climatic shifts with concomitant environmental changes on millennial and sub-millennial time-scales. Indeed this was the prevailing view espoused widely in the models in chapter 3.0, where the emphasis was on the *uniqueness* of the MIS 3 climatic and environmental changes and the role that they subsequently played in Neanderthal extinction. Following a review of the palaeoclimatic and palaeoenvironmental literature in chapter 4 it became apparent that the MIS 5d-a phase had not received the same degree of treatment or perhaps been the subject of as much focus as later phases of the IG-G (i.e. MIS 3). As the work proceeded, several important papers served to develop the view that the post-Eemian phase, far from being characterised by essentially geologically stable, high-amplitude climate phases, was in fact characterised by a finer-grained fabric of climatic and environmental disruption. Fig. 7.1 illustrates this complexity, and in using the stratigraphic system of Klotz *et al.* (2004) we see that at least 15 reversions between cold and warm conditions occurred across this 37 kyr timeframe.



MIS 5a	cp5d	Oscillatory		St. Germain II
	cp5c	Oscillatory		
	cp5b	Oscillatory		
	cp5a	Warm		
MIS 5b	cp4c	Cold		Melisey II
	cp4b	Warm		
	cp4a	Cold		
MIS 5c	cp3e	Warm	1c	St. Germain I
	cp3d	Cold		
	cp3c	Warm		
	cp3b	Cold	1b	
	cp3a	Warm	1a	
MIS 5d	cp2c	Warm		Melisey I
	cp2b	Cold		
	cp2a	Warm		

Figure 7.1 The 15 major climate and environmental oscillations comprising the post-Eemian oscillations

This stage in general was subsequently referred to throughout the thesis as the *post-Eemian oscillations*. Far from being environmentally stable as the general ice and marine proxies suggest, it appears instead that vast areas of northern, eastern and central Europe (the NP and CP in this study) witnessed extensive environmental re-organisation at millennial timescales. Klotz *et al*'s (2004) paper was central in this regard to developing this theme, which is worth re-stating here. During the Eemian-Melisey 1 transition MAT declined by as much as 14°C over northern and southern Europe (Guiot *et al.* 1989; Cheddadi *et al.* 1998) with MST between 3°C and 10°C and MWT of -12°C (Aalbersberg and Litt 1998). This temperature decline probably coincides with the C24 iceberg discharge event observed in the North Atlantic marine cores at *ca.* 113-110 ka. Klotz *et al.* (2004) reported a distinct short-lived amelioration (cp2b) within the Melisey I and report that this led to the re-emergence of deciduous flora across parts of southern (Les Echets) and eastern Europe (Samerberg). A reversion back to colder and drier conditions occurred late in the Melisey I (cp2c) resulting in lower MWT and MST. The Melisey I amelioration appears to be inconspicuous in marine and ice core records and but for the recognition of this reversion in terrestrial pollen sequences it is probable that the Melisey I would have been interpreted in general terms as a long, cold but stable phase.

The St. Germain I was further split into three phases: phase 1a saw thermophilous woodland (e.g. *Carpinus*) in the more easterly sites (e.g. Les Echets) (de Beaule and Reille, 1984). Easterly and northerly sites (e.g. Jammertal, Füramoos and Samerberg) show weaker deciduous signatures with *Pinus*/*Picea* woodland, and few poorly expressed thermophilous species (e.g. *Quercus*, *Corylus* and *Carpinus*). Optimum conditions corresponded to only the first third of the phase (cp3a) and were marked by MWT of 2.2°C and MST of 18.5°C in the east while in the west a MWT of -7˚C and MST 14.8°C prevailed. The Montaigu event (St. Germain 1b) saw a decline in deciduous elements at Les Echets and a *Picea* decline in the northern and eastern sites. NAP values increased, in conjunction with *Betula* and *Pinus*. This was a classic pre-MIS 3 environmental disruption which had particularly strong effects in the southern study region (e.g. Les Echets). MWT and MST declined to -13.5°C and 14.8°C respectively. St. Germain 1c saw *Pinus*, *Quercus*, *Corylus* and *Carpinus* woodlands become re-established. We see then that northern, eastern and southern Europe experienced pronounced environmental changes during MIS 5d at similar frequencies to disruptions which characterised parts of Europe during MIS 3. The thermal optimum corresponds to sub-zone cp3c and this saw MWT of 0°C at Les Echets, while further to the east MWT was -5.4°C. MST reached 18.3°C in the southern region and 17°C in the central region. Further climate deterioration within the interstadial (cp3d) saw temperature decline and forest decline, before a further period of amelioration (cp3e) prior to the Melisey II.

The Melisey II saw a much stronger *Artemisia* signature with pocket woodlands of *Pinus* and *Betula*. MWT dropped to -17°C while MST remained at 15°C (cp4a). Amelioration (cp4b) saw MWT rise to 8°C and this improvement was recorded widely across Europe in Les Echets, Füramoos, Jammertal and Samerberg before temperature declined to -16°C in cp4c. Clearly then, the Melisey II was at least tripartite in nature, demonstrating once more the oscillatory nature of the pre-MIS 3 higher latitudes of Europe. The St. Germain II (cp5a) saw major environmental change with a 90% increase thermophilous taxa (*Quercus*, *Corylus* and *Carpinus*) in the southern region (Les Echets) while in the north and east coniferous woodland was present. MWT of 3°C and MST of 19.7°C prevailed in the southern region, while MWT of -4˚C and MST of 17.7°C characterized the central region. Klotz *et al.* (2004) indicate that a cooling-warming cycle (cp5c) occurred in Les Echets and Samerberg prior to another short term oscillation (cp5d) between 76 ka and 75.5 ka (Les Echets) followed by NAP increase. While the Melisey I was characterised by cooler conditions than the Melisey II, the St. Germain II appears to have been a warmer phase with stronger thermophilous values than the St. Germain I. It was clear that the post-Eemian oscillations resulted in greater levels of environmental disruption in the higher latitudes of Europe than elsewhere and it was concluded that they represented the early stages of a process that was eventually to perturb the lower latitudes (principally the SP and MP) during the Middle Pleniglacial. In this interpretation it was concluded that it was premature to claim, be it directly or indirectly, that the climatic and environmental changes of MIS 3 were unique, or that Neanderthals encountered such disruptions only during MIS 3. It was also suggested that the Early Pleniglacial was the critical agent in 'homogenising' the higher latitudes in environmental terms and destabilising the lower latitude provinces – or – in a sense initiating the ensuing MIS 3 disruption. The realisation that the post-Eemian oscillations were comparable in a sense to the disruptions of MIS 3 provided an opportunity to explore and test one of the main aims of the thesis: *did Neanderthals cope with oscillatory environments in pre-MIS 3 contexts?* Fig. 5.13 and the resultant discussion showed that for the earlier post-Eemian few data were available to approach this question with any confidence. No archaeological data were available to explore the question whether or not Neanderthals were present in the higher latitudes of Europe (particularly the NP) during the post-Eemian oscillations and how they fared against these changes, so this potentially interesting question was left unexplored. It may well have been the case that the early post-Eemian oscillations in northern and central Europe were severe and discouraged Neanderthal populations from establishing a meaningful foothold in these regions. Other regions did provide clearer inights. With regard to the general pattern illustrated in fig. 5.13 sub-regional Neanderthal presence in France appears to have been more or less continuous during the post-Eemian phase. We see that

Neanderthal presence in southern Europe seems to have been continuous from the Eemian into the St. Germain I interstadial. By *ca.* 100 ka humans seem to have been absent from the north and central study provinces altogether. Similarly, the MP at this time appears to have been largely uninhabited and we must wait until the St. Germain II until we see more intense and continual occupation of parts of the Mediterranean. The reasons why Neanderthals had by this point colonised regions hitherto uninhabited are no doubt complex and any conclusions made are necessarily speculative. Nevertheless, it was suggested that this new occupation pattern is largely accounted for in terms of palaeoclimatic and palaeoenvironmental change which had probably by now opened up parts of the Mediterranean that were previously dense forest. Certainly the broad pattern in fig. 5.13 supports the view that a process of demic retreat occurred, driven perhaps by the post-Eemian oscillations, leading to more continuous occupation and denser population levels in ecologically more stable areas of Europe. But at the same time this study does not support the view that Neanderthal populations situated in the higher latitudes (i.e. the NP/CP) slowly diffused southward throughout the course of the post-Eemian, so it remains open to debate whether Neanderthals retreated/migrated from an adjacent region, perhaps further to the east or the Levant. Alternatively, the increased numbers of occupied sites in the SP and MP may well have been the result of local population increase alone.

With regard to related work we saw previously in chapter 3 how Stringer *et al.* (2003) reported a stress minimum at *ca.* 80 ka BP (MIS 5a) during which conditions were more favourable for Neanderthals thus accounting for their greater archaeological visibility during MIS 5a. And indeed this view is supported here. In broad terms population recovery appears to have occurred widely across the SP and MP after 80 ka BP (fig. 5.13) and for the next 10 kyr or so, the population in the SP appears to have been high. Fig. 5.14 shows a clear fall in the number of occupied sites across both the SP and MP between *ca.* 67-64 ka. This apparent decline in the number of occupied sites is probably real (and not an artefact of sampling/local research history) because it is observed over such a narrow timeframe and in two different provinces. Stringer *et al.* (2003) argued that at *ca.* 65 ka BP parts of Europe were under severe environmental stress and the data discussed herein appear to support the idea proposed by Stringer *et al.* that Neanderthal populations probably survived in refugia from which they recovered during the early part of MIS 3. Neanderthal presence during the Early Pleniglacial was largely unspectacular. Occupation was restricted it would appear, to specific locations in the SP and MP. What the data make clear is that at this time Neanderthal population levels were extremely low across much of the study range.

Figs 5.15 and 5.16 and the resultant discussion show that population recovery in the SP and MP during the early stages of the Middle Pleniglacial was rapid; however this was not the case in the NP and CP, where few determinations were available, while what descriptive evidence is available, is broad and could correlate with other time phases. But perhaps the most significant result, I would argue, is the drastic demographic crash that appears to have taken place within southern and Mediterranean Neanderthal populations at *ca.* 50 ka. That Neanderthal populations appear to have been substantially reduced at this time stands in marked contrast to the findings of Stringer *et al.* (2003) who argued instead that Neanderthal populations at this time experienced the second of two distinct *stress minima*. As with the earlier stress minimum at *ca.* 80 ka, one could predict that Neanderthal populations should have responded to this climatic amelioration accordingly, colonising into much wider geographic areas. And indeed this is the argument one would conclude from Stringer *et al.* (2003 fig. 13.5b) which shows that approximately 55 instances of "Neanderthal and Mousterian" archaeological finds, the second highest number of the last 100,000 years, are associated with the 50 ka mark. But after closer consultation of the Stage 3 Project Archaeological Database (the source of fig. 13.5b), one is left with the question: *where are these dates?* Only 5 determinations fall within the 50 ka millennium and all of these have errors ranging between 5,000 to 8,000 years. The purported stress minimum of Stringer *et al.* (2003) does not in fact coincide with a phase of amelioration but rather a phase of cooling during the pre-H5 phase (figs 5.24 and 5.29), which saw temperature decline steadily by some 3° or 4°C (perhaps more in western Europe) between GISP2 interstadial 14 through to 13. What is perhaps unusual is that this rather conspicuous decline in the number of radiocarbon determinations (fig. 5.16) coincides with this rather benign phase of largely stable, though cooling palaeotemperature. Does this pattern reflect a synchrony between climate change and Neanderthal population history? This question was explored in section 5.11. Neanderthal population distribution was certainly different to that of the post-H6 phase as fewer sites appear to have been occupied in the SP in contrast to the MP where there appears to have been a broader occupation. This observation aside, nothing really stands out in terms of the palaeoclimatic history corresponding to the post-H6 and pre-H5 phase that can account for the regional decline witnessed in the SP and MP. We have a demonstration whereby regional populations (as determined by the number of occupied sites and determinations) fell, somewhat distinctively across both the SP and MP between *ca.* 52-47 ka, and it is this strong regional signature which in all likelihood contributes to the pattern shown in fig. 5.42, where a decline in sites and dates is observed across all areas. With the onset of H5 and the period thereafter the question can be approached with greater confidence. For the first time we see that Neanderthal population appears to have been largely unperturbed by H5 – one of the strongest and most clearly registered palaeoclimatic events of the Middle Pleniglacial. We see that population distribution south of 50° appears to have been broadly comparable with the post-H6 and pre-H5 phases. Irrespective of who authored the EUP industries situated in the NP (whether Neanderthals or modern humans) we could posit that this pattern reflects regional abandonment, in close synchrony with H5. Whatever the underlying causes were of why the NP was abandoned, this remains an interesting avenue for further research. It should also be noted that the effects of strongly-registered palaeoclimatic changes such as HE resulted in greater levels of disruption in more ecologically sensitive regions, or refugia, such as the Mediterranean. The H5 cycle, coupled with the relatively abundant archaeological data for this phase allowed an assessment to be made relating to how Neanderthal populations at the regional scale responded to high-magnitude, rapid climate change. What the data make clear is that Neanderthals <u>do not</u> appear to have abandoned the western European margin. This is probably because of one of two factors: either H5 did not have a broad environmental impact across the core Neanderthal range, or alternatively, the Neanderthals, in whatever way, coped with the resultant disruption. Based on the regional environmental reconstructions in chapter 4, it would appear that environmental disruption was manifested quite differently across parts of Europe, some of which were clearly more sensitive to climatic change than others. The implications are that regional Neanderthal populations should not necessarily display any simple synchrony in terms of growth or decline with a particular climate event and that population response will differ between regions. So the available evidence showed that

Neanderthal populations appear to have undergone some reduction at a regional scale (in the SP and MP) during what could be perceived as a rather benign (stable but cooling) period of climate during post-H6 and pre-H5, before experiencing a period of general regional expansion during a major climatic downturn – H5 (with the exception of what would appear to have been some regional abandonment of the NP and CP). Significantly, it appears that the pattern of an increase in the occupied sites and number of determinations which began during H5 reached an early plateau that remained essentially stable until the pre-H4 phase. Apparent regional declines, such as those seen in figs 5.15 (*ca.* 42-41 ka) and 5.16 (*ca.* 50-49 ka and 42-41 ka) could be real, and may reflect a delayed response in terrestrial ecosystems to climate change. It is possible that the apparent decline at the regional scale (fig. 5.16) at *ca.* 40 ka may have been linked to sharp interstadial events (e.g. GISP2 DO 10 and/or 9). Whether or not coeval ecological change can be identified at some of these site levels would help clarify whether this pattern is real and further research would help clarify this question. One interesting pattern was observed in the central province and this concerned the purported appearance of modern humans, who it seems, had begun to colonize this area by at least *ca.* 44 ka. The Aurignacian people appear to have followed the broad trend observed in the adjacent study areas in the sense that a regional population increase seems to have taken place during the post-Hasselo stadial (41.5-40 cal kyr BP, Renssen and Vandenberghe 2003).

Langbroek (2001) made the claim that modern humans were equipped with a more sophisticated land-use strategy than the Neanderthals and it was this difference which augmented modern human settlement across Europe at the expense of the Neanderthals during the post-Hengelo period. This proposition was tested as part of the examination of the broad distribution pattern of Neanderthal populations in chapter 5.0. While the basic proposition posed by Langbroek, that a major demographic change occurred during the proceeding several thousand years after the Hengelo could not be supported across all areas of Europe, one element of the hypothesis may be supported by the settlement pattern in the CP, which displays a strong increase in 'modern human' occupation in the 5,000 yrs or so after the Hengelo (but again, this element of the hypothesis is based on a strict Aurignacian = modern human relationship). As we have seen such claims range from uncertain to spurious. At this point in time and with the current evidence available we cannot say for certain that modern humans or Neanderthals were the inhabitants of these areas at this time. Finlayson and co-workers (Finlayson 2004; Finlayson *et al.* 2004) were quite correct in their refutation of d'Errico and Sánchez Goñi's (2003) claim that if Neanderthals were susceptible to extinction because of climatic change then they should have died-out during earlier phases of change. This is because historical processes would have led to distinct differences between populations separated by time, and these differences in turn would have influenced the ways in which different populations responded to climate change. It could be argued that d'Errico and Sánchez Goñi's (2003) view is at odds with ecological theory (in the sense that population structure and birth/death rates all change over time), as well as evolutionary theory (in the sense that Neanderthal populations did not accrue biological adaptations nor innovate cultural adaptations to cope with change). It was shown in fig. 5.42 how Neanderthal regional populations appear to have steadily increased during the earlier stages of the Middle Pleniglacial, and that this growth was apparently uninterrupted by short, DO events or the H5. In this light, it seems that the data support the views of Finlayson (2004) in the sense that Neanderthal populations managed to survive distinct episodes of major climate change. Indeed the conclusion reached here is that these earlier phases of disruption were insufficient to extirpate or even significantly disrupt regional Neanderthal populations. But by *ca.* 38-37 ka, we see for the first time a clear correlation between a major climate change, the H4, and a clear decline not only in Neanderthal sites but also date determinations. Fig. 5.42 and the resultant discussion seems to be consistent with the views of Finlayson (2004) and Finlayson *et al.* (2004), and shows that this particular episode of disruption may have fragmented Neanderthal populations at this time. I say *may* because H4 may not have been the single most important factor involved in population decline. It is suggested that the previous disruption, perhaps during the pre-H4 phase or during the rapid amelioration of GISP2 DO IS8 could also have played a significant role in this observed pattern, and that some of these determinations may in fact provenance to slightly earlier or later periods.

Mellars (1996, 1998, 2006) has been a strong advocate of the idea that the Hengelo interstadial, which occurred prior to HE4, was a key factor in the demographic changes of Middle Pleniglacial Europe. More specifically, the rapid spread of modern human populations was facilitated by major improvements in climatic conditions at this time. In a more recent summary, Mellars (2006) noted that new techniques such as ultrafiltration are particularly effective at removing recent carbon from bone collagen and that this pre-treatment technique has led to dates that are frequently between 2,000 and 7,000 years older than initial estimates. In the same publication it was suggested that archaeological dates calibrated against the Notcal04 "best estimation" curve support the idea that modern humans spread from the Near East into parts of southwest Europe over a 5,000 year period between 46,000-41,000 yr cal. BP. To be sure, the application of these new techniques to archaeological materials can only be viewed as good news, but the fact remains that this purported dispersal of modern humans still appears to have begun prior to the Hengelo, so it seems difficult to gauge how important this specific event may have been to a process which appears to have already been underway, especially when Mellars (2006) states that the Hengelo occurred between 43,000-41,000 yr BP cal. There is also considerable uncertainty with regard to the onset and duration of the Hengelo interstadial, which could correspond with either GISP2 DO IS 12 or 8 dated to *ca*. 39-36 ka and 32-28 ka respectively (Westaway 2003: fig. 6). Fig. 5.17 shows that modern humans (inferred from the Aurignacian) appear to have settled across parts of the MP and CP several thousand years earlier than the SP and NP. On present evidence it seems too ambitious to single out a particularly narrow climate phase (such as the Hengelo) as of primary significance for the appearance of modern humans across parts of Europe, particularly when there are several other well-expressed ameliorations closely spaced in time and adjacent to that particular episode which provide equally plausible windows of opportunity for human migration (e.g. GISP2 DO 11, 10, 9 and 8). On a related theme one clear point to emerge from the discussion of European environments in chapter 4.0, was the fact that chronostratigraphic factors are often highly complex and the subsequent interpretation of terrestrial records can be controversial. It is extremely challenging to attempt to make distinctions between, say, 'moderate cold' and 'severe cold' in the terrestrial record. Many of these purported 'severe' events failed to result in qualitatively larger-scale environmental changes than less severe events, while some GISP2 DO events seem to have failed to result in a meaningful terrestrial response whatsoever. A final word with regard to modern human migration and the Hengelo interstadial: many of the determinations that fall outside the Hengelo timeframe may be inaccurate (*cf.* Pettitt

1999) so it is possible that Mellars' basic contention, that the Hengelo was a critical time phase for the Late Pleistocene European demographic changes is in fact sound. No doubt future findings will clarify the role played by the Hengelo interstadial in the demographic changes of Middle Pleniglacial Europe. Further research is required to clarify the role of the Hengelo as a primary driver for major Neanderthal and/or modern human demographic changes.

Fig. 5.36 (H4 Neanderthal distribution) and fig. 5.38 (post-H4 Neanderthal distribution) show that the broad distribution pattern between the two phases was the same. The only apparent difference is that Neanderthals appear to have occupied the perimeter of the Iberian Peninsula in greater numbers. This pattern does not appear to support the views of Mellars (2006) and d'Errico and Sánchez Goñi's (2003), who believe that the H4 had a clear influence on Neanderthal populations or was a driver in their extinction. The basic pattern of a reduction in the number of occupied sites coupled with the number of determinations for the H4 phase supports the findings made by Gamble *et al.* (2004), who found that climate affects population contraction rather than expansion. But it must be stressed that the H4 phase did not completely extirpate Neanderthal populations in either of the core southern or Mediterranean provinces. Fig. 5.39 shows that the basic distributional pattern is the same during the pre-H3 phase and that a strong Neanderthal presence appears to have been maintained along the southwest and southeast Iberian margins. This pattern continued into the H3 phase with no observed decline in regional populations in any of the study provinces; the implication being that Neanderthals, having recovered from the H4 low, became re-established in significant numbers prior to as well during the H3 phase. Stringer *et al.* (2003) argued that a second stress peak or plateau occurred at *ca.* 30 ka. They suggested that the prolongation and accumulation of stress toward MIS 3/2 appears to have exceeded the earlier peak at *ca.* 65 ka. They suggest that if Neanderthal population levels were already small (why would they necessarily be small during the previous several thousand years of non-stress climate?) at this time, then this could have caused their extinction. Evaluating the merit of the 30 ka stress episode is more problematic than the 65 ka episode because we do not have a great deal to go on in terms of Neanderthal population history for the subsequent several thousand years or so that would help place the 30 ka hypothesis in context.

Nevertheless some observations can be made. The H3 event (*ca.* 31.5-29 ka) essentially correlates with the peak of Stringer *et al's* 30 ka stress phase, and this suggests to me that the Heinrich event itself was the major contributing factor to the stress peak (note also that the onset of stress appears to have begun by at least 35 ka BP, Stringer *et al.* 2003 fig. 13.5a). Fig. 5.41 and the accompanying discussion shows Neanderthal distribution is still by and large highly visible in the SP and MP. It would be interesting to reconstruct in more detail the ecological context of sites situated in the SP at this time with respect to earlier phases to determine whether the H3 could have decimated populations across this province. Neanderthal distribution in the MP is principally located south of the 40° parallel, and indeed recent reports suggest that Neanderthals may have maintained a regional presence here as late as 28 ka (Finlayson *et al.* 2006).

The basic premise outlined here then, is that Neanderthal populations assessed regionally, do not appear to have responded in a simple, normative manner to climate change. This is an important point worth re-emphasising. Neanderthals do not appear to have been significantly disrupted by three out of four major climate changes of the Middle Pleniglacial (HE 6, 5 and 3). While this does not rule out climate *sensu stricto* as a dominant or even sole cause in Neanderthal demise, it should persuade workers to consider environmental change (changes in the human socio-behavioural domain) as a continuous and dynamic process, multi-scalar in nature with conditions and resources moving on different wavelengths and at different amplitudes even within discrete climate periods such as 'stadial' and 'interstadial'. To view human socio-behavioural change from fine grained responses (such as behavioural adaptation in the archaeological record) to coarse population-scale migrations under broad traditional approaches will never truly elaborate the processes at play.

In heated exchange between Finlayson *et al.* (2004) and d'Errico and Sánchez Goñi (2004), the issue of competition between modern humans and Neanderthals was addressed. Despite a general agreement from both parties that biologically-based arguments rooted in cognitive differences are unsatisfactory models in themselves to account for Neanderthal extinction, both parties attached very different levels of importance to the issue of competitive exclusion and the role it played in Neanderthal disappearance. Finlayson *et al.*, on the one hand, are firmly of the view that competition played no part at all, and that, simply stated, Neanderthals responded to the given ecological circumstances of Middle Pleniglacial Europe in different ways to modern humans. d'Errico and Sánchez Goñi (2004) on the other hand argue that in terms of competition other factors must be taken into account besides purely ecological ones. They state that:

> "[competition is] a confrontation in which traditional knowledge, representations of oneself and the others, and even the contingent decisions taken by individuals, blend with environmental constraints to produce, according to the moment and the place, mutual avoidance, cultural and/or biological interaction, genocide etc".
>
> d'Errico and Sánchez Goñi (2004:1210)

While this statement is no doubt true in part, it is largely subjective and relates to a multiplicity of hypothetical outcomes that may or may not have occurred, that were or were not important, that resulted in meaningful change, or were expressed at the requisite scale to influence human population dynamics. Finlayson *et al.'s* approach, by contrast, is at least partially testable and can be explored using palaeoclimatic, environmental and archaeological evidence. Using principally the palaeoclimatic and archaeological record of Iberia both Finlayson *et al.* and d'Errico and Sánchez Goñi formulated their respective positions and extrapolated these to other regions. Both parties make strong claims which were in a sense overambitious for two main reasons. The first reason applies mainly to Finlayson *et al.,* who make no assessment of adjacent regions. Thus their claim that carrying capacity was reached has only limited value because it applies only to the region with which they are most familiar – principally the southern Iberian Peninsula. It was argued in chapter 4.0 that an alternative hypothesis envisaged that large parts of northern and/or central Europe may have been far more homogenous and environmentally stable than lower latitude regions hence the basis for inferring competition in such regions may have been more realistic. Similarly, Finlayson *et al.* did not consider the possibility that competition may still have played an important role as respective groups sought to acquire resources that were largely stable in ecological terms (such as living space, water or places of high-symbolic value). Of course, landscape features such as these may have varied across different climatic regimes, but they would have been far more predictable and resilient variables than say herd ungulates, for example. The second reason concerns the claim made by d'Errico and Sánchez Goñi, in finding it unreasonable to conceive of an "*independent demographic explosion*" (d'Errico and Sánchez Goñi 2004:1210) of the Neanderthals without invoking modern humans as the cause. But the authors fail to elaborate on this basic proposition, treating it instead in inferential terms before suggesting that no single climate phase could have resulted in Neanderthal extinction. Their point relating to climate change, that Neanderthal retreat and extinction cannot be attributed to a *particular* (or single) climate event in MIS 3, is unclear, because this is precisely the underlying basis to their subsequent claim, that climatic improvement (presumably during a post-H4 interstadial) directly facilitated the substitution of Neanderthals by modern humans in southern Iberia. As we have seen (figs 5.21, 5.38, 5.39, 5.41 and accompanying discussion) Neanderthals appear to have maintained a significant presence across many of the presumably favourable locales which were inhabited previously during the Middle Pleniglacial. Nor is there any clear evidence that the post-H4 Neanderthals in southern Iberia were in a sense displaced to 'less-favourable' sites following the appearance of modern humans in that region, because the pattern of occupied sites remained largely the same. Neanderthal demographic structure viewed and compared regionally provides the investigator an opportunity to contextualise or at least speculate on how population history varied over time, to identify core areas of habitual occupation, to assess geographic range and also the role played by climate and environmental change in these processes. Chapter 5 demonstrated that specific local studies and approaches coupled with climatically broad reconstructions do not suffice and at the very least a regional approach is required simply because Neanderthals do not appear to have responded in a uniform manner to climate change in all places and at all times.

Broadly speaking, however, it can be tentatively suggested that three distinct periods resulted in low-population levels across probably all of the study provinces. The first of these occurred at *ca.* 100 ka when population was low in the higher latitudes of Europe because of the ensuing environmental disruptions of the post-Eemian oscillations which, it was argued, were essentially analogous with the later MIS 3 oscillations which disrupted the lower latitudes of Europe. It appears that the post-Eemian oscillations did, at first, exclude

Neanderthals from establishing a foothold in northern Europe for the first several thousand years or so of this phase. It appears that these disruptions limited the scope of Neanderthal settlement during MIS 5c to MIS 5a (*ca.* 94 ka to 72 ka) to the southern and Mediterranean regions.

A second phase at *ca.* 65 ka coincided with the MIS4-3 transition; however, it is important to mention that the H6 event at *ca.* 60 ka may also have played a role by imposing further acute stress on the environments of Early Glacial Europe. The archaeological data at this time show a clear reduction both in the number of available determinations and occupied sites, before a gradual recovery across the SP and MP. In contrast with the SP and MP, Neanderthal presence in the NP and CP still appears to have been largely negligible at this time.

A third phase at *ca.* 50 ka again saw a clear fall in occupied sites in the SP and MP and this also coincided with very low population levels in the NP and CP. As discussed above, this did not coincide with any particular episode of climate change other than a gradual and steady decline in global temperature over several thousand years. Certainly the absence of archaeological data for the NP and CP suggests that Neanderthals were unable to exploit the higher latitudes particularly during the 100 ka and 65 ka episodes (oscillatory environments and cold environments respectively). What is clear is that during these three timeframes Neanderthal population levels were low across all of the study provinces. Whether this reflects a pattern of regional abandonment or local regional extinction provides an avenue perhaps for further research. The question of where and when these refugia were located lies beyond the scope of this thesis; however, if Neanderthals abandoned western Europe during these episodes then it can be hypothesised that their core area was situated further to the east, perhaps somewhere bordering the circum-Mediterranean or the Levant.

Chapters 2.0 and 3.0 looked explicitly at the basis for biological and behavioural distinctions between modern humans and Neanderthals as well as current environmentally driven modes of Neanderthal extinction. It is an inescapable fact that most hypotheses of Neanderthal extinction invariably rely on assumed socio-behavioural distinctions between two broad human populations – The European Neanderthals and the African modern humans – to provide a methodological distinction that facilitates an explanation for the demographic changes that took place in the Late Pleistocene. While the Aurignacian humans were clearly adopting a broader range of expressionistic behaviour (e.g. symbolic bone and antler artefacts) as several sites situated in the Swabian Jura in the central province show (e.g. Bockstein-Törle, Hohlenstein-Stadel, Hohlenstein-Bärenhöhle and Vogelherd) (Conard and Bolus 2003) it remains to be seen how important these features were in different environmental situations. In my mind it is certainly difficult to imagine, in light of the Neanderthals abilities to subsist utilizing 'modern' hunting methodologies in a variety of climatic and environmental contexts (chapter 3.8), how local cultural features such as personal ornamentation would have improved on what already seemed to be effective exploitation strategies which were clearly adaptive in nature. Similarly, there is good evidence that Neanderthals themselves were manufacturing personal ornamentation, bone and antler tools independently (d'Errico *et al.* 1998), while Valdes *et al.* (2000) made a case that four out of five technological processes are shared between the Mousterian and Aurignacian at El Castillo, indicating that 'fundamental' change was perhaps endogenous to Europe. Local occurrences of behavioural experimentation are recurrent in the archaeological record and are recorded in other regional contexts. McBrearty and Brooks (2000) suggested that many instances of emergent behaviour such as blades, microliths and dietary shifts did not appear closely together in time and space. Bone tools were also utilized by the inhabitants of Blombos Cave (Henshilwood and Sealy 1997); Barham (2002a) reported backed blades dating to *ca.* 300 ka in central Africa; much later in time, another blade and microlith industry - the Howieson's Poort - was ultimately described in purely ecological terms. It is argued that behaviour such as that very briefly outlined above should be explored in purely ecological terms, as local responses to new ecological contexts. These were 'emergent modern' behaviours, alternative means of satisfying changing demands and meeting new requirements. This process may have resulted in the fixation of certain socio-behaviours and the challenge as I see it is to better understand why certain socio-behavioural traits seem to have been better employed, or used more consistently in some areas over others. If there was a difference between Neanderthals and modern humans it was one of degree, and it should be measured in terms of the *difference in the strategic employment* of socio-behaviours such as land use, subsistence and territoriality within and between regional populations over the course of the Upper Pleistocene.

7.5 Further Work

It is clear that climatically driven hypotheses of Neanderthal extinction can be tested. The correct employment of climatic proxies to appropriately framed study regions will better constrain the conditions of abrupt climate events such as H4 and it is useful to see the contribution made by Sepulchre *et al* (2007) in this light. As refinements are made both in the dating of archaeological sequences and climate records we will be able to draw firmer conclusions about increasingly more important themes of behavioural response to climate change. There seems little doubt that major, albeit indirect contributions to the Neanderthal debate could also be made by genetic and bioarcheological studies. If Neanderthal populations were reduced through the effects of climate change it was probably because they failed to adapt to the new set of prevailing ecological circumstances that ensued during and after such events. In this regard it is correct to visualise Neanderthals as 'mere' components of an ecological landscape. Major climate events such as Heinrich events would have aridified large areas of western Europe leading to a decline in biomass which could have severely disrupted ungulate prey density consequently leading to a reduction in Neanderthal population density. Future work could consider the genetic lineages of many Neanderthal prey faunas asking specifically whether bioarchaeological studies can in any way test for regional population crashes of key prey fauna. Similarly, genetic studies may also demonstrate clear genetic bottlenecks in key prey species coincident with purported phases of Neanderthal decline. These questions necessarily involve more holistic and inter-disciplinary efforts but the the potential answers gained from such approaches would no doubt shed further light on the theme of climatically-mediated Neanderthal extinction.

That Neanderthals and modern humans were resident in Iberia between 30 ka to 20 ka is an observation agreed on by most workers today, but the related themes of sympatry, allopatry and assimilation remain hotly contested and find differing levels of support between different workers. Recent work summarised by Finlayson *et al.* (2008) contends that late Neanderthal populations such as those of Gorham's Cave were in fact residents of a *haven within a refugium*. To be sure, the environmentally heterogeneous areas of the southern European peninsulas acted as glacial strongholds for many fauna and flora and Neanderthals at Gibraltar no doubt profited because such habitats consisted of a highly diverse, densely packed flora and fauna as reconstructions have shown. Finlayson *et al* (2008) believe that Heinrich event 2 at around 24 ka cal BP was severe enough to alter such haven habitats and kill off any surviving Neanderthals in this part of Europe. The difficulty, as I see it with such a view, stems from the fact that Finlayson is a proponent of the idea that Neanderthals were capable of behaviour that is regarded as modern, so it seems highly unusual that Neanderthal populations did not adjust their behaviour accordingly in the face of the considerable selection pressure exerted on the ecological landscape during Heinrich event 2 (to say nothing of the fact that Neanderthals appear to have disappeared from much of Europe by this time). In this regard I feel that the notion of a glacial stronghold, which was no doubt important for many fauna and flora, has been overstated in the Neanderthal case (e.g. Finlayson and Carrion, 2007; Finlayson *et al.*, 2008). The full story of Neanderthal disappearance cannot be explained through the events recognised in a single regional study nor can they be satisfactorily explained via a single process (i.e. the appearance of modern humans or a single, specific climate change event). The wider context is the key to unlocking such an understanding. As such we must place greater focus on assessing Neanderthal population history over specific time frames and from this try and deduce how and in what ways populations responded and how behaviours were modulated or innovated. In this regard chapter 5.11, through the use of callibrated C^{14} determinations and specific climate events, represents an emerging view of variation at the regional Neanderthal population level to climate change. This discussion was rather (intentionally) coarse-grained and it did not consider the use of more detailed case-studies of the sites discussed in the text, nor did it use local environmental reconstructions of fauna or flora, or socio-behavioural assessments based on relevant archaeology to the phases of time which were of interest. It was felt that to enter such detail, when the main goal was to shed light on Neanderthal demographic change at the regional level before, during and after major climate events, would have been unrealistic given the scope of the study. Further work would develop these themes and could involve more detailed regional assessments of Neanderthal populations over the time frames of interest. I would envisage that such analysis would take place on a timeframe preceding, during and after Heinrich events or major D-O events. Reconstructing inhabited sites alongside faunal and floral habitats (as far as this is possible) would allow us to see how

Neanderthals responded and coped with ecological change. The overriding aim would be to generate a fuller understanding of regional patterns as well as the identification of underlying regional differences in behaviour over time. The preliminary assesment made here clearly shows that Neanderthal populations maintained regional continuity across broad areas of Europe through Heinrich events 6, 5 and 3. But without integrated studies and finer-grained reconstructions of the Neanderthal sites in question we cannot choose with confidence between two competing hypotheses: that Neanderthals coped with the ensuing ecological disruption and adapted new behaviours accordingly, or climate events, such as Heinrich event 5, did not lead to major change in Neanderthal habitats. At the same time a more intergrated and finer-grained approach is required or we will never fully understand the mechanisms creating this apparent inconsistency which sees some events such as H4 having resulted in widespread population decline over broader areas of Europe (chapter 5.12) while others such as H2 purportedly led to Neanderthal decimation in a region somewhat perplexingly considered a refugia for a range of other fauna and flora (H2, Finlayson *et al.*, 2008).

7.6 Summary

- The post-Eemian oscillations disrupted the environments of the higher latitudes of Europe in similar ways to how the MIS 3 oscillations disrupted the lower latitudes.

- With the exception of end-member climate states such as glacial and interglacial, climatic instability was a normal aspect of the cycle; however, its frequency and magnitude varied.

- The post-Eemian oscillations appear to have prevented Neanderthals from settling in the higher-latitudes. Neanderthals do not appear to have colonized parts of the northern and central provinces until these regions were more ecologically stable or homogeneous.

- By the Middle Pleniglacial, Neanderthals appear to have been equipped to deal with rapidly changing, environmentally unstable habitats; however, more work is required to clarify whether some of the core areas of habitation were impacted in environmental terms by climate change.

- Neanderthal population history is complex. No simple synchrony can be demonstrated between climatic change and Neanderthal demic change.

- Heinrich events 6, 5, 4 and 3 represent in climatic terms four of the most strongly registered events of the last interglacial-glacial cycle. Only Heinrich event 4 appears to have decimated Neanderthal population structure at the inter-regional scale.

- Neanderthal populations may have been disrupted by competition with modern human populations during ecologically stable *and* unstable phases. In accordance with ecological theory and several models reviewed here competition may have arisen between different cultural groups or species attempting to gain control of primary fauna and flora during phases of climatic and ecological equilibrium. As MIS3 appears to have witnessed rapid ecological changes over short periods of time it would appear that any interaction between different groups in direct competition for resources would be sporadic and potentially limited in scope and scale. However we must also consider the possibility that competition may have still occurred between different human cultural groups for access to non-biotic resources (e.g. preferred places of habitation, raw material outcrops, symbolic landscape features etc) that were not perturbed or influenced by climatic change in the same ways as fauna and fauna were. Therfore it could be more informative to consider competition but under a new light which goes beyond the current idea of which species or groups were 'best-suited' for whichever form of hunting for whatever type of fauna. Current views on Neanderthal subsistence practises are growing more and more in favour of the view that Neanderthals were formidable and sophisticated hunters (chapter 3.8 & 3.9). As such it could serve useful to consider in in what other ways Neanderthals' behaviour deviated from that of modern humans in terms of how they may have percieved the non-biotic components of the landcape.

- Rapid climate change, or cumulative climate stress does not appear to have been the principal or direct factor involved in Neanderthal extinction.

- A single climate event (possibly H4) may have triggered a set of circumstances that could have resulted in Neanderthal extinction. But, to stress the point again, no *single* episode of climate change appears to have completely killed-off Neanderthal populations at even the regional scale.

- Previous stress phases (such as the ones purported here to have occurred at *ca.* 100, 65 and 50 ka) may have led to regional abandonment and local extinction in Europe and forced Neanderthals to retreat east along the Mediterranean and/or into the Near East.

- Modern human territorial occupation of the central province may have prevented Neanderthals from migrating into Mediterranean or eastern refugia that served as core areas during other stress phases (e.g. 100, 65 and 50 ka).

- In environmental terms, the central province may have been more productive and facilitated the survival of modern humans. The central province (as well as areas further to the east) probably comprised a modern human *core area*. Neanderthals over the course of the interglacial-glacial cycle were only intermittently present in the central province.

7.7 Epilogue

It was argued, albeit in general and at times rudimentary terms in chapter 6.0, that variation and innovation in human behaviour can be approached from the perspective of condition-resource variation. Similarly it was argued that human migration and extinction can also be approached in terms of condition-resource dynamics. It was argued that new thinking is required if we are to understand archaeological patterning in an environmental context. Many attempts to do so are currently hindered by climatic nomenclature that fails to convey underlying ecological complexity. In this sense the problems of the existing system of interpretation, based principally on the application of existing climate terminology, were shown to be unsound.

The role of climate and environment as drivers in the trajectory of change on this planet is well documented: it is regarded as the principal influence on the evolution of dispersal, migration and extinction of a broad array of taxa considered in largely biogeographical perspective, (e.g. Lahr and Foley 1998, 2003). Similarly, non-climatic factors such as tectonics, involved in shaping the types of habitats, or the *instability* deemed central in creating environmental diversity, have been empasised as potent factors driving selection pressure, speciation or behavioural innovation (King and Bailey 2006). In a similar fashion it was argued that condition-resource variation across Europe and elsewhere provided the basis for what I believe was the underlying driver of the emergence of socio-behavioural innovation. Condition resource variation was proposed as a methodological starting point that would provide a *better basis* to understand the nature of settings inhabited by Neanderthals during an extensive period of time that was clearly, over large areas of Europe, non-uniform in nature, that is to say, comprised of biota that are not found in sympatry today (*cf.* Huntley and Allen 2003; Stewart *et al.* 2003 chapter 4). It is acknowledged that at this stage, then, in the absence of a better understanding of the nature of these conditions and resources it would be perhaps premature to speculate as to which variations and combinations of environmental circumstances may have posed direct challenges to human populations, or in a sense driven socio-behavioural change. But it is at least hypothesised that certain regions comprised of dynamic, non-analogue condition-resources may have been critical, not just in driving socio-behavioural change but also in driving local extinction.

The problems in reconstructing past environments are of course beset by all the issues of chronological uncertainty, notwithstanding the issues of the coarseness of archaeological, climatological and environmental proxies. However work by the Stage 3 Project has shown that advances can be made in an appreciation not just of past environments, but of past environments which have no modern analogues (Stewart *et al.* 2001[12]). It is perhaps a greater understanding of these data, alongside detailed inferences about the nature and dynamic of the resultant biotic communities during these phases that will allow archaeologists to proceed in more detail to speculate in which ways the archaeological record, particularly in terms of lithic technology, was or was not, an adaptation to such circumstances. In turn this may provide an alternative viewpoint to the largely prevailing consensus that interprets such differences, at least in Europe, in largely cognitive terms between species of humans – the Neanderthals and modern humans.

---

[12] Stewart, J.R., M. van Kolfschoten, A. Markova & R. Musil, 2001. Stage Three Project Mammalian Database. http://www.esc.esc.cam.ac.uk/oistage3/Details/Homepage.html.

References

Aalbersberg, G., & Litt, T. (1998). 'Multiproxy Climate Reconstructions for the Eemian and Early Weichselian', *Journal of Quaternary Science*, **13**: 367-90.

Adler, D.S, Bar-Yosef, O., Belfer-Cohen, A., Tushabramishvili, N., Boaretto, E., Mercier, N., Valladas, H., Rink, W.J. (2008). 'Dating the demise: Neanderthal extinction and the establishment of modern humans in the southern Caucasus', *Journal of Human Evolution*, **55**: 817-833.

Akazawa, T., Aoki, K., & O. Bar-Yosef (eds.) (1998) Neanderthals and Modern humans in Western Asia. New York (NY): Plenum Press.

Aldhouse-Green, S., & Pettitt, P. (1998) Paviland Cave: contextualizing the 'Red Lady', *Antiquity* (**72**) 756-72.

Allen, J.R.M., Brandt, U., Braver, A., Hubberten, H.-W., ten co-authors (1999) 'Rapid last glacial environmental fuctuations: new evidence from Southern Europe during the last Glacial Period', *Nature*, **400**: 740-433.

Allen, J.R.M., Watts, W.A., & Huntley, B. (2000a) 'Weichselian Palynostratigraphy, Palaeovegetion and Palaeoenvironment; the Record from Lago Grande di Monticchio, southern Italy', *Quaternary International*, **73/90**: 91-110.

Allen, J.R.M & Huntley, B. (2000b) 'Weichselian Palynological Records from Southern Europe: Correlation and Chronology', *Quaternary International*, **73/74**: 111-125.

Allsworth-Jones, P. (1986) *The Szeletian and the transition from Middle to Upper Palaeolithic in Central Europe*, Oxford: Oxford University.

Ambrose, S.H. & Lorenz, K.G. (1990) 'Social and ecological models for the Middle Stone Age in Southern Africa in', Mellars, P.A. (ed.). *The Emergence of Modern Humans*, pp. 3-33. New York: Cornell University Press.

Ambrose, S.H. (1998) 'Late Pleistocene human population bottlenecks, volcanic winter, and differentiation of modern humans', *Journal of Human Evolution,* **34**: 623-651.

Ambrose, S.H. (2002) Small things remembered: origins of early microlithic industries in sub-Saharan Africa. In: Elston, R., & Kuhn, S. (Eds.), *Thinking Small: Global Perspectives on Microlithic Technologies*. Archaeological Papers of the AAA. No. 12, pp. 9-29.

Ambrose, S.H. (2006) 'Howiesons Poort lithic raw material procurement patterns and the evolution of modern human behavior: A response to Minichillo', *Journal of Human Evolution*, **50**: 365-369.

Arnold, N.S., van Andel, T.H., & Valen, V. (2002) 'Extent and Dynamics of the Scandinavian Ice Sheet during Oxygen Isotope Stage 3 (65,000–25,000 yr B.P.)', *Quaternary Research*, **57**: 38-48.

Barham, L.S., AC Pinto Llona, & Stringer, C.B. (2002) 'Bone tools from Broken Hill (Kabwe) cave, Zambia, and their evolutionary significance', *Before Farming*, **2(3)**: 1-12.

Barron, E.J & Pollard, D. (2002) 'High-Resolution Climate Simulations of Oxygen Isotope Stage 3 in Europe', *Quaternary Research*, **58**: 296-309.

Barton, N. (2000) 'Mousterian shellfish and hearths: late Neanderthal activities on Gibraltar', In C. Stringer, R. N. E. Barton, and J. C. Finlayson (eds.). *Neanderthals on the Edge* pp. 211-19. Oxbow Books, Oxford.

Bar-Yosef, O., & Vandermeersch, B. (1981) 'Notes concerning the possible age of the Mousterian layers Qafzeh Cave', In Cauvin, J., & Sanlaville, P., (eds) "Prehistoire du Levant C.N.R.S. Colloq, **598**: 281-286.

Behre, K.E. (1989) 'Biostratigraphy of the last glacial period in Europe', *Quaternary Science Reviews*, **8**: 25-44.

Bender, M., Sowers, T., Orchardo, M.-L., Grootes, P., Mayewski, P.A. & Meese, D.A. (1994) 'Climate correlation between Greenland and Antarctica during the past 100,000 years', *Nature*, **372**: 663–666.

Blackwell, B., & Schwarcz, H.P. (1986) 'U-series Analyses of the Lower Travertine at Ehringsdorf, DDR', *Quaternary Research*, **25**: 215-222.

Blades, B. (1999) 'Aurignacian settlement in the Vezere Valley', *Current Anthropology*, **40**: 712-718.

Blunier, T., & Brook, R.J. (1998) 'Asynchrony of Antarctic and Greenland Climate Change during the Last Glacial Period', *Nature*, **394**: 739-744.

Bocquet-Appel, J.P., & Demars, P.Y. (2000) 'Neanderthal contraction and modern human colonization of Europe', *Antiquity*, **74**: 544-52.

Bode, R. (2006) 'The Evolution of Arid Ecosystems in Eastern Africa', *Journal of Arid Environments,* **66**: 564-584.

Bolus, M. & Conard, N.J. (2001) 'The late Middle Palaeolithic and earliest Upper Palaeolithic of central Europe and their relevance for the Out of Africa hypothesis', *Quaternary International*, **75**: 29-40.

Bond, G.C., Heinrich, H., Broecker, W.S., Labeyrie, L., McManus, J., Andrew, J., Huon, S., Jantschik, R., Clasen,S., Simet, C., Tedesco, K., Klas, M., Bonani, G., & S. Ivy. (1992) 'Evidence for massive discharges of icebergs into the North Atlantic Ocean during the last glacial period', *Nature*, **360**: 245-251.

Bond, G.C., Broecker, W., Johnsen, S., McManus, J., Labeyrie, L., Jouzel, J., & Bonani, G. (1993) 'Correlations between climate records from North Atlantic sediments and Greenland ice', *Nature*, **365**: 143-147.

Bond, G., & Lotti, R.. (1995) 'Iceberg discharges into the North Atlantic on millennial time scales during the last glaciation', *Science*, **267**: 1005-1010.

Bos, J., Bohncke, S., Kasse, C., & Vandenberghe, J. (2001) 'Vegetation and Climate during the Weichselian Early Glacial and Pleniglacial in the Niederlausitz, eastern Germany - macrofossil and pollen evidence', *Journal of Quaternary Science,* **16:** 269-289.

Boule, M., & H.V. Vallois (1957) *Fossil Men: A Textbook of Human Palaeontology*, Thames and Hudson: London.

Bowen, D.Q. (1990) 'The last interglacial-glacial cycle in the British Isles', *Quaternary International*, **3**: 41-47.

Böttger, T., Junge, F.W., & Litt, T. (2000) 'Stable Climatic Conditions in Central Germany during the Last Interglacial', *Journal of Quaternary Science*, **15**:469-73.

Brace, C.L. (1964) *'A Consideration of Hominid Catastrophism',* Current Anthropology*, 5: 3-43.*

Brace, C.L. (1995) The Stages of Human Evolution. *Englewood Cliffs (NJ): Prentice Hall.*

Bräuer, G. (1984b) 'A craniological approach to the origin of anatomically modern Homo sapiens in Africa and implications for the appearance of modern Europeans'. In Smith, F.H., and Spencer, F. (eds.) *The Origins of Modern Humans: a World Survey of the Fossil Evidence*, pp. 327-410. New York: Alan R. Liss.

Bräuer, G. (1989) 'The Evolution of Modern Humans: A Comparison of the African and non-African Evidence', in Mellars, P., & Stringer, C. (eds.) *The Human Revolution: Behavioural and Biological Perspectives on the Origins of Modern Humans*, pp. 23-55. Edinburgh University Press.

Brauer, A., Mingram., F.U., Günter, C., Schettler, G., Wulf., S., Zolitscha., B. & Negendank, J.F.W. (2000) 'Abrupt Environmental Oscillations During the Early Weichselian Recorded at Lago Grande di Monticchio, southern Italy', *Quaternary International*, **73/74**: 79-90.

Bräuer, C.M., & Stringer, C.B. (2004) 'On the reliability of recent tests of the Out of Africa hypothesis for modern human origins', *The Anatomical Record Part A: Discoveries in Molecular, Cellular, and Evolutionary Biology*, **279a(2)**: 701-707.

Bricker, H.M. (1976) 'Upper Palaeolithic Archaeology', *Annual Review of Anthropology*, **5**:133-38.

Broecker, W.S. (1994) 'Massive iceberg discharges as triggers for global climate change', *Nature*, **372**: 421-424.

Burke, A. (2000a) 'Hunting in the Middle Palaeolithic',. *International Journal of Osteoarchaeology*, **10**: 281-285.

Burke, A. (2000b) 'The view from Starosele: Faunal exploitation at a middle palaeolithic site in western Crimea', *International Journal of Osteoarchaeology*, **10**: 325-335.

Burke, A. (2004) 'The Ecology of Neanderthals', Preface. *International Journal of Osteoarchaeology*, **14**: 155-161.

Burke, A. (2006) 'Neanderthal settlement patterns in Crimea: A landscape approach', *Journal of Anthropological Archaeology*, **25(4)**: 510-523.

Burjachs, F. & Juliá, R.. (1994) 'Abrupt climatic changes during the last glaciation based on pollen analysis of the Abric Romani, Catalonia, Spain', *Quaternary Research,* **42**: 308-315.

Cann, R., Stoneking, M., & Wilson, A. (1987) 'Mitochondrial DNA and Human Evolution', *Nature*, **325**: 31-6.

Cann, R., & Lum, J.K. (1992) 'Mitochondrial DNA and Human Evolution: Our One Lucky Mother' in, Nitecki M., & Nitecki, D (eds) *Origins of Anatomically Modern Humans*. pp 135-147. Plenum Press, New York.

Carrión, J.S., Riquelme, J.A., Navarro, C. & Munuera, M. (2001) 'Pollen in hyaena coprolites reflects late glacial landscape in southern Spain', *Palaeogeography, Palaeoclimatology, Palaeoecology*, **176**: 193-205.

Carrión, J.S., Errikarta, Y., Walker, M., Legaz, A, Chains, C., & A. Lopez. (2003) 'Glacial refugia of temperate, Mediterranean and Ibero-North African flora in south eastern Spain: New evidence from cave pollen at two Neanderthal Sites', *Global Ecology and Biogeography*, **12**: 119-129.

Carrion, J.S. (2004) 'The Use of Two Pollen Records from Deep Sea Cores to Frame Adaptive Evolutionary Change for Humans: a Comment on, 'Neanderthal Extinction and the Millenial Scale Climate Variabilty of OIS 3' by F. d'Errico and M.F. Sanchez Goni, *Quaternary Science Reviews*, **23**: 1217-1224.

Caspers, G., & Freund, H. (2001) 'Vegetation and Climate in the Early and Pleni- Weichselian in northern central Europe', *Journal of Quaternary Science*, **16**: 31-48.

Caspers, G., Freund, H., Merkt, J., & Müller, H. (2002) 'The Eemian interglacial in northwestern Germany', *Quaternary Research*, **58**: 49–52.

Chapman, M.R., & Shackleton, N.J. (1998) 'Millennial-scale fluctuations in North Atlantic heat flux during the last 150,000 years', *Earth and Planetary Science Letters*, **159**: 57–70.

Chapman, M.R., & Shackleton, N.J. (1999) 'Global ice-volume fluctuations, North Atlantic ice-rafting events, and deep-ocean circulation changes between 130 and 70 ka', *Geology*, **27**: 795–798.

Charles, C.D., Rind, D., Jouzel, J., Koster, R.D., & Fairbanks, R.G. (1994) 'Glacial–interglacial changes in moisture sources for Greenland: influences on the ice core record of climate', *Science*, **263**: 508-511.

Cheddadi, R., Mamakowa, K., Guiot, J., Beaulieu, J.L., Reille, M., Andrieu, V., Granoszewski, W., & Peyron, O. (1998) 'Was the Climate of the Eemian Stable? A Quantitative Climate Reconstruction from Several European Pollen Records', *Palaeoclimatology, Palaeontology and Palaeoecology*, **143**: 73-85.

Clark Howell, F. (1957) 'The evolutionary significance of variation and varieties of "Neanderthal" man', *The Quarterly Review of Biology*, **32(4)**: 330-347.

Clark Howell, F. (1998) 'Evolutionary Implications of Altered Perspectives on Hominine Demes and Populations in the Later Pleistocene of Western Asia' In Akazawa, T., Aoki, K., Bar-Yosef, O. (eds.) (1998) *Neanderthals and Modern Humans in Western Asia,* pp. 05-27. Plenum Press.

Desmond Clark, J., Beyene, Y., Wolde Gabriel, G., Hart, W.K., Renne, P.R., Gilbert, H., Defleur, A., Suwa, G., Katoh, S., Ludwig, K.R., Boisserie, J.R., Asfaw, B., & White, T.D. (2003) 'Stratigraphic, chronological and behavioural contexts of Pleistocene *Homo sapiens* from Middle Awash, Ethiopia', *Nature*, **423**: 747-752.

Conard, N.J., & M. Bolus (2003) 'Radiocarbon dating the appearance of modern humans and timing of cultural innovations in Europe: new results and new challenges', *Journal of Human Evolution*, **44**:331-371.

Conard, N.J., Grootes, P.M., & Smith, F.H. (2004) 'Unexpectedly recent dates for human remains from Vogelherd', *Nature*, **430**: 198-201.

Conard, N.J., &, Prindiville, T. (2000) 'Middle palaeolithic hunting economies in the Rhineland', *International Journal of Osteoarchaeology*, **10**: 286-309.

Condemi, S. (2000) 'The Neanderthals: *Homo neanderthalensis* or *Homo sapiens neanderthalensis*? Is there a contradiction between the palaeogenetic and the palaeoanthropological data*?'* In, *Neanderthals and Modern Humans - Discussing the Transition: Central and Eastern Europe from 50.000 - 30.000 B. P.* Neanderthal Museum, 2000. pp. 287-295.

Coope, G.R. & Angus, R.B. (1975) 'An ecological study of a temperate interlude in the Middle of the last glaciation based on fossil Coleoptera from Isleworth, Middlesex', *Journal of Animal Ecology*, **44**: 365–391.

Coope, G.R. (2002) 'Changes in the thermal climate in North-western Europe during Marine Oxygen Isotope Stage 3, estimated from fossil insect assemblages', *Quaternary Research*, **57**: 401-408.

Cortijo, E., Duplessy, J.-C., Labeyrie, L., Leclaire, H., Duprat, J., & van Weering, T.C.E. (1994) 'Eemian cooling in the Norwegian Sea and North Atlantic Ocean preceding continental ice-sheet growth', *Nature*, **372**: 446–449.

Cosgrove, R., & Pike-Tay, A. (2004) 'The Middle Palaeolithic and late Pleistocene Tasmania hunting behaviour: a reconsideration of the attributes of modern human behaviour', *International Journal of Osteoarchaeology*, **14**: 321-332.

Costamagno S., Meignen, L., Beauval, C., Vandermeersch, B., & Bruno, M. (2006) 'Les Pradelles (Marillac-le-Franc, France): A Mousterian reindeer hunting camp?', *Journal of Anthropological Archaeology*, **25(4)**: 466-484.

Dansgaard, W., Johnsen, S.J., Clausen, H.B., Dahl-Jensen, D., Cundestup, N.S., Hammer, C.U., Hvidberg, C.S., Steffensen, J.P., Sveinbj., A.E., Jouzel, J., & Bond, G. (1993) 'Evidence for general instability of past climate from a 250-kyr ice-core record', *Nature*, **364**: 218-220.

Davies, W., Stewart, J., & van Andel, T. H. (2000) 'Neanderthal landscapes: a preview', In Stringer, C., Barton, R.N.E. & Finlayson, J.C., (eds.) *Neanderthals on the Edge*, pp. 1-8. Oxbow Books, Oxford.

Davies, W. (2001) 'A very model of a modern human industry: new perspectives on the origins and spread of the Aurignacian in Europe', *Proceedings of the Prehistoric Society*, **67**: 195-217.

Davies, W., & Gollop, P. (2003) 'The Human Presence in Europe during the Last glacial Period II: Climate tolerance and Climate Preferences of Mid- and Late Glacial Hominids' In van Andel T.H. & Davies, W. (eds) *Neanderthals and modern humans in the European Landscape during the Last Glaciation*, Chapter 8, pp. 131-147. (McDonald Institute Monographs.) Cambridge: McDonald Institute for Archaeological Research.

Davies, W. (2006) 'The Chronology of the Aurignacian in Eastern Europe; the Changing Distribution of Modern Humans in the Environmental Content', Paper presented at the Environmental Factors in the Chronology of Human Evolution and Dispersal (EFCHED) Annual Workshop, Newcastle 2006.

Deacon, H. J. (1989) 'Late Pleistocene palaeoecology and archaeology in the Southern Cape, South Africa' In, Mellars, P. & Stringer, C.B. (eds) *The Human Revolution: Behavioural and Biological Perspectives on the Origins of modern Humans,* pp. 547-65. Edinburgh University Press.

de Beaulieu, J-L., & Reille, M. (1992a) 'Long Pleistocene sequences from the Velay Plateau (Massif Central, France). I. Ribains maar', *Vegetation History and Archaeobotany*, **1**: 233-242.

de Beaulieu, J-L., and Reille, M. (1992b) 'The last climatic cycle at La Grande Pile (Vosges, France). A new pollen profile', *Quaternary Science Reviews*, **11**: 431–438.

de Beaulieu, J-L., Andrieu-Ponel, V., Reille, M., Gruger, E., Tzedakis, C., & Svobodova, H. (2001) 'An attempt at correlation between the Velay pollen sequence and the Middle Pleistocene stratigraphy from Central Europe', *Quaternary Science Reviews*, **20**: 1593-1602.

Demars, P.Y. (1990) 'Les interstraitifcations entre Aurignacien et Châtelperronien á Roc-de-Combe et au Piage (Lot)' In Farizy, C. (ed.) *Palaeolithique moyen récent et Palaéolithique supérieur en Europe*, pp. 235-39. Nemours: Musee de Prehistoire d'Ile-de-France.

d'Errico, F., Zilhao, J., Julien, M., Baffier, D. & Pelegrin, J. (1998) 'Neanderthal acculturation in Western Europe? A critical review of the evidence and its interpretation', *Current Anthropology*, **39**: 1-43

d' Errico, F. (2003) 'The invisible frontier: A multiple species model for the origin of behavioural modernity', *Evolutionary Anthropology*, **12**: 118-202.

d'Errico, F., & Sánchez Goñi, M.F. (2003) 'Neanderthal Extinction and the Millennial Scale Climatic Variability of OIS 3', *Quaternary Science Reviews*, **22**: 769-88.

d'Errico, F., & Sánchez Goñi, M.F. (2004) 'A Garden of Eden for the Gibraltar Neanderthals? A Reply to Finlayson *et al'*, *Quaternary Science Reviews*, **23**: 1205-1216.

Dennell, R.. & Roebroeks, W. (2005) 'An Asian perspective on early human dispersal from Africa', *Nature*, **438**: 1099-1104.

Denton, G.H. & Hughes, T.J. (1981) *'The Last Great Ice Sheets'*, Wiley, New York.

Disotell, T.R. (1999) 'Human Evolution: Origins of Modern Humans Still Look Recent', *Current Biology*, **9(17)**: 647-650.

Donner, J. (1996) 'The Early and Middle Weichselian interstadials in the Central area of the Scandanavian glaciations', *Quaternary Science Reviews*, **15**: 471-79.

Drell, R..R..J. (2000) 'Neanderthals: A History of Interpretation', *Oxford Journal of Archaeology*, **19(1)**: 1-24.

Drucker, D. & Bocherens, H. (2004) 'Carbon and nitrogen stable isotopes as tracers of change in diet breadth during Middle and Upper Palaeolithic in Europe', *International Journal of Osteoarchaeology*, **14**: 162-177.

Duarte, C., Mauricio, J., Pettitt, P., Souto, P., Trinkaus, E., Van der Plicht, H., & Zilhao, J. (1999) 'The early Upper Paleolithic human skeleton from the Abrigo do Lagar Velho (Portugal) and modern human emergence in Iberia', *Proc. Natl. Acad. Sci*, **96**: 7604-7609.

Dyson-Hudson, R.., & E.A. Smith (1978) 'Human Territoriality: An Ecological Reassessment', *American Anthropologist*, **80**: 21–41.

Emiliani, C. (1955) 'Pleistocene Temperatures', *Journal of Geology*, **63**: 538-78.

Emontspohl, A. (1995) 'The North West European vegetation at the beginning of the Weichsellian Glacial (Brorup and Odderade Interstadials). New data for Northern France', *Review of Palaebotany and Palynology*, **85**: 231-42.

Estevez, J. (2004) 'Vanishing Carnivores: What can the disappearance of large carnivores tell us about the Neanderthal World?', *International Journal of Osteoarchaeology*, **14**: 190-200

Falgueres, C., Bahain, J.J., Yokoyama, Y., Arsuaga, J.L., Bermudez de Castro, J.M., Carbonell, E., Bischoff, J.L. & Dolo, J.M. (1999) 'Earliest humans in Europe: the age of TD6 Gran Dolina, Atapuerca, Spain. *Journal of Human Evolution*, **37**: 343-52.

Farizy, C. (1994) 'Behavioural and cultural changes at the Middle to Upper Palaeolithic transition in Western Europe' In Nitecki, M. & Nitecki, D. (eds.) *Origins of Anatomically Modern Humans*, pp. 93-100. Plenum Press, New York

Fauquette, S., Guiot, J., Menut, M., de Beaulieu, J. L., Reille, M., & Guenet, P. (1999) 'Vegetation and climate since the last Interglacial in the Vienne area (France)', *Global and Planetary Change*, **20**: 1-17.

Field, M.H., Huntley, B., & Muller, H. (1994) 'Eemian climate fluctuations observed in a European pollen record', *Nature*, **371**: 779–783.

Fedele, G.F., Giacco, B., Hajdas, I. (2008) 'Timescales and cultural processes at 40,000 BP in the light of the Campanian Ignimbrite eruption, Western Eurasia', *Journal of Human Evolution*, **55**: 834-857.

Finlayson, C., & Giles Pacheco, F. (2000) 'The southern Iberian Peninsula in the late Pleistocene: geography, ecology and human occupation'. In Stringer, C.B., Barton, R.N.E. & Finlayson, J.C. (eds.) *Neanderthals on the edge*, pp. 139-154. Oxford, Oxbow books.

Finlayson, C., Fa, A., Finlayson, G., Pacheco, F.G. & Vidal, J.R. (2004) 'Did the Moderns Kill off the Neanderthals? A reply to F. d'Errico and Sanchez Goni'. *Quaternary Science Reviews*, **23**: 1205-1216.

Finlayson, C. (2004a) 'Biogeography and evolution of the genus Homo', *Trends in Ecology and Evolution*, **20 (8)**: 457-63.

Finlayson, C. (2004b) *Neanderthals and Modern Humans: An Ecological and Evolutionary Perspective.* Cambridge Studies in Biological and Evolutionary Anthropology. Cambridge University Press. 2004.

Finlayson, C., Giles Pacheco, F., Rodríguez-Vidal, J., Fa, D. A., Gutierrez López, J. M., Santiago Pérez, A., Finlayson, G., Allué, E., Baena Preysler, J., Cáceres, I., Carrión, J. S., Fernández Jalvo, Y., Gleed-Owen, C. P., Jimenez Espejo, F., López, P., López Sáez, J. A., Riquelme Cantal, J. A., Sánchez Marco, A., Giles Guzman, F., Brown, K., Fuentes, N., Valarino, C. A., Villalpando, A., Stringer, C. B., MartinezRuiz, F. & Sakamoto, T. (2006) 'Late survival of Neanderthals at the southernmost extreme of Europe', *Nature*, **443**: 850-853.

Finlayson, C., & Carrión, J.S (2007) 'Rapid ecological turnover and its impact on Neanderthal and other human populations', *Trends in Ecology and Evolution*, Vol. **22 (4)**, 213-222.

Finlayson, C., Fa, D., Jimenez Espejo, F., Carrión, J.S., Finlayson, G., Pachéco, G., Vidal, J. R., Stringer, C, & Martinéz Ruiz, F. (2008) 'Gorham's Cave, Gibraltar - The persistence of a Neanderthal population', *Quaternary International*, **181**: 64-71.

Fiore, I., Gala, M., & Tagliacozzo, A. (2004) 'Ecology and subsistence strategies in the eastern Italian Alps during the Middle Palaeolithic',. *International Journal of Osteoarchaeology*, **14**: 273-286.

Foley, R.A. & Lahr, M.M. (1997) 'Mode 3 technologies and the evolution of modern humans', *Cambridge Archaeological Journal*, **7(1)**: 3-36.

Foley, R. (1989) 'The Ecological Conditions of Speciation: a Comparative Approach to the Origins of Anatomically Modern Humans" In Mellars, P & Stringer, C. (eds.) *The Human Revolution: Behavioural and Biological Perspectives on the Origins of Modern Humans*. pp. 298-321. Edinburgh University Press.

Forsstrom, L., & Punkari, M. (1997) 'Initiation of the Last Glaciation in Northern Europe,' *Quaternary Science Reviews*, **16**: 1197-1215.

Forsstrom, L. (2001) 'Duration of Interglacials: a controversial question', *Quaternary Science Reviews*, **20**: 1577-1586.

Frenzel, B., Pecsi, M., & Velichko, A.A. '*Atlas of Paleoclimates and Paleoenvironments of the Northern Hemisphere: Late Pleistocene-Holocene',* John Wiley & Sons Inc. 1992.

Gale, R & Carruthers, W. (2000) 'Charcoal and charred seed remains from Middle Palaeolithoc levels at Gorham's and Vanguard Caves', In Stringer, C., Barton, R.N.E., & Finlayson, J.C. (eds.) *Neanderthals on the Edge* pp. 207-10. Oxbow Books, Oxford.

Gallup, C.D., Cheng, H., Taylor, F.W., & Edwards, R.L. (2002) 'Direct determination of the timing of sea level change during Termination II', *Science*, **295**: 310–313.

Gambier, D. (1989) 'Fossil hominids from the early Upper Palaeolithic', In Mellars, P., & Stringer, C. (eds.) *The Human Revolution: Behavioural and Biological Perspectives on the Origins of Modern Humans.* pp. 194-212. Edinburgh University Press.

Gamble, C.S. (1978) 'Resource exploitation and the spatial patterning of hunter-gatherers: a case study', In Green, D., Haselgrove, C., & Spriggs, M. (eds.) *Social organisation and settlement.* pp. 153-85. Oxford:British Archaeological Reports, International series 47(i).

Gamble, C.S. (1984) 'Regional variation in hunter-gatherer strategy in the Upper Pleistocene of Europe', In Foley, R.., (ed.) *Hominid Evolution and Community Ecology: Prehistoric Human adaptation in Biological Perspective*. pp. 237-55. Academic Press.

Gamble, C.S. (1986) *The Palaeolithic Settlement of Europe*. Cambridge University Press 1986.

Gamble, C.S. (1994) *Timewalkers: the prehistory of global colonization*. Cambridge. Harvard University Press.

Gamble, C.S. (1999) *The Palaeolithic Societies of Europe*. Cambridge University Press 1999.

Gamble, C.S., Davies, W., Pettitt, P., & Richards, M. (2004) 'Climate change and evolving human diversity in Europe during the last glacial', *Phil. Trans. R. Soc. Lond. B*, **359**: 243–254.

Gaudzinski S., & Roebroeks W. (2000) 'Adults only. Reindeer hunting at the Middle Palaeolithic site Salzgitter Lebenstedt, Northern Germany', *Journal of Human Evolution*, **38**: 497-521.

Gaudzinski, S. (2004) 'A matter of high resolution? The Eemian Interglacial (OIS 5e) in north-central Europe and Middle Palaeolithic subsistence', *International Journal of Osteoarchaeology*, **14**: 201-211.

Gioia, P. (1990) 'An aspect of the transition between Middle and Upper Palaeolithic in Italy: the Uluzzian, In Farizy, C. (ed.) *Palaeolithique moyen recent et Palaeolithique superieur ancien en Europe*, pp. 241-250. Nemours:Musee de Prehistoire d'Ile de France.

Graves, P. (1991) 'New Models and Metaphors for the Neanderthal Debate', *Current Anthropology*, **32**: 13-41.

GRIP (Greenland Ice-Core Project Members) (1993) 'Climate instability during the last interglacial period recorded in the GRIP ice core', *Nature*, **364**: 203-207.

Grootes, P.M., Stuiver, M., White, J.W., Johnsen, S., and Jouzel, J. (1993) 'Comparison of oxygen isotope records from the GISP2 and GRIP Greenland ice cores', *Nature*, **366**: 552–554.

Guiot, J., de Beaulieu, J.L., Cheddadi, R., David, F., Ponel, P., & Reille, M. (1993) 'The climate in Western Europe during the last glacial/interglacial cycle derived from pollen and insect remains', *Palaeogeography, Palaeoclimatology, Palaeoecology*, **103**: 73–94.

Guiot, J. (1997) 'Palaeoclimatology: Back at the Last Interglacial', *Nature*, **419**: 25-27

Guiter, F., Andrieu-Ponel, V., de Beaulieu, J.L. (2003) 'The last climatic cycles in Western Europe: a comparison between long continuous lacustrine sequences from France and other terrestrial records', *Quaternary International*, **111**: 59-74.

Hammond, M. (1982) 'The expulsion of the Neanderthals from human ancestry: Marcellin Boule and the social context of scientific research', *Social Studies of Science*, **12**: 1-36.

Harrison, S.P., Kutzbach, J.E., Prentice, I.C., Behling, P.J., and Sykes, M.T. (1995) 'The response of northern hemisphere extratropical climate and vegetation to orbitally induced changes in insolation during the last interglaciation', *Quaternary Research* **43 (2)**, 174-184.

Harold, F. J. (1989) 'Mousterian, Châtelperronian and early Aurignacian in Western Europe: continuity or discontinuity?' In Mellars, P., & Stringer, C. (eds.) The human revolution: behavioural and biological perspectives on the origins of modern humans, pp. 677-713. Edinburgh: Edinburgh University Press.

Hawks, J., Oh, S., Hunley, K., Dobson, S., Cabana, G., Dayalu, P., & Wolpoff, M.H (2000) 'An Australasian test of the recent African origin theory using the WLH-50 calvarium', Journal of Human Evolution, 39: 1–22.

Hawks, J.D & Wolpoff, M.H. (2001) 'The four faces of Eve: Hypothesis compatability and Human origins', *Quaternary International*, **75**: 41-50.

Heinrich, H. (1988) 'Origin and consequences of cycling ice rafting in the Northeast Atlantic Ocean during the past 130,000 years', *Quaternary Research*, **29**: 142-152.

Hemming, S.R. (2004) 'Heinrich events: Massive late Pleistocene detritus layers of the North Atlantic and their global climate imprint', *Reviews of Geophysics*, **42**, RG1005.

Henning, G.J., Grun, R., & Brunnacker, K. (1983) 'Speleothems, travertines, and paleoclimates', *Quaternary Research*, **20(1)**: 1-29.

Henshilwood, C.S. & Marean, C.W. (2003) 'The origin of modern human behaviour: critique of the models and their test implications', *Current Anthropology*, **44**: 627-650.

Hicks, S. (1994) 'Present and past pollen records of Lapland forests', *Review of Palaeobotany and Palynology*, **82**: 17-35.

Hicks, S. (2006) 'When no pollen does not mean no trees', *Vegetation History and Archaeobotany*. **15(4)**: 253-261.

Higham, T., *et al.* (In Press). Problems with radiocarbon dating the Middle to Upper Palaeolithic transition in Italy, Quaternary Science Reviews (**2009**), doi:10.1016/j.quascirev.2008.12.018

Hinnov, L., Schulzb, M., & Yiouc, P. (2002) 'Inter-hemispheric space–time attributes of the Dansgaard–Oeschger oscillations between 100 and 0 ka', *Quaternary Science Reviews*, **21**: 1213-1228.

Holliday, T.W. (1997a) 'Postcranial evidence of cold-adaptation in European Neanderthals', *American Journal of Physical Anthropology*, **104**: 245-258.

Hoffecker, J.F. & Cleghorn, N. (2000) 'Mousterian hunting patterns in the northwestern Caucasus and the ecology of the Neanderthals', *International Journal of Osteoarchaeology*, **10**: 368-378.

Hooten E.A. (1931) *Up from the Ape*. New York: Macmillan.

Houmark-Nielsen, M. (1989) 'The last interglacial–glacial cycle in Denmark', *Quaternary International* **3/4**: 31–39.

Huijzer, A.S., Isarin, R.F.B. (1997) 'The reconstruction of past climates using multi proxy-evidence: an example of the Weichselian Pleniglacial in northwest and central Europe', *Quaternary Science Reviews*, **16**: 513-533.

Huijzer, B., & Vandenberghe, J. (1998) 'Climatic reconstruction of the Weichselian Pleniglacial in north-western and central Europe', *Journal of Quaternary Science*, **13 (5)**: 391–417.

Hublin, J.J. (1993) 'Recent human evolution in northwestern Africa', In Aiken, M., Stringer, C., & Mellars, P. (eds.) *The Origin of Modern Humans and the Impact of Chronometric Dating*, pp. 118-131. Royal Anthropological Institute of Great Britain and Ireland.

Hublin, J.J., Barroso Ruiz, C., Medina Lara, P., Fontugne, M. & Reyss, J.-L. (1995) 'The Mousterian site of Zafarraya (Andalucia, Spain): dating and implications on the Palaeolithic peopling processes of Western Europe.', *Comptes rendus de l'Académie des sciences Paris* IIa. **321**: 931-7.

Huntley, B., Birks, H.J.B (1983) *An Atlas of the Past and Present Pollen Maps for Europe: 0-13000 BP*. Cambridge University Press, Cambridge, 667 pp.

Huntley, B. (1991) 'How plants respond to climate change: migration rates, individualism and the consequences for plant communities', *Annals of Botany* **67** (Suppl. 1): 15–22.

Huntley, B., & Allen J.R.M. (2003) 'Glacial Environments III: Palaeo-vegetation patterns in Late Glacial Europe', In van Andel, T.H. & Davies, W. (eds.) *Neanderthals and modern humans in the European Landscape during the Last Glaciation*, Chapter 6, pp. 79-103. (McDonald Institute Monographs.) Cambridge: McDonald Institute for Archaeological Research.

Imbrie, J., Hays, J.D., Martinson, D.G., McIntyre, A., Mix, A.C., Morley, J.J., Pisias, N.G., Prell, W.L., Shackleton, N.J. (1984) 'The orbital theory of Pleistocene climate: support from a revised chronology of the marine 18O record' In Berger, A.L., Imbrie, J., Hays, J., Kukla, G., Saltzman, B. (eds.), *Milankovitch and Climate*. D. Reidel, Dordrecht.

Imbrie, J., Mix, A.C., Martinson, D.G. (1993) 'Milankovitch theory viewed from Devils Hole', *Nature*, **363**: 531-533.

Jacobi, R. M., Rowe, P. J., Gilmour, M. A., Grun, R., Atkinson, T. C. (1997) Radiometric dating of the Middle Palaeolithic tool industry and associated fauna of Pin Hole Cave, Creswell Crags, England, *Journal of Quaternary Science*, **13**:29-42.

Jelenik, A.J. (1992) 'Hominids, Energy, Environment and Behaviour in the Late Pleistocene' In Nitecki, M. & Nitecki, D. (eds.) *Origins of Anatomically Modern Humans*. pp. 67-89. Plenum Press, New York.

Johnsen, S.J., Clausen, H.B., Dansgaard, W., Fuhrer, K., Gundestrup, N., Hammer, C.U., Iversen, P., Jouzel, J., Stauffer, B., & Steffensen, A.P. (1992) 'Irregular glacial interstadials recorded in a new Greenland ice core', *Nature*, **359**: 311-313.

Johnsen, S.J., Clausen, H.B., Dansgaard, W., Gundestrup, N.S., Hammer, C.U., & Tauber, H. (1995) 'The Eem stable isotope record along the GRIP ice core and its interpretation', *Quaternary Research*, **43**: 117-124.

Johnsen, S.J., Clausen, H.B., Dansgaard, W., Gundestrup, N.S.,Hammer, C.U, Andersen, U., Andersen, K.K., Hvidberg, C.S., Dahl-Jensen, D., Steffensen, J.P., Shoji, H., White, J.W.C., Jouzel, J., Fisher, D. (1997) 'The 18O record along the Greenland Ice Core Project deep ice core and the problem of possible Eemian climatic instability', *Journal of Geophysical Research*, **102** (C12), 26397-26410.

Johnsen, S.J., Dahl-Jensen, D., Gundestrup, N., Steffensen, J.P., Clausen, H.B., Miller, H., Masson-Delmotte, V., Sveinbj. orndottir, A.E., White, J. (2001) 'Oxygen isotope and palaeotemperature records from six Greenland ice-core stations: Camp Century, Dye-3, GRIP, GISP2, Renland and NorthGRIP', *Journal of Quaternary Science*, **16 (4)**: 299-307.

Jöris, O., & Adler, D., S. (2008) 'Setting the record straight: Toward a systematic chronological understanding of the Middle to Upper Paleolithic boundary in Eurasia', *Journal of Human Evolution*, **55**: 761-763.

Jouzel, J., Lorius, C., Petit, J.R., Genthon, C., Barkov, N.I., Kotlyakov, V.M., Petrov, V.M. (1987) 'Vostok ice core: a continuous isotope temperature record over the last climatic cycle (160,000 years)', *Nature*, **329**: 403-408.

Jouzel, J., Alley, R.B., Cuffey, K.M., Dansgaard, W., Grootes, P., Hoffmann, G., Johnsen, S.J., Koster, R.D., Peel, D., Shuman, C.A., Stievenard, M., Stuiver, M., White, J. (1997) 'Validity of the temperature reconstruction from water isotopes in ice cores', *Journal of Geophysical Research*, **102** (C12): 26471-26487.

Karabanov, E.B., Prokopenko, A.A., Williams, D.F., & Colman, S.M. (1998) 'Evidence from Lake Baikal for Siberian glaciation during oxygen-isotope substage 5d', *Quaternary Research*, **50**: 46-55.

King, G. & Bailey, G.H. (2006) 'Tectonics and human evolution', *Antiquity*, **80 (308)**: 265-286.

Kissel, C., Laj, C., Labeyrie, L., Dokken, T., Voelker, A., Blamart, D. (1999) 'Rapid climate variations during marine isotopic stage 3: magnetic analysis of sediments from Nordic seas and north Atlantic', *Earth and Planetary Science Letters*, **171**: 489-502.

Klein, R..G. (1983) 'The Stone Age Prehistory of Southern Africa', *Annual Review of Anthropology*, **1983**: 25-48.

Klein, R..G. (1999) *The Human Career: Human biological and cultural origins* Second edition. Chicago: The University of Chicago Press.

Klein, R..G. (1994) 'The problem of modern human origins' In Nitecki, M. & Nitecki, D. (eds.) *Origins of Anatomically Modern Humans*. pp. 3-15. 1994. Plenum Press, New York.

Klein, R.G. (2000) 'Archaeology and the evolution of human behaviour', *Evolutionary Anthropology*, **9(1)**: 17-36.

Klotz, S., Müller, U., Mosbrugger, V., de Beaulieu, J-L., & Reille, M. (2004) 'Eemian to early Würmian climate dynamics: history and pattern of changes in central Europe', *Palaeogeography, Palaeloclimtology, Palaeoecology*, **211**: 107-126.

Knudsen, K.L., Seidenkrantz, M.S., & Kristensen P. (2002) 'Last interglacial and early glacial circulation in the Northern North Atlantic Ocean', *Quaternary Research*, **58:** 22–26.

Korotaev, A.A. (1987) 'Effect of soil temperature and moisture content on root growth in coniferous cultures', *Soviet Forest Science*, **1987**: 52-61.

Kozlowski, J.K. (1990) 'A multi-aspectual approach to the origins of the Upper Palaeolithic in Europe' In Mellars, P. (ed.) *The Emergence of Modern Humans: an archaeological perspective* Edinburgh: Edinburgh University Press, 419-437.

Kramer, A., Crummett, T.L., & Wolpoff, M.H. (2001) 'Out of Africa and into the Levant: Replacement or Admixture in Western Asia?', *Quaternary International*, **75**: 51-63.

Krings, M., Capelli, C., Tschentscher, F., Geisert, H., Meyer, S., von Haeseler, A., Grossschmidt, K., Possnert, G., Paunovic, M., Paabo, S. (2000) 'A view of Neanderthal genetic diversity', *Nature Genetics*, **26**: 144-46.

Kukla, G., McManus, J.F., Rousseau, D.D., & Chuine, I. (1997) 'How long and how stable was the last interglacial?', *Quaternary Science Reviews*, **16**: 605-122.

Kukla, G.J., de Beaulieu, J.L., Svobodova, H., Andrieu-Ponel, V., Thouveny, N., Stockhausen, H. (2002a) 'Tentative correlation of pollen records of the last interglacial at Grande Pile and Ribains with Marine Isotope Stages', *Quaternary Research*, **58**: 32–35.

Kukla, G.J., Bender, M.D., Beaulieu, J.-L., de Bond, G., Broecker,W.S., Cleveringa, P.W., Gavin, J.E., Herbert, T.D., Imbrie, J., Jouzel, J., Keigwin, L.D., Knudsen, K.L., McManus, J., Merkt, J., Muhs, D.R., M. Muller, H., Poore, R.Z., Porter, S.C., Seret (2002b) 'Last interglacial climates', *Quaternary Research*, **58**: 2–13.

Kuman, K., Inbar, M., & Clarke, R.J. (1999) 'Palaeoenvironments and Cultural Sequence of the Florisbad Middle Stone Age Hominid Site, South Africa', *Journal of Archaeological Science*, **26**(**12**): 1409-1425.

Lahr, M.M and Foley, R.A. (1998) 'Towards a theory of modern human origins: geography, demography, and diversity in recent human evolution', *Yearbook of Physical Anthropology*, **41**: 137-176.

Lahr, M.M and Foley, R.A. (2003) 'Demography, dispersal and human evolution in the Lat Glacial Period', In van Andel, T.H. & Davies, W. (eds.) *Neanderthals and modern humans in the European Landscape during the Last Glaciation*, Chapter 14, (McDonald Institute Monographs.) Cambridge: McDonald Institute for Archaeological Research, 241-256.

Lahr, M.M. (1994) 'The Multiregional Model of modern human origins: a reassessment of its morphological basis', *Journal of Human Evolution*, **26**: 23-56.

Langbroek, M. (2001) 'The Trouble with Neanderthals', *Archaeological Dialogues*, **8**: 123-151.

Larnach, S.L. and Macintosh, N.W.G. (1974) 'A comparative study of Solo and Australian Aboriginal crania' In Elkin, A.P. & Macintosh, N.W.G. (eds.) *Grafton Elliot Smith: the Man and his Work* Sidney: Sydney University Press.

Larsen, E., Sejrup, H.P., Knudsen, K.L. (1995) 'Do Greenland ice cores reflect NW European interglacial climate variations?', *Quaternary Research*, **43**: 125-132.

Lieberman, D.E. (1995) 'Testing Hypothesis about Recent Human Evolution from Skulls: Integrating morphology, function, development, and phylogeny', *Current Anthropology*, **36**: 159-197.

Lindly, J.M & Clark, G.A. (1990) 'Symbolism and Modern Human Origins', *Current Anthropology*. **31**: 233-261.

Lowe, J.J and Walker, M.J.C. (1984) *Reconstructing Quaternary Environments*. Longman Scientific and Technical.

Lister, A.M. & Sher, A.V. (1995) 'Ice cores and mammoth extinction', *Nature*, **378**: 23-24.

Lombard, M. (2005) 'The Howiesons Poort of South Africa: what we know, what we think we know, what we need to know', *Southern African Humanities*, **17**: 33-55.

Lordkipanidze, D., Vekua, A., Ferring, R., Rightmire, G.P, Agusti, J., Kiladze, G., Mouskhelishvili, A., Nioradze, M., Ponce de Leon, MS., Tappen, M., & Zollikofer, CP. (2005) 'Anthropology: the earliest toothless hominin skull', *Nature*, **434**: 717-718.

Mackenzie, A., Ball, A.S., Virdee, S.R. *Ecology*. BIOS Scientific Publishers Limited 2001.

Maddy, D., Lewis, S.G., Scaife, R..G., Bowen, D.Q., Coope, G.R., Green, C.P., Hardaker, T., Keen, D.H., Rees-Jones, J., Parfitt, S., Scott, K. (1998) 'The Upper Pleistocene deposits at Cassington near Oxford', *Journal of Quaternary Science*, **13**: 205–232.

Magri, D. (1994) 'Late-Quaternary changes of plant biomass as recorded by pollen-stratigraphical data: a discussion of the problem at Valle di Castiglione, Italy', *Rev. Palaeobotan & Palynologyl*, **81**: 313-325.

Marks, A.E. (1990) 'The Middle and Upper Palaeolithic of the Near East and the Nile Valley: the problem of cultural transformations' In Mellars, P. & Stringer, C. (eds.) *The Human Revolution: Behavioural and Biological Perspectives on the Origins of Modern Humans*. pp. 56-80. Edinburgh University Press.

Martin, L. (2000) 'Gazelle (Gazella spp.) behavioural ecology: predicting animal behaviour for prehistoric environments in south-west Asia', *J. Zool., Lond.* **250**: 13-30.

Martinson, D.G., Pisias, N., Hays, J.D., Imbrie, J., Moore, T.C., & Shackleton, N.J. (1987) 'Age dating and the orbital theory of the ice ages: development of a high-resolution 0–300,000 year chronostratigraphy', *Quaternary Research*, **27**: 1–30.

McBrearty, S. (1990) 'The origin of Modern Humans', *Man*, **25**: 129-43.

McBrearty, S., & Brooks, A.S. (2000) 'The Revolution That Wasn't: a New Interpretation on the Origin of Modern Human Behaviour', *Journal of Human Evolution*, **39**: 453-563.

McCown, T.D. & Keith, A. (1939). *The Stone Age of Mount Carmel II: the Fossil Human Remains from the Levalloiso-Mousterian*. Oxford. Clarendon Press.

McManus, J.F., Bond, G.C., Broecker, W.S., Johnsen, S., Labeyrie, L., Higgins, S. (1994) 'High-resolution climate records from the North Atlantic during the last interglacial', *Nature*, **371**: 326-329.

McManus, J.F., Oppo, D., Cullen, J.C. (1999) 'A 0.5-million years record of millennial-scale climate variability in the North Atlantic', *Science*, **283**: 971-975.

Meese, D.A., Gow, A.J., Alley, R.B., Zielinski, G.A., Grootes, P.M., Ram, M., Taylor, K.C., Mayewski, P.A., & Bolzan, J.F. (1997) 'The Greenland Ice Sheet Project 2 depth-age scale: Methods and results', *J. Geophys. Res.*, **102**: 411–26.

Mellars, P.A, & Stringer, C. (1989a) 'Introduction', In Mellars, P.A. & Stringer, C. (eds.) *The Human Revolution: Behavioural and Biological Perspectives on the Origins of Modern Humans*. pp. 1-17. Edinburgh University Press.

Mellars, P.A. (1989b) 'Major Issues in the Emergence of Modern Humans', *Current Anthropology*, **30**: 349-85.

Mellars, P.A. (1996) *The Neanderthal Legacy: An Archaeological Perspective from Western Europe*. Princeton University Press, Princeton, NJ.

Mellars, P.A. (1998) 'The impact of climate changes on the demography of late Neanderthal and early anatomically modern populations in Europe' In Akazawa, T., Aoki, K., & Bar-Yosef, O. (eds.) *Neanderthals and Modern Humans in Western Asia* pp. 493-57

Mellars, P.A. (1999) 'The Neanderthal Problem Continued', *Current Anthropology*, **40**: 341-364.

Mellars, P.A. (2005) 'The Impossible Coincidence', A Single-Species Model for the Origins of Modern Human Behavior in Europe. *Evolutionary Anthropology*, **14**: 12-27.

Mellars, P.A. (2006a) 'Archaeology and the Dispersal of Modern Humans in Europe: Deconstructing the "Aurignacian"', *Evolutionary Anthropology*, **15**: 167-182.

Mellars, P.A. (2006b) 'A new radiocarbon revolution and the dispersal of modern humans in Eurasia', *Nature*, **439**: 931-935.

Mithen, S. (1996) *The Prehistory of the Mind.* Thames & Hudson.

Morgan, A. (1973) 'Late Pleistocene environmental changes indicated by fossil insect Faunas of the British Midlands', *Boreas*, **2**: 173-212.

Müller, H. (1974) 'Pollenanalytische Untersuchungen und Jahresschichtenzählung an der eem-zeitlichen Kieselgur von Bispingen/Luhe', *Geologisches Jahrbuch*, **A21**: 149–169.

Müller, U.C, & Bibusc, E. (2003) 'Vegetation response to rapid climate change in Central Europe during the past 140,000 yr based on evidence from the Furamoos pollen record', *Quaternary Research*, **59**: 235-245.

Muhs, D.R. (2002) 'Evidence for the timing and duration of the last interglacial period from high-precision Uranium-series ages of corals on tectonically stable coastlines', *Quaternary Research*, **58**: 36–40.

Münzel, S.C., & Conard, N.J. (2004) 'Change and continuity in subsistence during the Middle and Upper Palaeolithic in the Ach Valley of Swabia (south-west Germany)',. *International Journal of Osteoarchaeology*, **14**: 225-243.

Nei, M. (1987) *Molecular Evolutionary Genetics*. New York: Columbia University Press.

Nitecki, M.H., & D.V. Nitecki (1994) *Origins of anatomically modern humans*. New York, Plenum Press.

Oppo, D.W., Horowitz, M., & Lehman, S. J. (1997) 'Marine core evidence for reduced deep water production during Termination 2 followed by a relatively stable sub-stage 5e', *Paleoceanography*, **12**: 51–63.

Otte, M. (1990) 'From the Middle to the Upper Palaeolithic: the nature of the transition' In Mellars, P. (ed.) *The Emergence of Modern Humans*, pp. 438-56. Edinburgh, Edinburgh University Press.

Ovchinnikov I.V., Götherström A., Romanova G.P., Kharitonov V.M., Lidén K. & Goodwin W. (2000) 'Molecular analysis of Neanderthal DNA from the northern Caucasus', *Nature*, **404**: 490-3.

Pailler, D., & Bard, E. (2002) 'High frequency palaeoceanographic changes during the past 140 000 yr recorded by the organic matter in sediments of the Iberian Margin', *Palaeogeography, Palaeoclimatology, Palaeoecology*, **181**: 431-452.

Patou-Mathis, M. (2000) 'Neanderthal subsistence behaviours in Europe', *International Journal of Osteoarchaeology*, **10**: 379-395.

Patou-Mathis, M. (2004) 'Subsistence behaviours in a Middle Palaeolithic site in Poland: the Raj Cave', *International Journal of Osteoarchaeology*, **14**: 244-255.

Pavlov, P., Svendsen, J.I., & Indrelid, S. (2001) 'Human presence in the European Arctic nearly 40, 000 years ago', *Nature*, **413**: 64-67.

Pavlov, P., Roebroeks, W., & Svendsen, J.I. (2004) 'The Pleistocene colonization of northeastern Europe: a report on recent research', *Journal of Human Evolution*. **47**: 3-17.

Penck, A., & Brückner, E. (1909) *Die Alpen im Eiszeitalter*. Leipzig.

Petit, J.R., Jouzel, J., Raynaud, D., Barkov, N.I., Barnola, J-M., Basile, I., Bender, M., Chappellaz, J., Davis, M., Delaygue, G., Delmotte, M., Kotlyakov, V.M., Legrand, M., Lipenkov, V.Y., Lorius, C., Pepin, L., Ritz, C., Saltzman, E., Stievenard, M. (1999) 'Climate and atmospheric history of the past 420,000 years from the Vostok ice core Antarctic', *Nature*, **399**: 429-436.

Pettitt, P.B. (1999) 'Middle and early Upper Palaeolithic Crimea: the radiocarbon chronology', in *Préhistoire d'Anatolie: Genèse de deux mondes* ed. M. Otte. Liège: ERAUL **85**, 329-38.

Pettitt, P.B. (1999) 'Disappearing From the World: An Archaeological Perspective on Neanderthal Extinction', *Oxford Journal of Archaeology*. **18 (3)**: 217-240.

Pettitt, P.B. Ramsey, C.B., Hedges, R.E.M. & Hodgins, G.W.L. (2000) 'AMS radiocarbon dating at Oxford and its contribution to issues of the extinction of Neanderthals and the spread of Homo sapiens sapiens across Eurasia',. *Nuclear Instruments and Methods in Physics Research B* **172**: 751-755.

Ponel, P. (1995) 'Rissian, Eemian and Wurmian coleoptera assemblages from La Grande Pile (Vosges, France)', P*alaeogeography, Palaeoclimatology, Palaeoecology*, **114**: 1-41.

Pons, A., & Reille, M. (1988) 'The Holocene and Upper Pleistocene pollen record from Padul (Granada, Spain): a new study', *Palaeogeography, Palaeoclimatology, Palaeoecology*, **66**: 243-263.

Pope, G.G. (1992) 'The craniofacial evidence for the emergence of modern humans in China', *Yearbook of Physical Anthropology*, **35**: 243-86.

Prokopenko, A.A., Williams, D.F., Karabanov, E.B., & Khursevich, G.K. (2000). Continental response to Heinrich events and Bond cycles in sedimentary record of Lake Baikal, Siberia', *Global and Planetary Change*, **28**: 227-236.

Prokopenko, A., Karabanov, E., Williams, D., & Khursevich, G. (2002) 'The Stability and the Abrupt Ending of the Last Interglaciation in Southeastern Siberia in Southeastern Siberia', *Quaternary Research*, **58**: 56-59.

Rahmstorf, S. (2002) 'Ocean circulation and climate during the past 120,000 years', *Nature*, **419**: 207-214.

Ran, E.T.H., Bohncke, S. J. P., Van Huuisteden, K. J. & Vandenberghe, J. (1990) 'Evidence of episodic permafrost conditions during the Weichselian Middle Pleniglacial in the Hengelo Basin (The Netherlands)', *Geologie en Mijnbouw*, **69**: 207-218.

Raymo, M.E. (1997) 'The Timing of Major Climate Terminations', *Palaeooceanography*, **12**: 577-585.

Reille, M., Guiot, J. & de Beaulieu, J.L. (1992) 'The Montaigu Event: an abrupt climate change during the early Würm in Europe', In Kukla, G.J., Went, E. (eds.) *Start of a Glacial, NATO ASI Series*, vol. 13, pp. 89-95. Springer Verlag, Berlin-Heidelberg.

Reille, M. & de Beaulieu, J-L. (1995) 'Long Pleistocene pollen records from the Praxlaux crater, south-central France', *Quaternary Research*, **44**: 205-215.

Reille, M., Andrieu, V., de Beaulieu, J.L. (1998) 'A Long Pollen Record from Lac du Bouchet, Massif Central, France for the period 325-100ka BP (9c-5e)', *Quaternary Science Reviews*, **17**: 1107-1123.

Reille, M., de Beaulieu, J-L., Svobodova, H., Andrieu-Ponel, V., & Goeury, C. (2000) 'Pollen analytical biostratigraphy of the last five climatic cycles from a long continental sequence from the Velay region (Massif Central, France)', *Journal of Quaternary Science*, **15**: 665-685.

Relethford, J.H. (2001) 'Absence of Regional Affinities of Neanderthal DNA with Living Humans does not reject Multiregional Evolution', *American Journal of Physical Anthropology*, **115**: 95-98.

Richards, M.P., Pettitt, P.B., Trinkaus, E., Smith, F.H., Paunovic, M., & Karavanic, I. (2000) 'Neanderthal diet at Vindija and Neandertal predation: The evidence from stable isotopes', *Proc. Natl. Acad. Sci.* **97**: 7663-7666.

Richards, M.P., Pettitt, P.B., Stiner, M.C., & Trinkaus, E. (2001) 'Stable isotope evidence for increasing dietary breadth in the Europeab mid-Upper Palaeolithic', *Proc. Natl. Acad. Sci.* **98**: 6258-6532.

Rigaud, J-P. (2000) 'Late Neanderthals in the south-west of France and the emergence of the Upper Palaelithic', In Stringer, C., Barton, R.N.E., Finlayson, J.C. (eds.) *Neanderthals on the Edge*, pp. 27-31. Oxbow Books, Oxford.

Rightmire, P. (1989) 'Middle Stone Age Humans from Eastern and Southern Africa' In mellars, P., & Stringer, C (eds.) *The Human Revolution: Behavioural and Biological Perspectives on the Origins of Modern Humans*, pp. 109-23. Edinburgh University Press.

Rignot, E. & Kanagaratnam, P (2006) 'Changes in the Velocity Structure of the Greenland Ice Sheet', *Science*, **7 (311)**: 986-990.

Rioual, P., Ponel, A., Rietti-Shati, M., Battarbee, R., de Beaulieu, J., Cheddadi, R., Reille., M., Svobodovaß, M., & Shemesh, A. (2001) 'High-resolution record of climate in France during the last Glacial Period', *Nature*, **413**: 293-296.

Roche, D., Paillard, D., & Cortijo, E. (2004) 'Constraints on the duration and freshwater release of Heinrich event 4 through isotope modelling', *Nature*, **18**: 379-382.

Roebroeks, W., Conard, N. J., & van Kolfschoten, T. (1992) 'Dense forests, cold steppes and the Palaeolithic settlement of northern Europe', *Current Anthropology*, **33**: 551–586.

Roebroeks, W. (1994) 'Updating the Earliest Occupation of Europe', *Current Anthropology*, **35**: 301-05.

Rousseau, D.D., Antoine, P., Hatte, C., Lang, A., Zöller, L., Fontugne, M., Othman, D., Luck, J.M., Moine. O., Labonne., M., Bentaleb, & I., Jolly (2002) 'Abrupt millennial climatic changes from Nussloch (Germany) Upper Weichselian eolian records during the Last Glaciation', *Quaternary Science Reviews*, **21**: 1577-1582.

Sachs, J.P., & Anderson, R.F. (2005) 'Increased productivity in the subantarctic ocean during Heinrich events', *Nature*, **434**: 1118-1122.

Sánchez Goñi, M., Eynaud, F., Turon, J.L., & Shackleton, N.J. (1999) 'High resolution palynological record of the Iberian margin: direct land-sea correlation for the Last Interglacial complex', *Earth Planetary Science Letters*, **171**: 123-137.

Sánchez Goñi, M., Turon, J.L., Eynaud, F., & Gendreau, S. (2000) 'European climatic response to millennial-scale changes in the atmosphere–ocean system during the last glacial period', *Quaternary Research*, **54**: 394-403.

Sánchez Goñi, I. Cacho, J. Turon, J. Guiot, F. Sierro, J. Peypouquet, J. Grimalt, & N. Shackleton. (2002) 'Synchroneity between marine and terrestrial responses to millennial scale climatic variability during the last glacial period in the Mediterranean region', *Climate Dynamics*, **19(1)**: 95-105.

Sánchez Goñi, M., & d'Errico, F. (2004) 'A stationary Mediterranean forest in southeastern Iberia during OIS 3? A Reply to the Comments by J.S. Carrion', *Quaternary Science Reviews*, **23**: 1217-1224.

Sandgarthe, D.M., & Hatden, B. (2003) 'Did Neanderthals eat inner bark?', *Antiquity*, **67**: 710-118.

Sarnthein, M, Kennetth, J.P, Allen, J.R.M., Beerd, J., Grootese, P., Lajf, C., McManusg, J., Rameshh, R. SCOR-IMAGES Working Group. (2002) 'Decadal-to- Millennial-scale climate variability—chronology and mechanisms: summary and recommendations', *Quaternary Science Reviews*, **21**: 1121-1128.

Schreve, D.C. & Thomas, G.N. (2001) 'Critical issues in European Quaternary Biostratigraphy', Quaternary *Science Reviews*, **20**: 1577–1582.

Seidenkrantz, M-S., Bornmalm, L., Johnsen, S.J., Knudsen, K.L., Kuipers, A., Lauritzen, S.-T., Leroy, S.A.G., Mergeai, I., Schweger, C. & Van Vliet-Lanoe, B. (1996) '2-Step Deglaciation at the Oxygen Isotope Stage 6-5e Boundary: the Zeifen-Kattegat Climate Oscillation', *Quaternary Science Reviews*, **15**: 63-75.

Sepulchre, P., Ramstein, G., Kageyama, M., Vanhaeren, M., Krinner, G., Sánchez Goñi, M. & F., d'Errico, F. (2007) 'H4 abrupt event and Late Neanderthal presence in Iberia', *Earth and Planetary Science Letters* **258**: 283–292.

Shackleton, N.J. (1969) 'The last interglacial in the marine and terrestrial records', *Proceedings of the Royal Society of London B*, **174**: 135-154.

Shackleton, N.J., Hall, M.A., & Vincent, E. (2000) 'Phase relationships between millennial-scale events', 64,000-24,000 years ago. *Paleoceanography*, **15**: 565-569.

Shackleton, N.J. Chapman, M., Sanchez-Goni, M.F., Pailler, D., & Lancelot, Y. (2002) 'The classic Marine Isotope Substage 5e', *Quaternary Research*, **58**: 14-16.

Shackleton, N.J., Sanchez-Goni, M.F., Pailler, D., & Lancelot, Y. (2003) 'Marine Isotope Substage 5e and the Eemian Interglacial', *Global and Planetary Change*, **36**: 151-55.

Shea, J.J. (2006) 'The Human Revolution Rethought', *Evolutionary Anthropology*. **15**: 42-43.

Shennan, S., & Edinborough, K. (2007) 'Prehistoric population history: from the Late Glacial to the Late Neolithic in Central and Northern Europe', *Journal of Archaeological Science*, **34**: 1339-1345.

Shi, C., Zhu, R., Glass, B.P., Dingsong, L., Zeman, A., Suchy, V. (2003) 'Climate variations since the last interglacial recorded in Czech loess', *Geophysical Research Letters*, **30 (11)**: 1-4.

Simmons, T., & Smith, F.H. (1991) 'Late Pleistocene human population relationships in Africa, Europe and the circum-Mediterranean', *Current Anthropology*, **32**: 623-27.

Simmons, T. (1994) 'Archaic and Modern *Homo sapiens* in the Contact Zones: Evolutionary Schematics and Model Predictions' In Nitecki, M. & Nitecki, D. (eds.) *Origins of Anatomically Modern Humans*, pp. 201-221. New York (NY): Plenum Press.

Simmons, T., & Smith, F.H. (1991) 'Human Population Relationships in the Late Pleistocene', *Current Anthropology*, **2 (5)**: 623-627.

Smith, F.H. (1994) 'Samples, species, and speculations in the study of modern human origins' In Nitecki, M. & Nitecki, D. (eds.) *Origins of Anatomically Modern Humans* , pp. 228-49. New York (NY): Plenum Press.

Smith, L.S., & Harrold, F.B. (1997) 'A Paradigm's Worth of Difference? Understanding the Impasse over Modern Human Origins', *Yearbook of Physical Anthropology*, **40**: 113-138.

Smith, F.H., Trinkaus, E., Pettitt, P.B., Karavanić, I & Paunović, M., (1999) 'Direct radiocarbon dates for Vindija G1 and Velika Pećina Late Pleistocene hominid remains', *Proceedings of the National Academy of Sciences*, **96**: 12281-6.

Soffer, O., (1989) 'The Middle to Upper Palaeolithic Transition on the Russian Plain' In Mellars, P., & Stringer, C. (eds.) *The Human Revolution: Behavioural and Biological Perspectives on the Origins of Modern Humans*, pp. 714-43. Edinburgh University Press.

Soffer, O., (1994) 'Ancestral lifeways in Eurasia-the Middle and Upper Palaeolithic Records' In Nitecki, M. & Nitecki, D. (eds.) *Origins of Anatomically Modern Humans*, pp. 101-105. New York (NY): Plenum Press.

Stage Three Project. (2003) 'The stage 3 project archaeological database' [online]. Available: http://www.esc.cam.ac.uk/oistage3/Secure/OIS-3i.html#maplot [2004, September 1].

Steele, T.E. (2004) 'Variation in mortality profiles of red deer (Cervus elaphus) in Middle Palaeolithic assemblages from Western Europe', *International Journal of Osteoarchaeology*, **14**: 307-320.

Stenseth, N.C., Mysterud, A., Ottersen, G., Hurrell, J.W., Chan, K.S., & Lima, M. (2002) 'Ecological effects of climate fluctuations', *Science*, **297**: 1292-1296.

Stewart, J.R..T., van Kolfschoten, A. Markova & R. Musil. (2003a) 'The mammalian faunas of Europe during Oxygen Isotope Stage Three', In van Andel, T.H. & Davies, W. (eds.)

Neanderthals and modern humans in the European Landscape during the Last Glaciation, Chapter 7, pp. 221-32. (McDonald Institute Monographs.) Cambridge: McDonald Institute for Archaeological Research.

Stewart, J.R. (2004) 'Neanderthal-modern human competition? A comparison between the mammals associated with Middle and Upper Palaeolithic industries in Europe during OIS 3', *International Journal of Osteoarchaeology*, **14**: 178-189.

Stewart, J.R. (2005) 'The ecology and adaptation of Neanderthals during the non-analogue environment of Oxygen Isotope Stage 3', *Quaternary International*. **137**: 35-46.

Stockhausen, H. & Thouveny, N. (1999) 'Rock-magnetic properties of Eemian maar lake sediments from Massif Central, France: a climatic signature?', *Earth Planet. Sci. Lett.*, **173**: 299-313.

Straus, L.G. (2001) 'Africa and Iberia in the Pleistocene', *Quaternary International*. **75(1):** 91-102.

Stringer, C.B. (1974) 'Population relationships of later Pleistocene hominids: A multivariate study of available crania', *Journal of Archaeological Science*, **1**: 317-42.

Stringer, C.B. & Trinkaus, E. (1981) 'The Shanidar Neanderthal Crania' In, *Aspects of Human Evolution*, pp. 129-65. London, Taylor and Francis.

Stringer, C.B. (1989) 'The Origin of Early Modern Humans: a Comparison of the European and non-European Evidence', In Mellars, P. & Stringer, C. (eds.) *The Human Revolution: Behavioural and Biological Perspectives on the Origins of Modern Humans*, pp. 232-45. Edinburgh University Press.

Stringer, C.B. (1992b) 'Replacement, continuity and the origin of *Homo sapiens*' In G. Bräuer & F. Smith (eds.) *Continuity or Replacement: controversies in Homo sapiens evolution*, pp. 9-24. Rotterdam, Balkema.

Stringer, C.B. & Gamble, C. (1993) *In Search of the Neanderthals: solving the Puzzle of Human Origins*. London. Thames and Hudson.

Stringer, C.B. (1994) 'Out of Africa - A Personal History' In Nitecki, M. & Nitecki, D. (eds.) *Origins of Anatomically Modern Humans*. pp. 149-170. Plenum Press, New York.

Stringer, C.B. & Andrews, P. (1988) 'Genetic and Fossil Evidence for the Origin of Modern Humans', *Science*, **239**: 1263-68.

Stringer, C. B. & Grün, R. (1991) 'Time for the Last Neanderthals', *Nature*, **351**: 701-2

Stringer, C.B. (1998) 'Chronological and Biogeographic Perspectives on Later Human Evolution', In Akazawa, T., Aoki, K., Bar-Yosef, O. (eds.) *Neanderthals and Modern Humans in Western* Asia. pp. 29-37.

Stringer, C.B., & Davies, W. M. (2001) 'Those Elusive Neanderthals', *Nature*, **413**: 791-792.

Stringer, C.B. (2002a) 'New Perspectives on the Neanderthals,' *Hominid Evolution*, **59**: 58-59.

Stringer, C.B. (2002b) 'Modern human origins: progress and prospects', *Philosophical Transactions of the Royal Society: Biological Sciences*, **357**: 563-579.

Stringer, C.B., Pälike, T., van Andel, T.H., Huntley, B., Valdes, P., & J.R.M. Allen, (2003). Climatic stress and the extinction of the Neanderthals, In van Andel, T.H., & Davies, W. (eds.) *Neanderthals and modern humans in the European Landscape during the Last Glaciation*, Chapter 13, pp. 233-40. (McDonald Institute Monographs.) Cambridge: McDonald Institute for Archaeological Research.

Swisher, C.C., Curtis, G.H., Jacob, T., Getty, A.G., Suprijo, A., & Widiasamoro. (1994) 'Age of the earliest known hominids in Java, Indonesia', *Science*, **263**: 1118-1121.

Sykes, B. (1999) 'The molecular genetics of European ancestry', *Phil.Trans. R. Soc. Lond. B*, **354**: 131-139.

Tattersall I. (1986) 'Species concepts and species identification in human evolution', *Journal of Human Evolution*, **15**: 165-175.

Tattersall, I., & Schwartz, J. (1999) 'Hominids and hybrids: The place of Neanderthals in human evolution', *Journal of Human Evolution*, **15**:165-175.

Taylor, K.C., Hammer, C.U., Alley, R.B., Clausen, H.B., Dahl-Jensen, D., Gow A.J., Gundestrup, N.S., Kipfstuhl, J., Moore, J.C., & Waddington, E.D. (1993) 'Electrical conductivity measurements from the GISP2 and GRIP Greenland Ice Cores', *Nature*, **366**: 549-552.

Templeton A.R. (1993) 'The 'Eve' hypothesis: a genetic critique and reanalysis', *American Anthropologist*, **95**: 51–72.

Thieme, H. (1997) 'Lower Palaeolithic hunting spears from Germany', *Nature*, **385**: 807-817.

Tinner, W. & Lotter, A.F. (2001) 'Central European vegetation response to abrupt climate change at 8.2 ka', *Geology*, **29**: 551-554.

Thouveny, N., de Beaulieu, J. L, Bonifay, E., Creer, K. M., Guiot, J., Icole, J., Johnsen, S., Jouzel, J., Reille, M., Williams., T., & Williamson. D. (1994) 'Climate variations in Europe over the past 140kyr deduced from rock magnetism', *Nature*, **371**: 503-06.

Thouveny, N., Moreno, E., Delanghe, D., Candon, L., Lancelot, Y., & Shackleton, N.J. (2000) 'Rock-magnetism of Pleistocene sediments of the Portuguese margin: detection of Heinrich events and implications for paleoenvironmental reconstructions', *Earth Planetary Science Letters*, **180**: 61-75.

Trinkaus, E. (1986) 'The Neanderthals and Modern Human Origins', *Annual Review of Anthropology*, **15**: 193-218.

Trinkaus, E., & Shipman, P. (1993) *The Neanderthals: changing the image of mankind*. London. Jonathan Cape.

Trinkaus, R., Zilhão, J., & Duarte, C. (2001) 'O Menino do Lapedo: Lagar Velho 1 and perceptions of the Neanderthals', *Archaeological Dialogues*, **8**: 49-69.

Turner, C. (2002a) 'Problems of the duration of the Eemian interglacial in Europe north of the Alps', *Quaternary Research*, **58**: 45-48

Turner, C. (2002b) 'Formal status and vegetational development of the Eemian interglacial in North-western and Southern Europe', *Quaternary Research*, **58**: 41-44.

Tzedakis, P.C. (1993) 'Long-term tree populations in northwest Greece through multiple Quaternary climate cycles', *Nature*, **364**: 437-440.

Tzedakis, P.C. (1994) 'Vegetation change through glacial-interglacial cycles: a long pollen sequence perspective', *Philosophical Transactions of the Royal Society of London* **B345**: 403-432.

Tzedakis, P.C. & Bennett, K.D. (1995) 'Interglacial vegetation succession: a view from Southern Europe', *Quaternary Science Reviews*, **14**: 967-982.

Tzedakis, P.C., Andrieu, V., de Beaulieu, J.-L., Crowhurst, S., Follieri, M., Hooghiemstra, H., Magri, D., Reille, M., Sadori, L., Shackleton, N.J., & Wijmstra, T.A. (1997) 'Comparison of terrestrial and marine records of changing climate of the last 500,000 years', *Earth and Planetary Science Letters*, **150**: 171-176.

Tzedakis, P.C., Frogley, M.R., & Heaton, T.H.E. (2002) 'Duration of last interglacial conditions in northwest Greece', *Quaternary Research*, **58**: 53–55.

Tzedakis, P.C. (2003) 'Timing and duration of Last Interglacial conditions in Europe: a chronicle of a changing chronology', *Quaternary Science Reviews*, **22**: 763–768.

Ukkonen, P., Lunkka, J. P., Jungner, H. & Donner, J. (1999) 'New radiocarbon dates from Finnish mammoths indicating large ice free areas in Fennoscandia during the Middle Weichselian', *Journal of Quaternary Science*, **14**: 711-14.

Urey, H.C. (1947) 'The thermodynamic properties of isotopic substances', *J. Chem. Soc.* **1947**: 562-581.

Valladas, H., Reyss, J.L., Joron†, J.L., Valladas, G., Bar-Yosef, O & B. Vandermeersch (1998) 'Thermoluminescence dating of Mousterian "Proto-Cro-Magnon" remains from Israel and the origin of modern man', *Nature*, **331**: 614-616.

Valensi, P. (2000) 'The archaeozoology of Lazaret Cave (Nice, France)', *International Journal of Osteoarchaeology*, **10**: 357-367.

Valensi, P., & Psathi, E. (2004) 'Faunal Exploitation during the Middle Palaeolithic in south-eastern France and north-western Italy', *International Journal of Osteoarchaeology*, **14**: 256-272.

van Andel, T.H., & Tzedakis, P.C. (1996) 'Palaeolithic landscapes of Europe and environs, 150,000–25,000 years ago', *Quaternary Science Reviews*, **15**: 481–500.

van Andel T.H. (2002) 'The climate and landscape of the middle part of the Weichselian glaciation in Europe: The Stage 3 Project', *Quaternary Research*, **57**: 2-8.

van Andel, T.H., & Davies, W. (2003). *Neanderthals and modern humans in the European landscape during the last glaciation: archaeological results of the Stage 3 Project*, edited by Tjeerd H. van Andel & William Davies. (McDonald Institute Monographs.) Cambridge: McDonald Institute for Archaeological Research.

van Andel, T.H., (2003a) 'The Stage 3 Project: Initiation, Objectives, Approaches', In van Andel, T.H. & Davies, W. (eds.) *Neanderthals and modern humans in the European landscape during the last glaciation*, Chapter 1 pp. 1-8. (McDonald Institute Monographs.) Cambridge: McDonald Institute for Archaeological Research.

van Andel, T.H. (2003b) 'Glacial Environments I: the Weichselian climate in Europe between the end of OIS-5 Interglacial and the last glacial maximum', In van Andel, T.H. & Davies, W. (eds.) *Neanderthals and modern humans in the European landscape during the last glaciation*, Chapter 2 pp. 9-30. (McDonald Institute Monographs.) Cambridge: McDonald Institute for Archaeological Research.

van Andel, T.H. (2003c) 'Humans in the Ice Age – The Stage 3 Project: Overture or Finale?', In van Andel, T.H. & Davies, W. (eds.) *Neanderthals and modern humans in the European landscape during the last glaciation*, Epilogue, pp. 257-265. (McDonald Institute Monographs.) Cambridge: McDonald Institute for Archaeological Research.

van Andel, T.H., W. Davies, B. Weninger & O. Jöris, (2003a) 'Archaeological dates as proxies for the spatial and temporal human presence in Europe: a discourse on the method', In van Andel, T.H. & Davies, W. (eds.) *Neanderthals and modern humans in the European Landscape during the Last Glaciation*, Chapter 3, pp. 21-30. (McDonald Institute Monographs.) Cambridge: McDonald Institute for Archaeological Research.

van Andel, T.H., W. Davies, B. Weninger, (2003b) 'The human presence in Europe during the last glacial period I: human migrations and the changing climate', In van Andel, T.H. & Davies, W. (eds.) *Neanderthals and modern humans in the European Landscape during the Last Glaciation*, Chapter 4, pp. 31-56. (McDonald Institute Monographs.) Cambridge: McDonald Institute for Archaeological Research.

Vandenberghe, J. (1992) 'Geomorphology and climate of the cool oxygen isotope stage 3 in comparison with the cold stages 2 and 4 in The Netherlands', *Zeitschrift fur Geomorphologie*, Supplement Band, **86**: 65–75.

Vandenberghe, J., Coope, G.R. & Kasse, K. (1998a) 'Quantitative reconstructions of palaeoclimates during the last interglacial - glacial in western and central Europe: an introduction', *Journal of Quaternery Science*, **13**: 361-366.

Vandermeersch, B. (1989) 'The Evolution of Modern Humans: Recent Evidence from Southwest Asia' In Mellars, P. & Stringer, P. (eds.) *The Human Revolution: Behavioural and Biological Perspectives on the Origins of Modern Humans*. pp.155-65. Edinburgh University Press.

Van Huisstedejef, Ko., Vandenberghe, J., & D. Pollard (2003) 'Palaeotemperature reconstructions of the isotope Stage 3 compared with climate model results', *J. Quaternary Sci.* **18**: 453-464.

Van Vliet-Lanoë, (1989) 'Dynamics and extent of the Weichselian permafrost in western Europe (stage 5^{e} to 1)', *Quaternary International* **3–4:** 109-114.

Wainscoat J.S., Hill A.V.S., Boyce AL, Flint J, Hernandez M, Thein SL, Old JM, Lynch JR, Falusi AG, Weatherall DJ, & Clegg JB (1986) 'Evolutionary relationships of human populations from an analysis of nuclear DNA polymorphisms', *Nature*, **319**: 491-493

Walkling, A.P. & Coope, G.R. (1996) 'Climatic reconstructions from the Eemian/Early Weichselian tradition in Central Europe based on the coleopteran record from Gröbern (Germany)', *Boreas*, **25**: 145-159.

Watts, W.A., Allen, J.R.M., Huntley, B., & Fritz, S.C. (1996) 'Vegetation history and palaeoclimate of the last glacial period at Lago Grande di Monticchio Southern Italy', *Quaternary Science Reviews*, **15**: 133-53.

Watts, W.A., Allen, J.R.M. & Huntley, B. (2000) 'Palaeoecology of Three Interstadial Events during MIS 3 and 4: a Lacustrine Record from Lago Grande di Monticchio, southern Italy', *Palaeogeography, Palaeoclimatology, Palaeoecology*, **155**: 83-93.

Weidenreich F. (1943) 'The skull of Sinanthropus pekinensis: a comparative study of a primitive hominid skull', *Palaeontologica Sinica* **D10**: 1-485.

Whallon, R. (1989) 'Elements of Cultural Change in the Later Palaeolithic', In Mellars, P., & Stringer, C. (eds.) *The Human Revolution: Behavioural and Biological Perspectives on the Origins of Modern Humans*, pp. 433-455. Edinburgh University Press"

White, T.D., Asfaw, B., DeGusta, D., Gilbert, H., Richards, G.D., Suwa, G., & Clark-Howell, F. (2003) 'Pleistocene Homo sapiens from Middle Awash, Ethiopia', *Nature*, **423**:742-747.

Willis, K.J. (1996) 'Where did all the flowers go? The fate of temperate European flora during glacial periods,' *Endeavour*, **20(3)**: 110-114.

Willis, K.,J. Rudner, E., & Sumegi, K. (2000) 'The full-glacial forests of Central and Southeastern Europe,' *Quaternary Research*, **53**: 203-213.

Willis, K.J.; Rudner, E. & Sumegi, P. (2001) 'Letter to the Editor', *Quaternary Research*, **55**: 388-389.

Willis, K.J. & van Andel, T.H. (2004) 'Trees or no trees? The environments of central and eastern Europe during the last glaciation', *Quaternary Science Reviews*, **(23/24)**: 2369-2387.

Winograd, I.J., Landwehr, J.M., Ludwig, K.R., Coplen, T.B., & Riggs, A.C. (1997) 'Duration and structure of the past four interglaciations', *Quaternary Research*, **48**: 141-154.

Winograd, I.J., Coplen, T.B., Landwehr, J.M., Riggs, A.C., Ludwig, K.R., Szabo, B.J., Kolesar, P.T., & Revesz, K.M., (1992) 'Continuous 500,000-year climate record from vein calcite in Devils Hole, Nevada',. *Science*, **258**: 255-260.

Woillard, G. (1979) 'Abrupt end to the last interglacial in northeast France', *Nature*, **281**: 558–562.

Wolpoff, M.H., Wu, X., & Thorne, A.G. (1984) 'Modern *Homo sapiens* origins: a general theory of hominid evolution involving the fossil evidence from East Asia', In Smith, F.H., & Spencer, H. (eds.) pp. 411-483. *The Origins of Modern Humans: a World Survey of the Fossil Evidence*. New York: Alan R. Liss:

Wolpoff, M. (1989). 'Multiregional evolution: The fossil alternative to Eden', In Mellars, P., & Stringer, C. (eds.) pp. 62-109. *The Human Revolution: Behavioural and Biological Perspectives on the Origins of Modern Humans*. Edinburgh University Press.

Wolpoff, M.H., Thorne A.G., Smith F.H., Frayer D.W., & Pope G.G. (1992) 'Multiregional evolution: A World-wide source for modern human populations', In *Origins of Anatomically Modern Humans*. pp. 175-95. Plenum Press, New York.

Wolpoff, M & Caspari, R.. (1996) 'The modernity mess', *Journal of Human Evolution*, **30**: 167-172.

Wolpoff, M.H., Hawks, J., & Caspari, R.. (2000) 'Multiregional, Not Multiple Origins', *American Journal of Physical Anthropology*, **112**: 129-136.

Wolpoff, M.H, Hawks, J., Frayer, J.W., & Hunley, K. (2001) 'Modern Human Ancestry at the Peripheries: A Test of the Replacement Theory', *Science*. **291**: 293-297.

Wolpoff, M. H., Mannheim, B., Mann, A., Hawks, J., Caspari, R., Rosenberg, K. R., Frayer, D. W., Gill, G. W., & Clark, G. (2004) 'Why not the Neanderthals?', *World Archaeology*, **36(4)**: 527-546 *Debates in World Archaeology*.

Worsley, P. (1983) 'A Pleistocene Succession from beneath the Chelford sands at Oakwood Quarry, Cheshire', *Geological Journal*, **18**: 307-324.

Wu, Xinzhi. (2004) 'On the origin of modern humans in China', *Quaternary International*, **117**: 131–140.

Zagwijn, W.H. (1961) 'Vegetation, climate and radiocarbon datings in the Late Pleistocene of the Netherlands, Part I: Eemian and Early Weichselian. Mededelingen', *Geologische Stichting*, NS, **14**: 15–45.

Zagwijn, W.H. (1974) 'The Pliocene-Pleistocene boundary in western and southern Europe', *Boreas*, **3**: 75-97.

Zagwijn, W.H. (1994) 'Reconstruction of climate change during the Holocene in western and central Europe based on pollen records of indicator species', *Vegetation History and Archaeobotany*, **3**: 65-88.

Zagwijn, W.H. (1996) 'An analysis of Eemian climate in Western and Central Europe', *Quaternary Science Reviews*, **15**: 451-469.

Zilhão, J. (2000) 'The Ebro Frontier: "A Model for the Late Extinction of Iberian Neanderthals", In Stringer, C., Barton, R.N.E., & Finlayson, J.C. (eds.) *Neanderthals on the Edge* pp. 111-49. Oxbow Books, Oxford.

Zilhão, J., & d'Errico, F. (1999) 'The Chronology and Taphonomy of the Earliest Aurignacian and its Implication for the Understanding of Neanderthal Extinction', *Journal of World Prehistory*. **13 (1)**: 1-68.

Zilhão, J. & Trinkaus, E., (eds.) (2003) 'Portrait of the artist as a child. The Gravettian human skeleton from the Abrigo do Lagar Velho and its archeological context', *Trabalhos de Arqueologia*, **22** (whole volume).

Zubrow, E. (1989) 'The Demographic Modelling of Neanderthal Extinction', In Mellars, P., & Stringer, C. (eds.) *The Human Revolution: Behavioural and Biological Perspectives on the Origins of Modern Humans*, pp. 212-232. Edinburgh University Press.

Appendix A

Study Region	Country	Site	layer	Dating Method	Archaeology	Date	Sigma	MIS 3	Lab.	Reference
Med	Gibraltar	Ibex Cave	unit 3	ESR: EU	FAUNA/pre-Mousterian	~37,000		MIS 3	?	S3P
Med	Gibraltar	Ibex Cave	unit 3	ESR: LU	FAUNA/pre-Mousterian	~49,000		MIS 3	?	S3P
Med	Italy	Buca della Iena	C	U-series	pre-Mousterian	<41,000	0	MIS 3	?	S3P
Med	Italy	Buca della Iena	C	U-series	pre-Mousterian	<51,000	0	MIS 3	?	S3P
Med	Italy	Gr. Romanelli	H	U-series	pre-Mousterian	<69,000	0	MIS 3	?	S3P
Med	Italy	Gr. dei Moscerini	38	ESR: LU	Mousterian [& FAUNA]	101000	5000	MIS 3	MO-38*	S3P
Med	Portugal	Columbeira, Gruta Nova	8	Th/U	Mousterian	101487	38406	MIS 3	SMU-236E1	S3P
Med	Italy	Gr. dei Moscerini	33	ESR: LU	Mousterian [& FAUNA]	106000	17000	MIS 3	MO-33*	S3P
	France	Pie[d] Lombard [cave] [Tour[r]ettes-sur-Loup]	4el-4d	TL	Typical Mousterian	108400	9800	MIS 3	??	S3P
Med	Portugal	Salemas [algar]	T.V.b	C14	Mousterian	27457	1127	MIS 3	ICEN-383	S3P
Med	Spain	Aitzbitarte III	VI [level 16]	[AMS] C14	Gravettian [Noailles]	27466	1072	MIS 3	Ua-2628	S3P
South	France	Les Pecheurs [Casteljau]	F10/11	C14	Aurignacian 0	27479	1168	MIS 3	Ly-2339	S3P
South	France	Gr des Fieux [Miers]	F1 c	C14	Aurignacian*	27524	1060	MIS 3	Gif-6304	S3P
Med	Portugal	Abrigo do Lagar Velho	[-2.5m below level 6]	AMS C14	?Gravettian	27536	1031	MIS 3	OxA-8422	S3P
South	France	La Ferrassie	D2	C14	Gravettian [Perigordian V]	27547	1084	MIS 3	Gif-2696	S3P
South	France	Abri Pataud	5	C14	Gravettian [Perigordian IV]	27551	1262	MIS 3	W-191	S3P
North	Switzerland	Schnurenloch	7c [-2.5-3.5m]	C14	?Late Middle Palaeolithic	27569	1085	MIS 3	B-158	S3P

Central	Austria	Willendorf II	below 8 / B3	AMS C14	Gravettian	27593	1007	MIS 3	GrA-492	S3P
South	France	Solutre [O/A]	"sondage C"	C14	Aurignacian/Gravettian	27601	1070	MIS 3	Ly-317	S3P
North	U.K.	Church Hole		AMS C14	FAUNA	27602	1027	MIS 3	OxA-5800	S3P
North	Belgium	Maisieres-Canal	occup. Horizon	C14	Gravettian	27629	1072	MIS 3	Lv-305/2	S3P
South	France	Les Vignes [St-Martin sous Montaigu]	hearth	C14	Gravettian [Perigordian V]	27667	1024	MIS 3	Ly-309	S3P
North	U.K.	Robin Hood's Cave		AMS C14	?Gravettian	27669	1000	MIS 3	OxA-6188	S3P
South	France	Roc de Combe [Nadaillac]	4	AMS C14	??	27675	2117	MIS 3	OxA-1440	S3P
South	France	Gr d'Echenoz-la-Meline [La Baume]	II	C14	Mousterian	27677	1087	MIS 3	Ly-550	S3P
North	U.K.	Paviland Cave [Goat's Hole]	occup. horizon	AMS C14	?Gravettian	27678	995	MIS 3	OxA-7111	S3P
South	France	Tuto de Camalhot [St-Jean de Verges]	-	C14	Aurignacian I	27695	1026	MIS 3	Gif-2941	S3P
South	France	Gr. Pegourie [Caniac du Causse]	9b	C14	Early Magdalenian [a raclettes]	27698	1297	MIS 3	Ly-1835	S3P
South	France	Abri du Facteur	10/11	AMS C14	Gravettian [Noailles]	27710	991	MIS 3	OxA-584	S3P
North	Belgium	L'Hermitage [Huccorgne]	4	C14	Gravettian [Perigordian Vc]	27717	969	MIS 3	CAMS-589	S3P
Med	Italy	Gr. Paglicci	21C	C14	Evolved Gravettian	27719	970	MIS 3	F-53	S3P
South	France	Abri Pataud	3	AMS C14	Gravettian [Perigordian VI]	27724	1080	MIS 3	OxA-164	S3P
South	France	Vignaud	c13	C14	?early Aurignacian	27733	959	MIS 3	Ly-3761	S3P
South	France	Le Flageolet I [Bezenac]	VI	C14	Gravettian [Font Robert]	27752	968	MIS 3	Ly-2722	S3P
Med	Italy	Bilancino	on gravels	AMS C14	Gravettian	27764	944	MIS 3	Beta-93272	S3P
South	France	Abri Pataud	6	AMS C14	latest Aurignacian	27784	1038	MIS 3	OxA-582	S3P

Central	Germany	Das Geissenklosterle	[I]	AMS C14	[Gravettian]	27812	909	MIS 3	OxA-5157	S3P
South	France	Abri du Facteur	10/11	AMS C14	Gravettian [Noailles]	27823	977	MIS 3	OxA-585	S3P
North	Belgium	Maisieres-Canal	humic bed 2	C14	Gravettian	27824	1028	MIS 3	Lv-306	S3P
South	France	Abri Pataud	3	AMS C14	Gravettian [Perigordian VI]	27853	1045	MIS 3	OxA-165	S3P
South	France	Abri Pataud	3	AMS C14	Gravettian [Perigordian VI]	27889	960	MIS 3	OxA-686	S3P
North	Belgium	Trou Walou	B5X	?	Gravettian	27889	950	MIS 3	Lv-1837	S3P
South	France	Roc de Combe [Nadaillac]	3	AMS C14	Gravettian [Per V]	27892	871	MIS 3	OxA-1258	S3P
South	France	Canecaude I [Villardonel]	4	C14	Aurignacian ["typical"]	27898	869	MIS 3	Gif-2710	S3P
North	Belgium	Trou du Renard	hearths: arch. level 1	C14	Aurignacian III*	27908	893	MIS 3	Lv-721	S3P
Med	Portugal	Abrigo do Lagar Velho	[-2.5m below level 6]	AMS C14	?Gravettian	27917	824	MIS 3	OxA-8423	S3P
Med	Spain	Aitzbitarte III	VI [level 14]	[AMS] C14	Gravettian [Noailles]	27918	866	MIS 3	Ua-2626	S3P
Med	Spain	Nerja Vestibulo	13a+b	C14	indeterminate Upper Palaeolithic	27919	1643	MIS 3	UBAR-340	S3P
South	France	Le Piage [Fajoles]	??	AMS C14	"Upper Palaeolithic"	27921	903	MIS 3	OxA-1750	S3P
North	U.K.	Hyaena Den		AMS C14	FAUNA	27931	836	MIS 3	OxA-5805	S3P
South	France	Arcy-sur-Cure [Grande Grotte?]	??	AMS C14	"Upper Palaeolithic" ["Gravettian"?]	27953	850	MIS 3	OxA-4999	S3P
South	France	Gr d'Enlene [Montesquieu-Avantes]	5	C14	Gravettian [Perigordian V]	27954	830	MIS 3	Gif-6656	S3P
North	U.K.	Hyaena Den		AMS C14	?Gravettian	27956	813	MIS 3	OxA-3451	S3P
South	France	Grotte Chauvet	Hilaire [bear] cavern ["sol"]	?AMS C14	"Palaeolithic"	27958	791	MIS 3	Lyon-235(OxA)	S3P
South	France	Le Flageolet I [Bezenac]	I/III	AMS C14	Late Gravettian	27965	1010	MIS 3	OxA-448	S3P

North	U.K.	Coygan Cave	layer 5	AMS C14	FAUNA	27967	815	MIS 3	OxA-2509	S3P
Med	Italy	Gr. La Cala	tg.10	AMS C14	Gravettian	27967	783	MIS 3	OxA-6263	S3P
Med	Spain	Aitzbitarte III	VI [level 15]	[AMS] C14	Gravettian [Noailles]	27978	881	MIS 3	Ua-2627	S3P
South	France	Grande Grotte, Arcy-sur-Cure	??	[AMS] C14	"Upper Palaeolithic" ["Gravettian"?]	27991	811	MIS 3	??	S3P
South	France	La Ferrassie	D2	C14	Gravettian [Perigordian V]	27991	920	MIS 3	Gif-2698	S3P
Med	Portugal	Abrigo do Lagar Velho	[-2.5m below level 6]	AMS C14	?Gravettian	27992	786	MIS 3	OxA-8421	S3P
Med	Spain	Cariguela	??	TL	Mousterian	28000		MIS 3	TB-2	S3P
Central	Germany	Obere Klause	G	AMS C14	Gravettian	28005	822	MIS 3	OxA-5721	S3P
Med	Italy	Gr. del Broion	D	AMS C14	Gravettian	28017	837	MIS 3	UtC-2694	S3P
South	France	Roc de Combe [Nadaillac]	2	AMS C14	Gravettian [Per V]	28020	839	MIS 3	OxA-1257	S3P
Central	Austria	Willendorf II	8 / B2	AMS C14	Gravettian	28020	751	MIS 3	GrA-894	S3P
	France	A. Moula [Soyons]	-0.7-2.0m	C14	?Mousterian	28021	1981	MIS 3	Ly-1595	S3P
South	France	Abri du Facteur	10/11	AMS C14	Gravettian [Noailles]	28023	948	MIS 3	OxA-586	S3P
Med	Italy	Gr. Paglicci	21D	C14	Evolved Gravettian	28032	847	MIS 3	F-55	S3P
South	France	Abri du Facteur	10/11	AMS C14	Gravettian [Noailles]	28046	949	MIS 3	OxA-583	S3P
North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	28056	774	MIS 3	OxA-6983	S3P
South	France	Le Flageolet I [Bezenac]	VIII/1	AMS C14	Aurignacian II	28108	954	MIS 3	OxA-597	S3P
South	France	Gr. Cosquer [Cap Morgiou, Marseille]	parietal art	AMS C14	"Cheval 5"	28118	795	MIS 3	GifA-96072	S3P
Med	Portugal	Salemas [algar]	T.V.b	C14	Mousterian	28118	924	MIS 3	ICEN-379	S3P

Med	Portugal	Salemas [algar]	T.V.b	C14	Mousterian	28118	924	MIS 3	ICEN-384[!]	S3P
South	France	Gr. Cosquer [Cap Morgiou, Marseille]	parietal art	AMS C14	Hand stencil no. 12	28120	813	MIS 3	GifA-95538	S3P
South	France	Grotte Chauvet	Echantillon 5	?AMS C14	"Palaeolithic" ["sols sur les [dessins de] Rennes"]	28121	1085	MIS 3	Lyon-118(OxA)	S3P
Med	Portugal	Abrigo do Lagar Velho	[-2.5m below level 6]	AMS C14	?Gravettian	28130	755	MIS 3	GrA-13310	S3P
South	France	Le Piage [Fajoles]	J	C14	Aurignacian I	28174	877	MIS 3	Gif-5029	S3P
Med	Spain	Aitzbitarte III	VI [level 11]	[AMS] C14	Gravettian [Noailles]	28187	858	MIS 3	Ua-2245	S3P
Med	Italy	Bilancino	on gravels	AMS C14	Gravettian	28239	746	MIS 3	Beta-93271	S3P
South	France	La Quina Y-Z [Villebois la Valette]	2	C14	final [Quina] Mousterian	28319	805	MIS 3	GrN-2325	S3P
Med	Portugal	Casa da Moura	1b	C14	Gravettian?	28346	817	MIS 3	TO-1102	S3P
Med	Italy	Gr. Salomone	pre-Aurignacian level	Th/U	early Aurignacian*	28361	817	MIS 3	-	S3P
	France	Le Pre-Brun/Le Saut-du-Perron [St.-Maurice-sur-Loire]	hearth	C14	Gravettian	28418	2106	MIS 3	Ly-391	S3P
Med	Spain	Aitzbitarte III	V [level 7]	C14	Gravettian [Noailles]	28442	1303	MIS 3	I-15208	S3P
	France	Les Pecheurs [Casteljau]	5 [Base]	C14	Mousterian*	28455	1248	MIS 3	Ly-2342	S3P
South	France	Le Raysse [Brive-la-Gaillarde]	4	C14	Gravettian [Per V]	28531	1273	MIS 3	Ly-2782	S3P
Med	Spain	Zafarraya Cave	I [3-7]	TL	Late Mousterian	28558	1589	MIS 3	Gif-9140-II	S3P
South	France	Fontenioux [St Pierre de Maille]	2	C14	AurignacianV	28728	1235	MIS 3	Ly-2785	S3P
Central	Germany	Hohle[r] Fels	??	AMS C14	[Gravettian]	28740	1229	MIS 3	OxA-	S3P
Med	Italy	Gr. del Fossellone	21	C14	Aurignacian I	28750	1463	MIS 3	-	S3P

North	Belgium	Gr du Spy	middle bed	C14	Aurignacian	28775	1237	MIS 3	IRPA-203	S3P
Central	Austria	Willendorf II	8 / B2	C14	Gravettian	28775	1187	MIS 3	GrN-17801	S3P
South	France	Roc de Combe [Nadaillac]	1b	AMS C14	??	28808	1208	MIS 3	OxA-1255	S3P
Med	Italy	Gr. del Broion	E	AMS C14	Gravettian	28811	1181	MIS 3	UtC-2693	S3P
Central	Austria	Langenlois	?level 2	C14	Gravettian	28826	1363	MIS 3	H-2218-1537	S3P
North	Belgium	Gr. du Haleux [Sprimont]	??	C14	Aurignacian	28828	1283	MIS 3	Lv-1241	S3P
Central	Austria	Alberndorf [in der Riedmark]	??	[AMS?] C14	"Late Aurignacian"/?Gravettian	28833	1220	MIS 3	VRI-1536	S3P
South	France	Roc de Combe [Nadaillac]	6	AMS C14	?Aurignacian	28839	1536	MIS 3	OxA-1260	S3P
South	France	Abri du Facteur	10/11	AMS C14	Gravettian [Noailles]	28841	1272	MIS 3	OxA-594	S3P
	France	Gr Gra[p]pin [Arlay]	e	C14	FAUNA [pre-Magdalenian]	28852	1335	MIS 3	Ly-498	S3P
Med	Spain	Aitzbitarte III	VI [level 9]	[AMS] C14	Gravettian [Noailles]	28862	1214	MIS 3	Ua-2244	S3P
South	France	Abri Pataud	eboulis 3-4	AMS C14	Gravettian [Perigordian Vc - Noailles]	28864	1286	MIS 3	OxA-687	S3P
South	France	Fontenioux [St Pierre de Maille]	1	C14	Gravettian [Perigordian IVa]	28870	1218	MIS 3	Ly-2784	S3P
North	Belgium	Maisieres-Canal	clay layer	C14	Gravettian [Font Robert]	28885	1110	MIS 3	Lv-353	S3P
Central	Germany	Magdalenahohle	B [lower part is light-reddish in colour, but becoming a yellow-greyish ["loessic"] colour near the top [?of the slope]	C14	Gravettian [cf. some material from Paviland]	28888	1291	MIS 3	Bn-	S3P
Med	Spain	Rascano Cave	7	C14	?Ancient Aurignacian	28961	1548	MIS 3	BM-1456A	S3P
South	France	Abri du Facteur	10/11	AMS C14	Gravettian [Noailles]	28969	1254	MIS 3	OxA-595	S3P
South	France	Grotte du Renne, Arcy-	Xb	C14	Lower Chatelperronian	28981	1177	MIS	GrN-4251	S3P

		sur-Cure						3		
South	France	Grotte Chauvet	"Mouchage torche (humus)"	AMS C14	[Upper Palaeolithic - humus]	28989	1344	MIS 3	GifA-95158	S3P
Central	Austria	Willendorf II	8 / B2	C14	Gravettian	28996	1118	MIS 3	GrN-21690	S3P
Med	Italy	Gr. di Sant'Agostino	red [mixed] layer	ESR: EU	Mousterian	29000	6000	MIS 3	**	S3P
	France	Le Flageolet I [Bezenac]	V	AMS C14	Gravettian [Noailles]	29011	1268	MIS 3	OxA-447	S3P
Med	Portugal	Lapa da Rainha	4	C14	Solutrean	29018	2033	MIS 3	ICEN-789	S3P
Central	Austria	Willendorf II	8 / B2	C14	Gravettian	29047	1094	MIS 3	GrN-20767	S3P
South	France	La Ferrassie	I2	C14	Aurignacian III	29064	1108	MIS 3	Gif-4272	S3P
Central	Austria	Willendorf II	8 / B2 [*echantillon II IV, level 9]	C14	Gravettian	29075	1312	MIS 3	GrN-11191	S3P
South	France	Le Piage [Fajoles]	K	C14	Aurignacian I	29088	1167	MIS 3	Gif-5030	S3P
South	France	Le Piage [Fajoles]	G-I	C14	Aurignacian I	29088	1167	MIS 3	Gif-5028	S3P
	France	Gr de la Mere Clochette	X	C14	Chatelperronian/?FAUNA	29093	1254	MIS 3	Ly-1863	S3P
North	Belgium	Trou de l'Abime, Couvin	II [base]: zone A [squares G6/7 & H6/7]	C14	Late Middle Palaeolithic [/Early Upper Palaeolithic]	29093	1254	MIS 3	Lv-720	S3P
	France	Gr. Tournal (or Grande Grotte de Bize) [Bize-Minervois]	PC (Sq. N32)	C14	"late Palaeolithic"	29132	1326	MIS 3	Ly-1896	S3P
North	U.K.	Ash Tree Cave	spit 28	AMS C14	FAUNA	29141	1100	MIS 3	OxA-5798	S3P
South	France	Gr Gra[p]pin [Arlay]	d	C14	FAUNA [pre-Magdalenian]	29175	1373	MIS 3	Ly-499	S3P
Central	Austria	Willendorf II	8 / B2	C14	Gravettian	29181	1064	MIS 3	GrN-17802	S3P
South	France	Abri Pataud	5	AMS C14	Gravettian [Perigordian IV]	29260	1457	MIS 3	OxA-581	S3P
Med	Spain	Nerja Vestibulo	13a+b	C14	indeterminate Upper Palaeolithic	29283	5157	MIS	UBAR-343	S3P

								3		
Med	Spain	Cova Beneito	upper [VIII]	C14	Aurignacian	29301	1370	MIS 3	Gif-7650	S3P
South	France	Abri Pataud	eboulis 3-4	AMS C14	Gravettian [Perigordian Vc - Noailles]	29374	1384	MIS 3	OxA-166	S3P
Med	Greece	Asprochaliko	9 [or 10?*]	C14	Gravettian	29374	1384	MIS 3	I-1956	S3P
Med	Gibraltar	Gorham's Cave	context 7 [?=D], combustion zone	AMS C14	Aurignacian[?]	29682	575	MIS 3	OxA-6997	S3P
Central	Belgium	Trou Walou	B5EX	?	Gravettian	29684	648	MIS 3	Lv-1867	S3P
South	France	Abri Pataud	4	AMS C14	Gravettian [Perigordian Vc - Noailles]	29705	1350	MIS 3	OxA-374	S3P
Med	Spain	L'Arbreda	-5.05-5.4m [Level H?]	C14	Archaic Aurignacian	29712	605	MIS 3	Gif-6422	S3P
Med	Italy	Gr. La Cala	tg.11	AMS C14	Gravettian	29726	548	MIS 3	OxA-6264	S3P
South	France	Abri Pataud	5	C14	Gravettian [Perigordian IV]	29744	568	MIS 3	Gx-1371	S3P
Central	Austria	Aggsbach	b (main level)	C14	Gravettian	29756	531	MIS 3	GrN-1354	S3P
North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	29777	589	MIS 3	OxA-6928	S3P
North	U.K.	Pontnewydd Cave		AMS C14	FAUNA	29815	557	MIS 3	OxA-4367	S3P
Central	Germany	Hohle[r] Fels	IIC	AMS C14	Gravettian	29822	563	MIS 3	OxA-4598	S3P
Med	Portugal	Caldeirao Cave	Jb	AMS C14	Gravettian? [non-diagnostic Early Upper Palaeolithic with blades and ornaments]	29835	555	MIS 3	OxA-5542	S3P
Central	Austria	Langenlois	?level 2	C14	Gravettian	29844	1972	MIS 3	KN-10b	S3P
South	France	Abri Pataud	5	C14	Gravettian [Perigordian IV]	29846	554	MIS 3	GrN-5012	S3P
South	France	La Ferrassie	[Els] G0	C14	Aurignacian III	29861	553	MIS 3	Gif-4266	S3P
South	France	Grotte Chauvet	"Mouchage torche (charbon 4)"	AMS C14	[Upper Palaeolithic - charcoal]	29870	576	MIS	GifA-95127	S3P

South	France	Le Flageolet I [Bezenac]	VII	C14	Gravettian [Per. V]	29870	695	3 MIS	Ly-2723	S3P
Central	Austria	Willendorf II	6 / B4	AMS C14	Gravettian	29870	559	3 MIS	GrA-1016	S3P
North	Belgium	Trou Magrite	2	C14	early Aurignacian	29871	1723	3 MIS	GX-17017G	S3P
Central	Germany	Bockstein-Torle	VII	C14	[early] Aurignacian	29876	570	3 MIS	H-4059-3356	S3P
South	France	Gr. Cosquer [Cap Morgiou, Marseille]	parietal art	AMS C14	"Bison 2"	29929	598	3 MIS	GifA-96069	S3P
	France	Trou du Rhinoceros [St-Pe-de-Bigorre]	??	C14	[Upper] "Palaeolithic"	29931	588	3 MIS	Ly-4044	S3P
North	U.K.	Kent's Cavern		AMS C14	FAUNA/Early Upper Palaeolithic	29937	581	3 MIS	OxA-5695	S3P
North	Belgium	L'Hermitage [Huccorgne]	4	AMS C14	Gravettian [Perigordian Vc]	29939	583	3 MIS	OxA-3886	S3P
South	France	Grande Grotte, Arcy-sur-Cure	??	AMS C14	"Upper Palaeolithic" ["Gravettian"?]	29946	633	3 MIS	OxA-5003	S3P
Med	Italy	Gr. La Cala	tg.1	AMS C14	Aur/Gravett	29949	581	3 MIS	OxA-5870	S3P
North	U.K.	Picken's Hole, Layer 5		C14		29949	2070	3 MIS	BM-655A	S3P
Med	Italy	Gr. Paglicci	23B	AMS C14	Gravettian	29952	598	3 MIS		S3P
South	France	A. Combe Sauniere [Sarliac-sur-l'Isle]	III C	AMS C14	"Ancient Magdalenian"	29959	993	3 MIS	OxA-482	S3P
South	France	La Ferrassie	E	AMS C14	Gravettian [Perigordian Va]	29962	724	3 MIS	OxA-404	S3P
Central	Germany	Das Geissenklosterle	[I]	AMS C14	[Gravettian]	29979	644	3 MIS	OxA-5159	S3P
	France	Gr. Cosquer [Cap Morgiou, Marseille]	"Sol pres des pingouins"	AMS C14	Associated parietal art	29982	611	3 MIS	GifA-92349	S3P
South	France	Abri Pataud	5	C14	Gravettian [Perigordian IV]	29989	628	3 MIS	Gx-1372	S3P
South	France	Abri Pataud	5	C14	Gravettian [Perigordian IV]	30024	611	3 MIS	GrN-4477	S3P
Med	Italy	Gr. La Cala	tg.3	AMS C14	Mousterian	30067	641	3 MIS	OxA-6266	S3P

								3		
	France	La Baume Longue [Dions]	basal fill, Grands Puits pit	C14	FAUNA / Middle Pal.	30073	1256	MIS 3	Ly-2415	S3P
Med	Italy	Gr Barbara	"tongue of sediment, adhering to the wall of the cave, and in a side fissure"	AMS C14	Aurignacian	30103	680	MIS 3	OxA-3609	S3P
South	France	Abri Pataud	4a	AMS C14	Gravettian [Perigordian Vc - Noailles]	30121	1198	MIS 3	OxA-167	S3P
Med	Spain	Alkerdi	2	C14	Gravettian	30138	741	MIS 3	GrN-20322	S3P
Central	Germany	Hohle[r] Fels	??	AMS C14	[Gravettian]	30146	764	MIS 3	OxA-4976	S3P
Central	Austria	Willendorf II	6 / B4	C14	Gravettian	30146	736	MIS 3	GrN-20768	S3P
Med	Spain	Cueto de la Mina	??	C14	Gravettian	30147	751	MIS 3	Ua-3587	S3P
Med	Portugal	Columbeira, Gruta Nova	16 (=7)	C14	Mousterian	30152	918	MIS 3	Gif-2703	S3P
South	France	Gr. du Castellas [Dourgne]	a fill level	C14	Upper Palaeolithic/FAUNA	30152	873	MIS 3	Ly-2251	S3P
Central	Germany	Das Geissenklosterle	It [sq. 89]	AMS C14	Gravettian	30175	753	MIS 3	OxA-5226	S3P
South	France	Le Flageolet I [Bezenac]	VI	AMS C14	Gravettian [Font Robert]	30210	1066	MIS 3	OxA-579	S3P
South	France	La Ferrassie	J	C14	Aurignacian II	30216	759	MIS 3	Gif-4273	S3P
North	Belgium	L'Hermitage [Huccorgne]	4	C14	Gravettian [Perigordian Vc]	30221	774	MIS 3	CAMS-589	S3P
	France	Montagne de Girault [Genay]	tranchee 1	C14	Mousterian	30240	1854	MIS 3	Ly-2663	S3P
Central	Austria	Aggsbach	c	C14	Gravettian	30241	773	MIS 3	GrN-2513	S3P
Med	Spain	Labeko Koba	IX (base)	C14	Chatelperronian	30252	820	MIS 3	Ua-3034	S3P
	France	Roc de Marcamps [Prignac-et-Marcamps]	8M30-N30	C14	Aurignacian	30255	1002	MIS 3	Ly-2682	S3P
North	U.K.	Soldier's Hole	spit 8	AMS C14	FAUNA	30297	860	MIS	OxA-2063	S3P

Med	Portugal	Vale Comprido	profile (northern cut)	TL	early Gravettian	30300	3900	MIS 3	BM-VCO12	S3P
Med	Spain	Budino 1 [Ganderas de Boudino]	??	C14	"Lower Palaeolithic" [Mousterian?]	30309	3333	MIS 3	I-2174	S3P
	France	L'Ermitage [Lussac-les-Chateaux]	??	C14	[Quina] Charentian Mousterian	30313	884	MIS 3	Ly-2756	S3P
South	France	Grotte du Renne, Arcy-sur-Cure	??	C14	Mousterian	30321	857	MIS 3	BM-1817R	S3P
South	France	Abri Pataud	6	AMS C14	latest Aurignacian	30323	987	MIS 3	OxA-689	S3P
South	France	Abri Pataud	6	AMS C14	latest Aurignacian	30323	987	MIS 3	OxA-690	S3P
Central	Austria	Salzofenhohle	Red-brown "phosphate earth" [="culture layer"*] from outer chamber	C14	Mousterian/FAUNA	30327	932	MIS 3	GrN-2104	S3P
Med	Italy	Gr. Paglicci	22B	AMS C14	Gravettian	30329	850	MIS 3		S3P
South	France	Abri Pataud	5	C14	Gravettian [Perigordian IV]	30346	873	MIS 3	Gx-1369	S3P
North	U.K.	Pin Hole Cave	-5 feet (Within Blade distribution - Jacobi et al. 1998).	AMS C14	FAUNA/Early Upper Palaeolithic	30365	895	MIS 3	OxA-1205	S3P
North	Belgium	Trou de l'Abime, Couvin	II [base]: zone A [squares G6/7 & H6/7]	AMS C14	Upper Palaeolithic	30366	884	MIS 3	OxA-2452	S3P
Med	Italy	Gr. La Cala	tg.3	AMS C14	Aur/Gravett	30398	888	MIS 3	OxA-5869	S3P
North	U.K.	Church Hole		AMS C14	FAUNA	30405	899	MIS 3	OxA-5799	S3P
North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	30407	903	MIS 3	OxA-6922	S3P
North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	30407	903	MIS 3	OxA-6926	S3P
	France	Les Pecheurs [Casteljau]	18A-F9	C14	Aurignacian I	30410	1131	MIS 3	Ly-2337	S3P
Med	Spain	Mougas	??	C14	??	30413	3874	MIS 3	?	S3P
North	U.K.	Picken's Hole, Layer 5		C14		30416	2319	MIS 3	BM-655B	S3P

	France	A du Mas Viel [St-Simon]	C	C14	Mousterian	30435	1004	3 MIS	Gif-3281	S3P
Med	Spain	Zafarraya Cave	I [3-7]	TL	Late Mousterian	30438	3036	3 MIS	Gif-9140-II	S3P
South	France	Le Flageolet I [Bezenac]	VIII/1	C14	Aurignacian II	30442	1132	3 MIS	Ly-2724	S3P
Central	Germany	Lommersum	IIc-7	C14	Early Aurignacian	30442	2906	3 MIS	Pta-2939	S3P
South	France	Gr de Hyenes, Brassempouy	level 2E [square BA11]	C14	"Ancient Aurignacian"	30443	921	3 MIS	Gif-9032	S3P
Med	Spain	Labeko Koba	VII (base)	C14	Proto-Aurignacian	30470	933	3 MIS	Ua-3320	S3P
South	France	Grotte Chauvet	"Mouchage torche (charbon 1)"	AMS C14	[Upper Palaeolithic - charcoal]	30478	920	3 MIS	GifA-95129	S3P
South	France	Grotte Chauvet	"Mouchage torche (charbon 1)"	AMS C14	[Upper Palaeolithic - charcoal]	30480	921	3 MIS	GifA-95130	S3P
Central	Austria	Langenlois	?level 2	C14	Gravettian	30485	890	3 MIS	KM-10/263	S3P
North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	30514	911	3 MIS	OxA-6986	S3P
South	France	Abri Pataud	4	C14	Gravettian [Perigordian Vc - Noailles]	30516	914	3 MIS	GrN-4280	S3P
South	France	Abri Pataud	4	AMS C14	Gravettian [Perigordian Vc - Noailles]	30519	1140	3 MIS	OxA-168	S3P
North	Germany	Das Geissenklosterle	[I]	AMS C14	[Gravettian]	30519	949	3 MIS	OxA-4855	S3P
North	U.K.	Pontnewydd Cave		AMS C14	FAUNA	30521	910	3 MIS	OxA-4373	S3P
	France	Gr de La Baume [Gigny sur Suran]	10	C14	[final] Mousterian	30529	1581	3 MIS	Ly-1701	S3P
South	France	La Ferrassie	K3b	C14	Aurignacian II	30545	890	3 MIS	Gif-4275	S3P
	France	Gr. Cosquer [Cap Morgiou, Marseille]	parietal art	AMS C14	Black hand stencil [MR7]	30554	896	3 MIS	GifA-92491	S3P
	France	Gr. Cosquer [Cap Morgiou, Marseille]	parietal art	AMS C14	Black hand stencil [MR7]	30555	911	3 MIS	GifA-92409	S3P
Med	Portugal	Figueira Brava Cave	2	Th/U	Mousterian	30561	11759	3 MIS	SMU-232E1	S3P

Central	Austria	Langenlois	?level 2	C14	Gravettian	30568	1326	MIS 3	KN-10c	S3P
South	France	Le Flageolet I [Bezenac]	IX	C14	Aurignacian	30595	1154	MIS 3	Ly-2726	S3P
Med	Italy	Gr. La Cala	tg.13	AMS C14	Aurignacian	30600	1061	MIS 3	OxA-5868	S3P
South	France	Pech de l'Aze II [Carsac]	3 ["travertine"]	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	30600	3700	MIS 3	632A	S3P
North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	30608	863	MIS 3	OxA-6984	S3P
North	U.K.	Bench Quarry "Tunnel" cavern	cave-earth	AMS C14	Early Upper Palaeolithic	30612	974	MIS 3	OxA-4985	S3P
Central	Germany	Hohle[r] Fels	??	AMS C14	[Gravettian]	30612	974	MIS 3	OxA-4978	S3P
Med	Portugal	Salemas [sima]	lower level	C14	Mousterian	30696	1142	MIS 3	ICEN-361	S3P
Med	Spain	Cueva Morin	8a	C14	Archaic Aurignacian	30804	1049	MIS 3	SI-952A	S3P
Med	Spain	Amalda Cave	VI	C14	Gravettian [Noailles]	30909	1237	MIS 3	I-11665	S3P
	France	Montagne de Girault [Genay]	tranchee 2 [East]	C14	Mousterian	30909	1237	MIS 3	Ly-2664	S3P
Med	Spain	Cueva Morin	7	C14	Archaic Aurignacian	30923	1814	MIS 3	SI-955A	S3P
Med	Spain	Amalda Cave	VI	C14	Gravettian [Noailles]	30936	1321	MIS 3	I-11664	S3P
Med	Italy	Gr. La Cala	QIII-I	C14	Gravettian [Perigordian V]	30967	2765	MIS 3	F-22	S3P
Med	Spain	Cariguela	??	TL	Mousterian	31,000-35,000		MIS 3	TB-5	S3P
Med	Italy	Gr. La Cala	QV-VI	C14	Gravettian [Perigordian V]	31044	2037	MIS 3	F-24	S3P
South	France	Le Flageolet I [Bezenac]	VIII/2	C14	Aurignacian	31072	1698	MIS 3	Ly-2725	S3P
North	Belgium	Goyet	??	AMS C14	Magdalanian	31083	401	MIS 3	GrA-3239	S3P
North	U.K.	Pin Hole Cave	(Within Blade distribution - Jacobi	AMS C14	FAUNA/Early Upper Palaeolithic	31097	765	MIS	OxA-1806	S3P

			et al. 1998).							
Central	Austria	Willendorf II	5 / C2	AMS C14	Gravettian	31108	409	MIS 3	GrA-218	S3P
	France	Gr. Cosquer [Cap Morgiou, Marseille]	parietal art	AMS C14	"Bison 2"	31144	484	MIS 3	GifA-95195	S3P
North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	31173	530	MIS 3	OxA-6994	S3P
North	U.K.	Tornewton Cave	reindeer stratum	AMS C14	FAUNA	31176	515	MIS 3	OxA-3185	S3P
Central	Austria	Krems-Wachtberg	-3-5m	C14	Gravettian	31196	405	MIS 3	GrN-3011	S3P
South	France	Le Piage [Fajoles]	??	AMS C14	"Upper Palaeolithic"	31222	416	MIS 3	OxA-3839	S3P
Central	Germany	Das Geissenklosterle	[I]	AMS C14	[Gravettian]	31254	568	MIS 3	OxA-4857	S3P
South	France	Roc de Combe [Nadaillac]	6	AMS C14	?Aurignacian	31255	529	MIS 3	OxA-1315	S3P
North	U.K.	Soldier's Hole	spit 9	AMS C14	FAUNA	31255	614	MIS 3	OxA-1956	S3P
	France	La Salpetriere [Remoulins]	30 M	C14	Late Aurignacian	31260	3754	MIS 3	Ly-944	S3P
North	U.K.	Picken's Hole, Layer 3		C14	[Early Upper Palaeolithic?]	31260	2803	MIS 3	BM-2117R	S3P
South	France	La Ferrassie	K2	C14	Aurignacian II	31262	401	MIS 3	Gif-4274	S3P
South	France	La Ferrassie	D2h	AMS C14	Gravettian [Perigordian Va]	31286	739	MIS 3	OxA-403	S3P
South	France	Abri Pataud	5	C14	Gravettian [Perigordian IV]	31292	426	MIS 3	Gx-1370	S3P
North	U.K.	Paviland Cave [Goat's Hole]	occup. horizon	C14	?Aurignacian	31324	1701	MIS 3	BM-1367	S3P
Med	Spain	Ruso [I]	??	C14	??	31325	382	MIS 3	B-70812	S3P
Central	Germany	Hohle[r] Fels	??	AMS C14	[Gravettian]	31339	800	MIS 3	OxA-5163	S3P
Central	Austria	Willendorf II	6 / B4	C14	Gravettian	31339	531	MIS 3	GrN-17803	S3P
Central	Austria	Willendorf II	6 / B4	AMS C14	Gravettian	31343	404	MIS 3	GrA-895	S3P

Med	Portugal	Caldeirao Cave	K [top]	AMS C14	late Mousterian	31358	633	3 MIS	OxA-1941	S3P
Med	Spain	Cueva Morin	8a	C14	Archaic Aurignacian	31361	599	3 MIS	SI-952	S3P
Central	Germany	Vogelherd Cave	IV/V	C14	Aurignacian [I]	31367	827	3 MIS	GrN-6662	S3P
South	France	Abri Pataud	5	C14	Gravettian [Perigordian IV]	31376	427	3 MIS	GrN-4662	S3P
Med	Spain	Cueva Morin	8a	C14	Archaic Aurignacian	31395	1723	3 MIS	SI-956	S3P
North	U.K.	Kent's Cavern	cave earth A2	C14	Aurignacian	31453	504	3 MIS	GrN-6325	S3P
	France	Gr. Cosquer [Cap Morgiou, Marseille]	parietal art	AMS C14	Hand stencil no. 19	31461	534	3 MIS	GifA-96073	S3P
North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	31462	575	3 MIS	OxA-6980	S3P
Med	Spain	Cueva Morin	10	C14	Chatelperronian	31479	618	3 MIS	SI-951	S3P
North	U.K.	Kent's Cavern		AMS C14	FAUNA/Early Upper Palaeolithic	31486	532	3 MIS	OxA-4436	S3P
	France	Abri du Facteur	21 [G]	C14	Aurignacian (evolved?)	31494	2211	3 MIS	Gif-67	S3P
North	U.K.	Paviland Cave [Goat's Hole]	occup. horizon	AMS C14	?Aurignacian	31495	506	3 MIS	OxA-7877	S3P
North	U.K.	Kent's Cavern		AMS C14	FAUNA/Early Upper Palaeolithic	31503	575	3 MIS	OxA-5693	S3P
North	U.K.	Hyaena Den		AMS C14	Mousterian	31522	556	3 MIS	OxA-4112	S3P
North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	31531	530	3 MIS	OxA-6982	S3P
	France	Gr. Cosquer [Cap Morgiou, Marseille]	"Sol pres des felins"	AMS C14	Associated parietal art	31535	542	3 MIS	GifA-92350	S3P
Med	Gibraltar	Gorham's Cave	D	C14	?Aurignacian	31544	495	3 MIS	GrN-1363	S3P
North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	31561	607	3 MIS	OxA-6921	S3P
Central	Austria	Krems-Wachtberg	-3-5m	C14	Gravettian	31562	582	3 MIS	GrN-	S3P

	France	Esquicho-Grapaou	C C2	C14	Mousterian	31574	1455	3 MIS	Ly-1793	S3P
North	U.K.	Hoyle's Mouth		AMS C14	?FAUNA/"Early Upper Palaeolithic"	31575	647	3 MIS	OxA-1024	S3P
Central	Germany	Das Geissenklosterle	It [sq. 130]	AMS C14	Gravettian	31603	616	3 MIS	OxA-5229	S3P
North	Belgium	Trou Walou	C6	?	Aurignacian	31609	892	3 MIS	GrN-22904	S3P
North	U.K.	Hyaena Den		AMS C14	Mousterian	31633	584	3 MIS	OxA-4111	S3P
North	Belgium	Maisieres-Canal	occup. horizon	C14	Gravettian [Font Robert]	31634	446	3 MIS	GrN-5523	S3P
North	Belgium	Trou Walou	C6	?	Aurignacian	31642	478	3 MIS	GrN-22769	S3P
North	U.K.	Kent's Cavern		AMS C14	FAUNA/Early Upper Palaeolithic	31679	540	3 MIS	OxA-4435	S3P
North	Belgium	Trou Magrite	3	C14	early Aurignacian	31684	3925	3 MIS	GX-18540G	S3P
North	U.K.	Cave 8, Uphill Quarry	??	AMS C14	Aurignacian?	31709	463	3 MIS	OxA-8408	S3P
Med	Italy	Gr. Paglicci	23A	AMS C14	Gravettian	31716	493	3 MIS		S3P
South	France	Roc de Combe [Nadaillac]	7a	AMS C14	Aurignacian I	31836	812	3 MIS	OxA-1261	S3P
South	France	Abri Pataud	5	C14	Gravettian [Perigordian IV]	31900	243	3 MIS	GrN-4634	S3P
South	France	La Ferrassie	D2x	AMS C14	Gravettian [Perigordian Va]	31909	1076	3 MIS	OxA-402	S3P
South	France	Grotte du Renne, Arcy-sur-Cure	XII	C14	Late Middle Palaeolithic	31944	1845	3 MIS	GrN-2376	S3P
Med	Italy	Gr. La Cala	QIV	C14	Gravettian [Perigordian V]	31976	2809	3 MIS	F-23	S3P
Med	Spain	Cariguela	??	TL	Mousterian	32000		3 MIS	TB-1	S3P
Med	Italy	Gr. di Sant'Agostino	red [mixed] layer	ESR: LU	Mousterian	32000	7000	3 MIS	**	S3P
North	U.K.	Paviland Cave [Goat's	occup. horizon	AMS C14	?Aurignacian	32013	1067	3 MIS	OxA-366	S3P

		Hole]						3		
Central	Germany	Das Geissenklosterle	Is [sq. 130]	AMS C14	Gravettian	32020	956	MIS 3	OxA-5227	S3P
South	France	Roche a Pierrot [St.-Cesaire]	6 [Ejo sup.]*	TL	"archaic" Aurignacian	32100	3000	MIS 3	**	S3P
Med	Portugal	Pego do Diabo	2 (base) [2b]	C14	Dufour Aurignacian	32106	1162	MIS 3	ICEN-732	S3P
	France	La Salpetriere [Remoulins]	G5	C14	[Ancient] Aurignacian	32119	1223	MIS 3	Ly-1804	S3P
North	U.K.	Kent's Cavern	cave earth A2	C14	Aurignacian	32185	897	MIS 3	GrN-6201	S3P
South	France	Les Pecheurs [Casteljau]	F13	C14	Aurignacian 0/Mousterian	32238	1355	MIS 3	Ly-2341	S3P
North	U.K.	Robin Hood's Cave	tip E/sharp scree USB	C14	Early Upper Palaeolithic	32240	1628	MIS 3	BM-602	S3P
South	France	Abri Pataud	5	AMS C14	Gravettian [Perigordian IV]	32246	1245	MIS 3	OxA-169	S3P
Central	Austria	Krems-Galgenberg	hauptkulturschicht in Hanglage	C14	Aurignacian?	32260	963	MIS 3	KN-4141	S3P
	France	Gr de La Baume [Gigny sur Suran]	8	C14	Levall. [laminar] Mousterian	32265	1439	MIS 3	Ly-789*	S3P
Central	Austria	Krems-Galgenberg	hauptkulturschicht in Hanglage	C14	Aurignacian?	32391	1010	MIS 3	KN-3941	S3P
South	France	La Ferrassie	K4	AMS C14	Aurignacian II	32409	1169	MIS 3	OxA-409	S3P
Central	Germany	Weinberghohlen [Mauern 2]	D [-1.5m] [2*]	C14	Gravettian	32428	746	MIS 3	GrN-6059	S3P
South	France	Solutre [O/A]	6 [sondage B]	C14	Gravettian	32434	1191	MIS 3	Ly-312	S3P
Med	Spain	Abric Romani	2	C14	Archaic Aurignacian	32471	944	MIS 3	NZA-1817	S3P
Med	Italy	Gr. Paglicci	22F4	AMS C14	Gravettian	32478	854	MIS 3		S3P
Central	Germany	Wildscheuer	III	AMS C14	Aurignacian	32496	823	MIS 3	OxA-7391	S3P
South	France	Roc de Combe [Nadaillac]	5	AMS C14	Aurignacian	32503	947	MIS 3	OxA-1441	S3P
	France	Gr. Cosquer [Cap	parietal art	AMS C14	"Signe ovale"	32518	827	MIS	GifA-96074	S3P

		Morgiou, Marseille]						3		
North	Belgium	L'Hermitage [Huccorgne]	4	C14	Gravettian [Perigordian Vc]	32540	816	MIS 3	CAMS-589	S3P
South	France	La Ferrassie	K3d	C14	Aurignacian III	32542	1517	MIS 3	Gif-2427	S3P
Med	Spain	Cueva Morin	7	C14	Archaic Aurignacian	32553	995	MIS 3	SI-955	S3P
North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	32581	886	MIS 3	OxA-7084	S3P
Central	Germany	Das Geissenklosterle	It [sq. 120]	AMS C14	Gravettian	32586	847	MIS 3	OxA-5228	S3P
South	France	La Rochette [St Leon sur Vezere]	5c	C14	Aurignacian I	32587	765	MIS 3	GrN-4529	S3P
South	France	Pech de l'Aze II [Carsac]	3 ["travertine"]	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	32600	3800	MIS 3	632C	S3P
North	U.K.	Pontnewydd Cave		AMS C14	FAUNA	32609	792	MIS 3	OxA-4372	S3P
Central	Austria	Willendorf II	below 6 / C2	C14	Gravettian	32641	815	MIS 3	GrN-17804	S3P
Med	Spain	Cova Negra	V [IV]	C14	Mousterian	32655	5931	MIS 3	?	S3P
Central	Germany	Hohle[r] Fels	I?	AMS C14	Upper Palaeolithic [from "Magdalenian"!]	32669	790	MIS 3	OxA-4597	S3P
	France	Vergisson, La Falaise	locus 3: fissure fill	C14	FAUNA/?Neanderthal remains	32674	848	MIS 3	Ly-1177	S3P
	France	Brassempouy [Grande Galerie 2]	2f sup. [square Q5]	C14	Aurignacian	32685	784	MIS 3	Gif-8173	S3P
Central	Germany	Hohle[r] Fels	??	AMS C14	[Gravettian]	32687	877	MIS 3	OxA-4980	S3P
South	France	Pech de l'Aze II [Carsac]	3 ["travertine"]	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	32700	4100	MIS 3	632A	S3P
North	U.K.	Kent's Cavern		AMS C14	FAUNA/Early Upper Palaeolithic	32706	815	MIS 3	OxA-4438	S3P
Med	Portugal	Columbeira, Gruta Nova	20 (=8)	C14	Mousterian	32712	998	MIS 3	Gif-2704	S3P
Med	Gibraltar	Gorham's Cave	context 15, combustion zone	AMS C14	?Early Upper Palaeolithic	32744	728	MIS 3	OxA-7792	S3P
North	U.K.	Kent's Cavern	cave earth A2	C14	Aurignacian	32750	762	MIS	GrN-6202	S3P

North	U.K.	Pontnewydd Cave		AMS C14	FAUNA	32767	745	3 MIS	OxA-4369	S3P
	France	Grotte de Courau (Grotte Saucet) [St-Pe-de-Bigorre]	??	C14	"Upper Palaeolithic"	32778	827	3 MIS	Ly-2858	S3P
South	France	La Ferrassie	I1	C14	Aurignacian III	32782	699	3 MIS	Gif-4271	S3P
South	France	Le Piage [Fajoles]	F	C14	Aurignacian I	32785	988	3 MIS	Gif-5027	S3P
North	U.K.	Little Hoyle Cave		AMS C14	FAUNA	32787	867	3 MIS	OxA-1492	S3P
Med	Gibraltar	Gorham's Cave	D	C14	?Aurignacian	32800	676	3 MIS	GrN-1455	S3P
	France	A. Brugas [?O/A] [Vallabrix]	4	C14	Quina Mousterian	32816	891	3 MIS	Ly-2351	S3P
South	France	La Ferrassie	G1 sagg[ital]	AMS C14	Aurignacian III/IV	32818	886	3 MIS	OxA-405	S3P
North	U.K.	Pontnewydd Cave		AMS C14	FAUNA	32829	857	3 MIS	OxA-1025	S3P
Med	Spain	Rascano Cave	7	C14	?Ancient Aurignacian	32834	1267	3 MIS	BM-1456	S3P
	France	Sirejol [Gignac]	fill of "fossiliferous clayey lumps"	C14	FAUNA [& Palaeolithic?]	32850	1466	3 MIS	Ly-767	S3P
North	U.K.	Kent's Cavern		AMS C14	FAUNA/Early Upper Palaeolithic	32895	669	3 MIS	OxA-5694	S3P
	France	Gr de Sanglier [?Reilhac, Lot]		AMS C14	?FAUNA [?pre-Magdalenian]	32896	797	3 MIS	OxA-5267	S3P
South	France	La Rochette [St Leon sur Vezere]	4	C14	Aurignacian II	32903	635	3 MIS	GrN-4530	S3P
North	U.K.	Paviland Cave [Goat's Hole]	occup. horizon	AMS C14	?Aurignacian	32908	625	3 MIS	OxA-7789	S3P
Central	Germany	Hohle[r] Fels	IIC	AMS C14	Gravettian	32916	661	3 MIS	OxA-4599	S3P
North	U.K.	Pontnewydd Cave		AMS C14	FAUNA	32930	659	3 MIS	OxA-4368	S3P
Central	Austria	Krems-Galgenberg	oberste funschichte	C14	Aurignacian?	32931	1050	3 MIS	GrN-15643	S3P

Med	Portugal	Foz do Enxarrique	C	U-series [Th/U]	Mousterian	32938	1055	MIS 3	SMU-225	S3P
South	France	Roc de Combe [Nadaillac]	7a	AMS C14	Aurignacian I	32957	742	MIS 3	OxA-1442	S3P
South	France	Grotte Chauvet	Echantillon 7	C14	"Palaeolithic" ["sols galerie Megaceros"]	32960	629	MIS 3	Ly-6878	S3P
Central	Germany	Lommersum	IIc-8	C14	Early Aurignacian	32980	828	MIS 3	Pta-3079	S3P
North	U.K.	Little Hoyle Cave		AMS C14	FAUNA	33012	732	MIS 3	OxA-1028	S3P
North	U.K.	Soldier's Hole	spit 13	AMS C14	FAUNA	33013	1053	MIS 3	OxA-692	S3P
Med	Gibraltar	Gorham's Cave	context 13a, combustion zone	AMS C14	?Early Upper Palaeolithic	33033	756	MIS 3	OxA-7110	S3P
Med	Gibraltar	Gorham's Cave	context 9 [?=D], combustion zone	AMS C14	Aurignacian[?]	33046	706	MIS 3	OxA-7077	S3P
	France	A. Sabourin [Dousse]	cultural layer	C14	Mousterian	33056	783	MIS 3	Ly-2753	S3P
Central	Germany	Das Geissenklosterle	It [sq. 99]	AMS C14	Gravettian	33079	610	MIS 3	OxA-4593	S3P
Med	Italy	Gr. Paglicci	24A1	AMS C14	Dufour Aurignacian	33079	705	MIS 3	UtC-	S3P
	France	Abri Caminade [Caneda]	lower layer	C14	Aurignacian I	33082	531	MIS 3	GrN-1491*	S3P
Central	Germany	Das Geissenklosterle	It [sq. 33]	AMS C14	Gravettian	33086	612	MIS 3	OxA-5706	S3P
Central	Germany	Das Geissenklosterle	It [sq. 130]	AMS C14	Gravettian	33086	595	MIS 3	OxA-4592	S3P
	France	Gr. St-Marcel [d'Ardeche] [Bidon]	E [-2.3m]	C14	Mousterian	33090	700	MIS 3	Ly-2276	S3P
North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	33092	597	MIS 3	OxA-6935	S3P
Central	Austria	Krems-Galgenberg	hauptkulturschicht in Hanglage	C14	Aurignacian?	33104	601	MIS 3	KN-3940*	S3P
	France	Jaurens [Nespouls]	clay cave floor	C14	FAUNA [including hominid tooth]	33109	1416	MIS 3	Ly-359	S3P
North	U.K.	Paviland Cave [Goat's		AMS C14	FAUNA/Early Upper Palaeolithic	33113	613	MIS 3	OxA-6933	S3P

		Hole]						3		
Central	Germany	Lommersum	IIc-6	C14	Early Aurignacian	33115	519	MIS 3	Pta-2918	S3P
South	France	Abri Pataud	7	C14	"evolved Aurignacian"	33116	604	MIS 3	GrN-3105	S3P
	France	Les Pecheurs [Casteljau]	F11-12	C14	Aurignacian 0	33116	849	MIS 3	Ly-2338	S3P
North	U.K.	West Pin Hole		AMS C14	FAUNA	33118	595	MIS 3	OxA-5803	S3P
Central	Germany	Lommersum	IIc-7	C14	Early Aurignacian	33135	584	MIS 3	Pta-2912	S3P
Med	Italy	Gr. La Cala	tg.14	AMS C14	Uluzzian	33138	493	MIS 3	OxA-6265	S3P
Central	Germany	Weinberghohlen [Mauern 2]	-0.7m [2*]	C14	Gravettian	33145	631	MIS 3	GrN-5000	S3P
North	Belgium	Trou Walou	C6C	?	Aurignacian	33160	698	MIS 3	Lv-1592	S3P
Central	Germany	Hohle[r] Fels	??	AMS C14	[Gravettian]	33191	718	MIS 3	OxA-5007	S3P
Central	Germany	Lommersum	IIc-8	C14	Early Aurignacian	33206	716	MIS 3	Pta-2937	S3P
North	U.K.	Leadenhall Street, London	?	C14	??	33214	582	MIS 3	GrN-4630	S3P
	France	Jaurens [Nespouls]	clay cave floor	C14	FAUNA [including hominid tooth]	33225	715	MIS 3	Ly-1939	S3P
Med	Spain	Mallaetes Cave	XII	C14	Aurignacian II	33230	725	MIS 3	KN-1926	S3P
Central	Austria	Krems-Galgenberg	hauptkulturschicht	[AMS] C14	Aurignacian?	33269	797	MIS 3	ETH-6023	S3P
North	U.K.	Soldier's Hole	spit 13	AMS C14	FAUNA	33275	779	MIS 3	OxA-2471	S3P
Med	Spain	Zafarraya Cave	I [3-7]	C14	Late Mousterian	33279	771	MIS 3	Gif-9140-II	S3P
South	France	Grande Grotte, Arcy-sur-Cure	??	[AMS] C14	"Upper Palaeolithic" ["Gravettian"?]	33281	870	MIS 3	??	S3P
Med	Spain	Labeko Koba	IX (middle)	C14	Chatelperronian	33298	813	MIS 3	Ua-3325	S3P
Med	Gibraltar	Gorham's Cave	context 9 [?=D], combustion zone	AMS C14	Aurignacian[?]	33310	810	MIS	OxA-7075	S3P

Central	Austria	Krems-Galgenberg	hauptkulturschicht in Hanglage	C14	Aurignacian?	33322	807	3 MIS	KN-3942	S3P
	France	Gr de Hyenes, Brassempouy	level 2DD [square BD4]	C14	"Ancient Aurignacian"	33323	856	3 MIS	Gif-9031	S3P
South	France	Les Pecheurs [Casteljau]	locus 1/2	C14	Aurignacian 0	33324	906	3 MIS	Ly-2340	S3P
South	France	Roc de Combe [Nadaillac]	1c	AMS C14	??	33329	836	3 MIS	OxA-1256	S3P
North	Belgium	Trou Walou	C6C	?	Aurignacian	33333	842	3 MIS	Lv-1587	S3P
North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	33337	829	3 MIS	OxA-6925	S3P
South	France	Gr. de Latrone [Ste. Anastasie]	Basal soil from Russan pit	C14	FAUNA/art	33338	1072	3 MIS	Ly-1966	S3P
North	Switzerland	Schnurenloch	7c [-2.5-3.5m]	C14	?Late Middle Palaeolithic	33344	834	3 MIS	GrN-4895	S3P
Med	Portugal	Figueira Brava Cave	lower level	C14	Mousterian	33374	854	3 MIS	ICEN-386	S3P
Central	Germany	Wildscheuer	III	AMS C14	Aurignacian	33374	854	3 MIS	OxA-6807	S3P
South	France	Combe Grenal [Domme]	2	C14	Mousterian	33387	928	3 MIS	GrN-4311	S3P
	France	Gr de La Baume [Gigny sur Suran]	8	C14	Levall. [laminar] Mousterian	33389	1494	3 MIS	Ly-566	S3P
North	U.K.	Kent's Cavern		AMS C14	FAUNA/Early Upper Palaeolithic	33422	908	3 MIS	OxA-6108	S3P
Med	Italy	Gr. La Cala [front part: "atrio"]	16-10 [underlies Gravettian level Q]	C14	early Aurignacian	33426	931	3 MIS	F-70	S3P
Med	Spain	Reclau Viver	T III	AMS C14	Aurignacian I	33431	905	3 MIS	OxA-3726	S3P
South	France	Le Piage [Fajoles]	??	C14	"Upper Palaeolithic"	33466	944	3 MIS	??	S3P
	France	Jaurens [Nespouls]	clay cave floor	C14	FAUNA [including hominid tooth]	33482	943	3 MIS	Ly-892	S3P
	France	Esquicho-Grapaou	BR1*	C14	Aurignacian 0/I	33540	1389	3 MIS	MC-983	S3P
Med	Spain	Cova Beneito	basal [X (D1)]	C14	Mousterian	33568	994	3 MIS	?	S3P

Med	Portugal	Salemas [sima]	lower level [1]	C14	Mousterian	33632	1180	3 MIS	ICEN-366	S3P
Med	Gibraltar	Gorham's Cave	context 9 [?=D], combustion zone	AMS C14	Aurignacian[?]	33641	1050	3 MIS	OxA-7074	S3P
South	France	Grotte Chauvet	art	AMS C14	bison	33679	1057	3 MIS	GifA-95128	S3P
Med	Italy	Gr. Breuil	3	ESR: EU	Mousterian	33700	3500	3 MIS	**	S3P
South	France	Roche a Pierrot [St.-Cesaire]	8 [Ejop sup.]*	TL	Chatelperronian	33700	5400	3 MIS	GifTH-103	S3P
Med	Gibraltar	Gorham's Cave	context 9 [?=D], combustion zone	AMS C14	Aurignacian[?]	33705	1094	3 MIS	OxA-7076	S3P
North	U.K.	Paviland Cave [Goat's Hole]	occup. horizon	AMS C14	?Aurignacian	33717	2200	3 MIS	OxA-365	S3P
North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	33768	1133	3 MIS	OxA-6923	S3P
South	France	Pech de l'Aze II [Carsac]	3 ["travertine"]	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	33800	4200	3 MIS	632D	S3P
Central	Poland	Oblazowa 1	VIII/IX	AMS C14	Gravettian [Eastern]	33855	1232	3 MIS	OxA-4585	S3P
Med	Spain	Jarama VI	2	C14	Mousterian	33878	3241	3 MIS	?	S3P
South	France	Pech de l'Aze II [Carsac]	3 ["travertine"]	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	33900	3400	3 MIS	632B	S3P
Central	Belgium	Trou Walou	C5A	?	Reworked	33950	1198	3 MIS	Lv-1557	S3P
North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	33972	1224	3 MIS	OxA-6930	S3P
Central	Germany	Wildscheuer	III	AMS C14	Aurignacian	33980	1396	3 MIS	OxA-7499	S3P
Central	Germany	Hohle[r] Fels	III	AMS C14	Upper Palaeolithic [Gravettian]*	34027	1064	3 MIS	OxA-4601	S3P
Med	Portugal	Lapa dos Furos	4 [pre-Mousterian]	C14	sterile [pre-Mousterian]	34030	1267	3 MIS	ICEN-472	S3P
Med	Portugal	Foz do Enxarrique	C	U-series [Th/U]	Mousterian	34088	800	3 MIS	SMU-226	S3P
Med	Portugal	Foz do Enxarrique	C	U-series [Th/U]	Mousterian	34093	920	3 MIS	SMU-224	S3P

Central	Austria	Willendorf II	5 / C2 [echantillon IV II, level 5]	C14	Gravettian	34126	1328	MIS 3	GrN-11193	S3P
Med	Spain	Ruso [I]	5a	C14	Aurignacian	34184	1678	MIS 3	B-70813	S3P
Central	Austria	Willendorf II	1? / D3? [*echantillon II, level 4]	C14	?Aurignacian/Early Upper Palaeolithic	34187	269	MIS 3	GrN-1287	S3P
South	France	Pech de l'Aze II [Carsac]	3 ["travertine"]	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	34200	4100	MIS 3	632C	S3P
Med	Spain	Labeko Koba	V	C14	ancient Aurignacian	34219	1258	MIS 3	Ua-3322	S3P
Central	Germany	Das Geissenklosterle	[IIa]	C14	Aurignacian I	34225	1230	MIS 3	H-4147-3346	S3P
	France	Sirejol [Gignac]	fill of "fossiliferous clayey lumps"	C14	FAUNA [& Palaeolithic?]	34237	1877	MIS 3	Ly-1225	S3P
Central	Belgium	Trou Magrite	2 base	C14	early Aurignacian	34528	2727	MIS 3	GX-18538G	S3P
Central	Austria	Krems-Galgenberg	hauptkulturschicht in Hanglage	C14	Aurignacian?	34531	744	MIS 3	GrN-15641	S3P
Central	Belgium	Trou Al'Wesse	? (old excavation)	AMS C14	Aurignacian	34560	1139	MIS 3	OxA-7496 (Lyon-592)	S3P
Central	Germany	Vogelherd Cave	IV	C14	Aurignacian II	34566	945	MIS 3	H-4053-3211	S3P
Central	Belgium	Maisieres-Canal	occup. Horizon	C14	Gravettian	34568	2396	MIS 3	Lv-304/2	S3P
South	France	Grotte du Renne, Arcy-sur-Cure	VII	C14	Aurignacian [II]	34614	427	MIS 3	GrN-1717	S3P
South	France	La Quina Y-Z [Villebois la Valette]	1	C14	Aurignacian I	34659	593	MIS 3	GrN-1489	S3P
Central	Belgium	Maisieres-Canal	palaeosol	C14	?Gravettian	34659	527	MIS 3	GrN-5690	S3P
South	France	Grotte Chauvet	art	AMS C14	rhino [opposed pair: right]	34698	687	MIS 3	GifA-95133	S3P
South	France	Les Cottes [St. Pierre de Maille]	E1	C14	Aurignacian I	34698	597	MIS 3	GrN-4258	S3P
South	France	Pech de l'Aze II [Carsac]	3 ["travertine"]	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	34700	3600	MIS 3	632B	S3P
South	France	Pech de l'Aze II	3 ["travertine"]	ESR: LU	Ferrassie Mousterian [or Typical	34800	4400	MIS 3	632D	S3P

		[Carsac]			Mousterian enriched in racloirs]					
South	France	Les Cottes [St. Pierre de Maille]	E2	C14	Aurignacian I	34808	486	MIS 3	GrN-4296	S3P
North	U.K.	Pin Hole Cave	70/7'-0" (Deeper than Upper Palaeolithic)	AMS C14	FAUNA/Early Upper Palaeolithic	34813	584	MIS 3	OxA-3791	S3P
Central	Belgium	Trou Magrite	4a	AMS C14	Mousterian / Transitional	34818	739	MIS 3	Cams-10358	S3P
South	France	Grotte Chauvet	art	AMS C14	rhino [opposed pair: left]	34852	685	MIS 3	GifA-95126	S3P
South	France	Abri Pataud	12	C14	Aurignacian 0	34864	591	MIS 3	GrN-4310	S3P
Med	Portugal	Figueira Brava Cave	indet. level [2, according to Zilhao [1998]]	C14	Mousterian	34878	787	MIS 3	ICEN-387	S3P
South	France	La Quina Y-Z [Villebois la Valette]	3	C14	final [Quina] Mousterian	34902	527	MIS 3	GrN-4449	S3P
	France	Les Rivaux, Loc. 1 [Espaly-St-Marcel]	base B unit [levels 312 & 316]	C14	Mousterian/FAUNA	34903	2139	MIS 3	Ly-1988	S3P
North	U.K.	Robin Hood's Cave		AMS C14	FAUNA/Early Upper Palaeolithic	34903	593	MIS 3	OxA-5802	S3P
South	France	Roche a Pierrot [St.-Cesaire]	6 [Ejo sup.]*	TL	"archaic" Aurignacian	34912	3615	MIS 3	GifTH-96	S3P
Central	Austria	Willendorf II	4 / C4	AMS C14	Aurignacian	34935	458	MIS 3	GrA-501	S3P
Central	Germany	Wildscheuer	III	AMS C14	Aurignacian	34952	683	MIS 3	OxA-7392	S3P
Central	Austria	Krems-Galgenberg	hauptkulturschicht in Hanglage	C14	Aurignacian?	34963	525	MIS 3	GrN-15642	S3P
South	France	Les Cottes [St. Pierre de Maille]	E3	C14	Aurignacian I	34979	539	MIS 3	GrN-4509	S3P
Med	Portugal	Almonda [EVS]	EVS Cone	U-Th	Mousterian	35000	2000	MIS 3	SMU-231E1	S3P
Med	Gibraltar	Gorham's Cave	same area & elevation as OxA-6075	OSL	?Mousterian	35000	7000	MIS 3	MacGor-3	S3P
Central	Germany	Hohle[r] Fels	IV	AMS C14	Upper Palaeolithic [Gravettian]*	35001	692	MIS 3	OxA-4600	S3P
South	France	Roc de Combe [Nadaillac]	10	AMS C14	early Chatelperronian	35001	872	MIS 3	OxA-1264	S3P
South	France	La Ferrassie	K4	C14	Aurignacian II	35009	481	MIS 3	Gif-4277	S3P

Central	Austria	Krems-Galgenberg	hauptkulturschicht	[AMS] C14	Aurignacian?	35011	556	3 MIS	ETH-6025	S3P
South	France	La Quina Y-Z [Villebois la Valette]	1	C14	Aurignacian I	35107	526	3 MIS	GrN-1493	S3P
Central	Germany	Das Geissenklosterle	IIb	C14	Aurignacian I	35108	906	3 MIS	Pta-2361	S3P
Med	Italy	Serino	hearth	C14	early Aurignacian	35114	817	3 MIS	F-108	S3P
North	U.K.	Pin Hole Cave		AMS C14	Early Upper Palaeolithic*	35168	696	3 MIS	OxA-3405	S3P
South	France	Grotte Chauvet	art	AMS C14	bison	35191	2260	3 MIS	GifA-95155	S3P
Central	Austria	Krems-Galgenberg	hauptkulturschicht	[AMS] C14	Aurignacian?	35221	627	3 MIS	ETH-6024	S3P
North	U.K.	Kent's Cavern	pink cave-earth	AMS C14	FAUNA/"Early Upper Palaeolithic"?	35276	1078	3 MIS	OxA-1029	S3P
North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	35276	1078	3 MIS	OxA-6931	S3P
Med	Italy	Abri Fumane	A2 [outer] [hearth S9]	AMS C14	Dufour Aurignacian	35393	698	3 MIS	UtC-2044	S3P
North	U.K.	Hyaena Den		AMS C14	FAUNA	35447	873	3 MIS	OxA-5701	S3P
Central	Belgium	Maisieres-Canal	occup. Horizon	C14	Gravettian	35475	2630	3 MIS	Lv-304/1	S3P
Central	Germany	Lommersum	IIc-4	C14	Early Aurignacian	35482	2276	3 MIS	H-4745-4144	S3P
Central	Germany	Das Geissenklosterle	II	TL	Aurignacian I	35600	3900	3 MIS	GK-6	S3P
South	France	Roche a Pierrot [St.-Cesaire]	8 [Ejop sup.]*	TL	Chatelperronian	35600	4600	3 MIS	GifTH-82	S3P
Central	Germany	Das Geissenklosterle	IV	ESR	Mousterian	35700	4800	3 MIS	92127a	S3P
Med	Spain	Zafarraya Cave	I [3-7]	TL	Late Mousterian	35774	3827	3 MIS	Gif-9140-II	S3P
Med	Spain	Zafarraya Cave	I [8]	TL	Late Mousterian	35774	3827	3 MIS	Gif/LSM-9140-I	S3P
	France	Sirejol [Gignac]	fill of "fossiliferous clayey lumps"	C14	FAUNA [& Palaeolithic?]	35800	2297	3 MIS	Ly-614	S3P

South	France	Grotte du Renne, Arcy-sur-Cure	XI	AMS C14	Late Middle Palaeolithic	35825	1207	3 MIS	OxA-3462	S3P
Med	Portugal	Columbeira, Gruta	7	Th/U	Mousterian	35876	27299	3 MIS	SMU-235E1	S3P
Med	Spain	Nova Valina	IV [a.k.a. "1"?]	C14	Chatelperronian	35905	2778	3 MIS	GrN-20833	S3P
	France	Perte de Bramarie [Caniac du Causse]	??	C14	FAUNA [& archaeology?]	35969	2271	3 MIS	Ly-1294	S3P
Central	Austria	Willendorf II	5 / C2	C14	Gravettian	36131	3308	3 MIS	H-246-231	S3P
Central	Austria	Willendorf II	4 / C4	C14	Aurignacian	36158	2186	3 MIS	H-249-1276	S3P
Med	Spain	Labeko Koba	VII (top)	C14	ancient Aurignacian	36168	1707	3 MIS	Ua-3321	S3P
North	U.K.	Bacon Hole		AMS C14	FAUNA	36180	1856	3 MIS	OxA-6022	S3P
Med	Spain	Cueva Morin	7/6	C14	Archaic Aurignacian	36184	1702	3 MIS	SI-954	S3P
Med	Spain	Castillo	18C	ESR [EU/LU]	Archaic Aurignacian*	36200	4100	3 MIS	**	S3P
Central	Germany	Das Geissenklosterle	[IIa]	C14	Aurignacian I	36213	1636	3 MIS	H-4279-3534	S3P
Med	Italy	Abri Fumane	D3b	AMS C14	Dufour Aurignacian	36276	1844	3 MIS	UtC-1775	S3P
Med	Spain	La Flecha	??	C14	post-Mousterian	36297	1706	3 MIS	?	S3P
North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	36298	1688	3 MIS	OxA-6924	S3P
South	France	Roche a Pierrot [St.-Cesaire]	8 [Ejop sup.]*	TL	Chatelperronian	36300	2700	3 MIS	**	S3P
	France	Esquicho-Grapaou	SLC1A	C14	Aurignacian 0	36311	2072	3 MIS	MC-1181	S3P
	France	Brassempouy [Grande Galerie 2]	2g sup. [square Q5]	C14	Chatelperronian	36339	1683	3 MIS	Gif-8172	S3P
	France	Gr de Hyenes, Brassempouy	2b [square BD4/5/6]	C14	Aurignacian	36342	1674	3 MIS	Gif-	S3P
Central	Germany	Lommersum	IIc-5	C14	Early Aurignacian	36358	1604	3 MIS	Pta-2753	S3P

Central	Germany	Hohlenstein-Stadel [IV]	[?IV]	C14	Early Aurignacian	36365	1778	MIS 3	H-3800-3025	S3P
South	France	Grotte du Renne, Arcy-sur-Cure	VII	C14	Aurignacian [II]	36382	1811	MIS 3	Ly-2162	S3P
	France	Esquicho-Grapaou	SLC1A	C14	Aurignacian 0	36403	1831	MIS 3	MC-1272	S3P
Med	Spain	Zafarraya Cave	I [8]	C14	Late Mousterian	36452	1620	MIS 3	Gif/LSM-9140-I	S3P
Central	Germany	Das Geissenklosterle	IIb	C14	Aurignacian I	36462	1692	MIS 3	Pta-2770	S3P
	France	Gr de Hyenes, Brassempouy	2a [square BD4/5/6]	C14	Aurignacian	36463	1620	MIS 3	Gif-	S3P
Central	Austria	Krems-Galgenberg	hauptkulturschicht	C14	Aurignacian?	36467	1596	MIS 3	GrN-16135	S3P
	France	Esquicho-Grapaou	SLC1A	C14	Aurignacian 0	36468	1811	MIS 3	MC-2160	S3P
Med	Spain	La Guelga	lower black level [cave interior]	C14	Aurignacian	36471	1897	MIS 3	GrN-18256	S3P
Central	Germany	Lommersum	IIc-3	C14	Early Aurignacian	36475	1672	MIS 3	H-4148-3347	S3P
South	France	Abri Pataud	7	C14	"evolved Aurignacian"	36480	1607	MIS 3	GrN-4531	S3P
South	France	Abri Pataud	8	C14	intermediate Aurignacian	36483	1602	MIS 3	GrN-6163	S3P
	France	A. Dubalen, Brassempouy	2b [square Y4/5]	C14	Chatelperronian	36525	1597	MIS 3	Gif-	S3P
Med	Italy	Abri Fumane	A1	AMS C14	Dufour Aurignacian	36532	1597	MIS 3	UtC-2049	S3P
Med	Italy	Castelcivita	gic	C14	Dufour Aurignacian	36540	1590	MIS 3	F-105	S3P
Central	Germany	Bockstein-Torle	VII	C14	[early] Aurignacian	36541	1605	MIS 3	H-4059-3527	S3P
South	France	Roc de Combe [Nadaillac]	5	AMS C14	Aurignacian	36544	1659	MIS 3	OxA-1259	S3P
South	France	Roc de Combe [Nadaillac]	1a	AMS C14	??	36544	1659	MIS 3	OxA-1254	S3P
South	France	Les Cottes [St. Pierre	G2	C14	Chatelperronian	36549	1596	MIS 3	GrN-4510	S3P

		de Maille]						3		
South	France	Abri Pataud	11	C14	Aurignacian I	36564	1594	MIS 3	GrN-4326	S3P
Med	Italy	Colombo Cave	4	C14	?post-Mousterian	36573	1573	MIS 3	GrN-5215	S3P
South	France	Le Flageolet I [Bezenac]	XI	AMS C14	Aurignacian I	36586	1595	MIS 3	GifA-95538	S3P
Med	Italy	Gr. Breuil	3	ESR: LU	Mousterian	36600	2700	MIS 3	**	S3P
South	France	Roche a Pierrot [St.-Cesaire]	8 [Ejop sup.]*	TL	Chatelperronian	36600	5000	MIS 3	GifTH-95	S3P
South	France	Roche a Pierrot [St.-Cesaire]	8 [Ejop sup.]*	TL	Chatelperronian	36600	4900	MIS 3	GifTH-53	S3P
Central	Germany	Hohlenstein-Stadel IV	Probe 1	AMS C14	[early Aurignacian]	36605	1551	MIS 3	ETH-2877	S3P
	France	Montagne de Girault [Genay]	tranchee 7	C14	Mousterian	36609	1634	MIS 3	Ly-3036	S3P
Med	Portugal	Oliveira Cave [Almonda cave system]	8	AMS C14	Mousterian	36635	1569	MIS 3	GrA-10200	S3P
Central	Germany	Lommersum	IIc-2	C14	Early Aurignacian	36636	1563	MIS 3	GrN-6699	S3P
North	U.K.	Torbryan 6 Cave	aeolian silts	AMS C14	FAUNA	36669	1506	MIS 3	OxA-3896	S3P
North	U.K.	Pin Hole Cave	-2'6" (Within Blade distribution - Jacobi et al. 1998).	AMS C14	FAUNA/Early Upper Palaeolithic	36679	1608	MIS 3	OxA-1206	S3P
Med	Italy	Abri Fumane	A2 [outer]	AMS C14	Dufour Aurignacian	36721	1469	MIS 3	UtC-2047	S3P
North	U.K.	Tornewton Cave	reindeer stratum	AMS C14	FAUNA	36751	1448	MIS 3	OxA-3892	S3P
South	France	Gr de Hyenes, Brassempouy	2a [square BC6/5-BD6]	C14	Aurignacian	36758	1441	MIS 3	Gif-	S3P
North	U.K.	Tornewton Cave	reindeer stratum	AMS C14	FAUNA	36768	1429	MIS 3	OxA-3893	S3P
North	U.K.	Bench Quarry "Tunnel" cavern	cave-earth	AMS C14	Early Upper Palaeolithic	36816	1612	MIS 3	OxA-4984	S3P
Central	Germany	Das Geissenklosterle	IIa [sq. 58]	AMS C14	Aurignacian I	36837	1405	MIS 3	OxA-5708	S3P
Med	Italy	Riparo Mochi	G	AMS C14	Dufour Aurignacian	36873	1347	MIS	OxA-3588	S3P

North	U.K.	Bench Quarry "Tunnel" cavern	cave-earth	AMS C14	Early Upper Palaeolithic	36875	1655	3 MIS	OxA-5961	S3P
Central	Austria	Willendorf II	4 / C4 [*echantillon II, level 4]	C14	Aurignacian	36877	1390	3 MIS	GrN-1273	S3P
Central	Belgium	Trou Al'Wesse	Associated Aurignacian	AMS C14	Aurignacian	36879	1363	3 MIS	Lyon-212 (OxA)	S3P
	France	Gr. Tournal (or Grande Grotte de Bize) [Bize-Minervois]	??	?TL	Mousterian	36902	4152	3 MIS	Gif-	S3P
South	France	Grotte Chauvet	art	AMS C14	rhino [opposed pair: right]	36937	1353	3 MIS	GifA-95132	S3P
Med	Italy	Abri Fumane	D6	AMS C14	Dufour Aurignacian	36939	1284	3 MIS	UtC-2046	S3P
	France	Jaurens [Nespouls]	clay cave floor	C14	FAUNA [including hominid tooth]	36950	1787	3 MIS	Ly-1938	S3P
Central	Poland	Oblazowa 1	VIII	AMS C14	Gravettian [Eastern]	36956	1310	3 MIS	OxA-4584	S3P
Med	Gibraltar	Gorham's Cave	context 24, remnant combustion zone	AMS C14	Transitional [Middle Palaeolithic-Upper Palaeolithic]	36970	1260	3 MIS	OxA-7857	S3P
Med	Italy	Abri Fumane	D3b	AMS C14	Dufour Aurignacian	36999	1236	3 MIS	UtC-2045	S3P
South	France	Les Cottes [St. Pierre de Maille]	I1	C14	Mousterian	36999	1236	3 MIS	GrN-4334	S3P
North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	37031	1296	3 MIS	OxA-6936	S3P
North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	37034	1450	3 MIS	OxA-6932	S3P
South	France	Abri Pataud	11	C14	Aurignacian I	37169	1151	3 MIS	GrN-4309	S3P
Central	Germany	Wildscheuer	III	AMS C14	Aurignacian	37169	1247	3 MIS	OxA-7390	S3P
Med	Spain	Valina	IV [a.k.a. "1"?]	AMS C14	Chatelperronian	37177	986	3 MIS	GrA-3014	S3P
Central	Austria	Krems-Galgenberg	probe aus wechselfeuchter Phase - obergrenze palaoboden	[AMS] C14	Aurignacian?	37204	998	3 MIS	ETH-6026	S3P
Central	Germany	Das Geissenklosterle	IIb	C14	Aurignacian I	37244	1084	3 MIS	Pta-2116	S3P

								3		
North	U.K.	Hyaena Den		AMS C14	FAUNA	37256	1227	MIS 3	OxA-5702	S3P
Med	Italy	Castelcivita	tg.29-30	C14	Dufour Aurignacian	37303	869	MIS 3		S3P
Med	Italy	Abri Fumane	A2 [outer] [hearth S10]	AMS C14	Dufour Aurignacian	37334	1023	MIS 3	UtC-2051	S3P
South	France	Abri Pataud	7	C14	"evolved Aurignacian"	37343	1059	MIS 3	GrN-3117	S3P
North	U.K.	Pontnewydd Cave		AMS C14	FAUNA	37367	1188	MIS 3	OxA-4371	S3P
South	France	Abri Pataud	7	C14	"evolved Aurignacian"	37381	1213	MIS 3	GrN-3116	S3P
South	France	Roche a Pierrot [St.-Cesaire]	8 [Ejop sup.]*	TL	Chatelperronian	37400	5200	MIS 3	GifTH-54	S3P
Med	Italy	Castelcivita	rsa (upper)	C14	Dufour Aurignacian	37401	1227	MIS 3	F-72	S3P
Med	Italy	Castelcivita	rsa (lower)	C14	Uluzzian	37401	1227	MIS 3	F-71	S3P
Med	Italy	Castelcivita	rsa (upper)	AMS C14	Dufour Aurignacian	37448	1091	MIS 3	Beta-58184/CAMS-4622	S3P
South	France	A. Combe Sauniere [Sarliac-sur-l'Isle]	X	AMS C14	Chatelperronian	37455	1399	MIS 3	OxA-6504	S3P
South	France	Grotte du Renne, Arcy-sur-Cure	VIII	C14	Final Chatelperronian	37457	1935	MIS 3	GrN-2163	S3P
South	France	Grotte du Renne, Arcy-sur-Cure	VIII	C14	Final Chatelperronian	37457	1935	MIS 3	Ly-2163	S3P
South	France	Abri Pataud	12	C14	Aurignacian 0	37499	1102	MIS 3	GrN-4327	S3P
Med	Spain	Zafarraya Cave	D	TL	Late Mousterian	37521	2262	MIS 3	-	S3P
	France	A. Moula [Soyons]	-4.1m	C14	Mousterian	37569	1964	MIS 3	Ly-2488	S3P
Central	Germany	Das Geissenklosterle	IIb [sq. 34]	AMS C14	Aurignacian I	37758	1735	MIS 3	OxA-5162	S3P
North	U.K.	Bacon Hole		AMS C14	FAUNA	37834	1664	MIS	OxA-5699	S3P

3

Central	Poland	Oblazowa 2		AMS C14	non-human?	37837	1766	MIS 3	OxA-3696	S3P
Central	Germany	Das Geissenklosterle	[IIIa]	AMS C14	Aurignacian 0	37865	1527	MIS 3	ETH-8268	S3P
	France	Le Flageolet I [Bezenac]	XI	AMS C14	Aurignacian I	37880	2059	MIS 3	OxA-598	S3P
South	France	Roc de Combe [Nadaillac]	7b	AMS C14	Aurignacian I	37883	1704	MIS 3	OxA-1262	S3P
Central	Belgium	Trou Walou	C7a	?	habitat d'ours	37905	2049	MIS 3	Lv-1641	S3P
	France	Gr. Tournal (or Grande Grotte de Bize) [Bize-Minervois]	C (Sq. K29)	C14	Mousterian	37914	1772	MIS 3	Ly-1676	S3P
Med	Italy	Castelcivita	pie	C14	Uluzzian	37933	1596	MIS 3	F-107	S3P
South	France	Grotte du Renne, Arcy-sur-Cure	XI	C14	Late Middle Palaeolithic	37939	1815	MIS 3	Ly-2164	S3P
	Hungary	Tata	culture layer	C14	Mousterian	37940	1631	MIS 3	GrN-3023	S3P
North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	37954	1722	MIS 3	OxA-7083	S3P
Central	Austria	Salzofenhohle	Red-brown "phosphate earth" [="culture layer"*] from outer chamber	C14	Mousterian/FAUNA	37954	3117	MIS 3	GrN-761	S3P
Med	Spain	Arenillas	II	C14	Aurignacian	37959	1984	MIS 3	GrN-	S3P
Med	Spain	Ermitons Cave	IV	AMS C14	Late Mousterian	37968	1557	MIS 3	OxA-3725	S3P
North	U.K.	Pontnewydd Cave		AMS C14	FAUNA	37979	1554	MIS 3	OxA-6267	S3P
South	France	Abri Pataud	14	C14	Aurignacian 0	37990	1585	MIS 3	GrN-4610	S3P
Central	Germany	Wildscheuer	III	AMS C14	Aurignacian	38023	1579	MIS 3	OxA-7393	S3P
South	France	La Ferrassie	K6	C14	Aurignacian I	38025	1536	MIS 3	GrN-5751	S3P

North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	38026	1589	MIS 3	OxA-6937	S3P
Central	Germany	Das Geissenklosterle	IIa [sq. 48]	AMS C14	Aurignacian I	38036	1519	MIS 3	OxA-5707	S3P
Med	Italy	Riparo Mochi	G	AMS C14	Dufour Aurignacian	38048	1574	MIS 3	OxA-3589	S3P
Central	Germany	Das Geissenklosterle	IIa [sq. 34]	AMS C14	Aurignacian I	38051	1665	MIS 3	OxA-5160	S3P
South	France	Roche a Pierrot [St.-Cesaire]	6 [Ejo sup.]*	TL	"archaic" Aurignacian	38062	4082	MIS 3	GifTH-60	S3P
North	U.K.	Coygan Cave	calcrete 1 [below Mousterian]	C14	pre-Mousterian	38095	1492	MIS 3	GrN-4400	S3P
North	U.K.	Robin Hood's Cave		AMS C14	FAUNA/Early Upper Palaeolithic	38096	1557	MIS 3	OxA-5801	S3P
South	France	Les Cottes [St. Pierre de Maille]	G1	C14	Chatelperronian	38098	1525	MIS 3	GrN-4333	S3P
Central	Germany	Das Geissenklosterle	II	TL	Aurignacian I	38100	2500	MIS 3	GK-4	S3P
Med	Portugal	Gato Preto	??	TL (*average of 2 determinations)	Dufour Aurignacian	38100	3900	MIS 3	BM*	S3P
South	France	Abri Pataud	12	C14	Aurignacian 0	38101	1513	MIS 3	GrN-4719	S3P
Med	Italy	Castelcivita	rpi	AMS C14	Uluzzian	38140	1513	MIS 3	GrN-13985	S3P
Central	Germany	Das Geissenklosterle	[IIIa]	AMS C14	Aurignacian 0	38147	1539	MIS 3	ETH-8269	S3P
South	France	Abri Pataud	14	C14	Aurignacian 0	38148	1510	MIS 3	GrN-4720	S3P
Central	Germany	Lommersum	IIc-1	C14	Early Aurignacian	38163	1518	MIS 3	GrN-6191	S3P
Med	Spain	Cova Beneito	upper [VIII]	AMS C14	Aurignacian*	38167	1649	MIS 3	AA-1388	S3P
Central	Germany	Das Geissenklosterle	II	C14	Aurignacian I	38169	1566	MIS 3	H-4751-4404	S3P
South	France	Grotte du Renne, Arcy-sur-Cure	XII	C14	Late Middle Palaeolithic	38175	1561	MIS 3	GrN-4256	S3P
Central	Belgium	Trou Magrite	2 base	C14	early Aurignacian	38176	2129	MIS 3	GX-18537G	S3P

North	U.K.	Pin Hole Cave	65/4'-0" (Within Blade distribution - Jacobi et al. 1998).	AMS C14	FAUNA/Early Upper Palaeolithic	38186	1536	MIS 3	OxA-3790	S3P
North	U.K.	Picken's Hole, Layer 3		C14	[Early Upper Palaeolithic?]	38197	2754	MIS 3	BM-654	S3P
South	France	Roche a Pierrot [St.-Cesaire]	8 [Ejop sup.]*	TL	Chatelperronian	38200	5300	MIS 3	GifTH-48	S3P
South	France	Roche a Pierrot [St.-Cesaire]	11	TL	Mousterian	38200	3300	MIS 3		S3P
North	U.K.	Hyaena Den		AMS C14	Mousterian	38214	1531	MIS 3	OxA-3277	S3P
Central	Germany	Wildscheuer	III	AMS C14	Aurignacian	38258	1685	MIS 3	OxA-6920	S3P
Central	Austria	Willendorf II	3 / C8 [*echantillon III, level 3]	C14	Aurignacian	38258	1685	MIS 3	GrN-11192	S3P
South	France	Grotte du Renne, Arcy-sur-Cure	VIII	C14	Final Chatelperronian	38260	1487	MIS 3	GrN-1736	S3P
Med	Spain	Mollet Cave	0.6-0.8m	AMS C14	Aurignacian	38260	1529	MIS 3	OxA-3728	S3P
South	France	Grotte du Renne, Arcy-sur-Cure	Xb	AMS C14	Lower Chatelperronian	38290	1519	MIS 3	OxA-3464	S3P
Central	Germany	Das Geissenklosterle	III	TL	Aurignacian 0	38300	5400	MIS 3	GK-8	S3P
Med	Spain	Labeko Koba	IX (base)	C14	Chatelperronian	38313	1712	MIS 3	Ua-3324	S3P
South	France	A. Combe Sauniere [Sarliac-sur-l'Isle]	VIII	AMS C14	Aurignacian	38338	1533	MIS 3	OxA-6507	S3P
Central	Germany	Das Geissenklosterle	[IIIa]	C14	Aurignacian 0	38361	1580	MIS 3	H-5118-4600	S3P
South	France	Abri Caminade [Caneda]	D21	AMS C14	Aurignacian [I]	38366	1575	MIS 3	GifA-97187	S3P
	France	Gr. Tournal (or Grande Grotte de Bize) [Bize-Minervois]	??	?TL	Mousterian	38382	9625	MIS 3	Gif-	S3P
South	France	Le Flageolet I [Bezenac]	XI	AMS C14	Aurignacian I	38434	1610	MIS 3	GifA-95559	S3P
South	France	Esquicho-Grapaou	SLC 1B	C14	Aurignacian 0	38448	2222	MIS 3	MC-2161	S3P

Med	Italy	Abri Fumane	A2 [inner] [hearth S14, level B2]	AMS C14	Dufour Aurignacian	38463	1508	MIS 3	UtC-2690	S3P
Central	Germany	Wildscheuer	III	AMS C14	Aurignacian	38463	1508	MIS 3	OxA-7394	S3P
North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	38473	1525	MIS 3	OxA-6934	S3P
North	U.K.	Bench Quarry "Tunnel" cavern	cave-earth	AMS C14	Early Upper Palaeolithic	38481	1779	MIS 3	OxA-1620	S3P
Med	Spain	L'Arbreda	BE116 [Level I?]	AMS C14	Late Mousterian	38491	1442	MIS 3	AA-3777	S3P
North	U.K.	Little Hoyle Cave		AMS C14	FAUNA	38534	1849	MIS 3	OxA-1491	S3P
South	France	La Quina Y-Z [Villebois la Valette]	3	C14	final [Quina] Mousterian	38543	1400	MIS 3	GrN-4494	S3P
North	U.K.	Pin Hole Cave	-3'9" (Within Blade distribution - Jacobi et al. 1998).	AMS C14	FAUNA/Early Upper Palaeolithic	38552	1641	MIS 3	OxA-1207	S3P
Med	Italy	Gr. Paglicci	24B2-1	AMS C14	Lowest Aurignacian	38555	1467	MIS 3	UtC-	S3P
Med	Spain	Arenillas	II	C14	Aurignacian	38580	1928	MIS 3	GrN-	S3P
Med	Portugal	Lapa dos Furos	4 [pre-Mousterian]	C14	sterile [pre-Mousterian]	38697	1518	MIS 3	ICEN-473	S3P
Central	Germany	Das Geissenklosterle	III	TL	Aurignacian 0	38700	3900	MIS 3	GK-9	S3P
Med	Spain	Valina	IV [a.k.a. "1"?]	C14	Chatelperronian	38700	2022	MIS 3	GrN-17729	S3P
South	France	Abri Pataud	14	C14	Aurignacian 0	38727	1283	MIS 3	GrN-4507	S3P
North	U.K.	Pin Hole Cave	66/4'-0" (Within Blade distribution - Jacobi et al. 1998).	AMS C14	FAUNA/Early Upper Palaeolithic	38757	1293	MIS 3	OxA-3407	S3P
North	U.K.	King Arthur's Cave	mammoth layer	AMS C14	FAUNA	38785	1857	MIS 3	OxA-1564	S3P
South	France	Grotte du Renne, Arcy-sur-Cure	VIII	C14	Final Chatelperronian	38830	1121	MIS 3	GrN-1742	S3P
North	U.K.	Kent's Cavern		AMS C14	FAUNA/Early Upper Palaeolithic	38846	1270	MIS 3	OxA-3449	S3P
North	U.K.	Hyaena Den		AMS C14	Mousterian	38857	1808	MIS 3	OxA-4113	S3P

South	France	Roc de Combe [Nadaillac]	7c	AMS C14	Aurignacian I	38864	1566	MIS 3	OxA-1263	S3P
South	France	Grotte du Renne, Arcy-sur-Cure	XII	C14	Late Middle Palaeolithic	38901	1271	MIS 3	GrN-4217	S3P
South	France	Abri Pataud	??	C14	"Aurignacian I"	38949	1365	MIS 3	GrN-3230	S3P
North	U.K.	Kent's Cavern		AMS C14	FAUNA/Early Upper Palaeolithic	38953	1224	MIS 3	OxA-3450	S3P
	France	Camiac[-et-St-Denis]	basal layer [D]	C14	"Chatelperronian"	38986	2075	MIS 3	Ly-1104	S3P
Med	Spain	Cariguela	??	TL	Mousterian	39000		MIS 3	TB-12	S3P
Med	Italy	Gr. di Sant'Agostino	spit 1	ESR: EU	Mousterian	39000	9000	MIS 3	**	S3P
North	U.K.	Tornewton Cave	reindeer stratum	AMS C14	FAUNA	39025	1247	MIS 3	OxA-3186	S3P
North	U.K.	Cae Gronw Cave	layer 20	AMS C14	FAUNA	39068	1833	MIS 3	OxA-6335	S3P
South	France	Grotte XVI [Cenac-et-Saint-Julien]	B	AMS C14	Chatelperronian	39100	1528	MIS 3	GifA-95581	S3P
North	U.K.	Soldier's Hole	spit 16	AMS C14	FAUNA	39100	1528	MIS 3	OxA-1465	S3P
North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	39182	1815	MIS 3	OxA-7086	S3P
Central	Belgium	Trou Walou	C7B	?	habitat d'ours	39251	2159	MIS 3	Lv-1642	S3P
Med	Italy	Gr. all'Onda		U-series	pre-Mousterian	39300	3200	MIS 3	?	S3P
North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	39361	1878	MIS 3	OxA-7085	S3P
Central	Austria	Krems-Hundssteig	brown layer [~10 cm thick, with series of hearths]	C14	[Dufour] Aurignacian	39404	2308	MIS 3	KN-I-654	S3P
Med	Italy	Riparo Mochi	G	AMS C14	Dufour Aurignacian	39411	786	MIS 3	OxA-3590	S3P
	France	Isturitz [Isturits]	V1 26	AMS C14	Aurignacian	39475	675	MIS 3	GifA-98233	S3P
Central	Germany	Das Geissenklosterle	III	TL	Aurignacian 0	39500	2100	MIS 3	GK-2	S3P

Central	Germany	Sesselfelsgrotte	G2	C14	Mousterian	39531	649	MIS 3	*5065	S3P
South	France	Combe Grenal [Domme]	2	C14	Mousterian	39536	664	MIS 3	GrN-4300	S3P
Med	Italy	Riparo Mochi	G	AMS C14	Dufour Aurignacian	39537	779	MIS 3	OxA-3592	S3P
Med	Spain	Abric Romani	2	C14	Archaic Aurignacian	39595	678	MIS 3	USGS-2840	S3P
Central	Germany	Sesselfelsgrotte	G2	C14	Mousterian	39621	668	MIS 3	*5052	S3P
South	France	La Quina Y-Z [Villebois la Valette]	2	C14	final [Quina] Mousterian	39696	730	MIS 3	GrN-2526	S3P
South	France	Le Moustier	H[2a-7c]	ESR: EU	Mousterian [MTA B]	39700	2400	MIS 3	**	S3P
	France	A. Castanet [Sergeac]	inferieur	AMS C14	Aurignacian	39716	1062	MIS 3	GifA-97313	S3P
	France	Grotte du Bison, Arcy-sur-Cure	H	AMS C14	Late Middle Palaeolithic?	39793	883	MIS 3	OxA-3460	S3P
Med	Portugal	Gruta do Escoural	test 3a [80-90]	U-Th	Mousterian	39800	10000	MIS 3	SMU-249	S3P
North	U.K.	Pontnewydd Cave		AMS C14	FAUNA	39808	894	MIS 3	OxA-4370	S3P
Med	Spain	Abric Romani	2	AMS C14	Archaic Aurignacian	39885	911	MIS 3	AA-8037A	S3P
South	France	Abri Caminade [Caneda]	F	AMS C14	Aurignacian [I]	39894	1064	MIS 3	GifA-97186	S3P
Med	Italy	Abri Fumane	A2 [inner] [hearth S14, level B1]	AMS C14	Dufour Aurignacian	39894	1064	MIS 3	UtC-2689	S3P
Med	Spain	Castillo	18C	ESR [EU/LU]	Archaic Aurignacian*	39900	4600	MIS 3	**	S3P
South	France	Caune de Belvis [Belvis]	[7]	AMS C14	Chatelperronian	39905	1094	MIS 3	AA-7390	S3P
Med	Spain	L'Arbreda	BE111[Level H?]	AMS C14	Archaic Aurignacian	39935	940	MIS 3	OxA-3730	S3P
Med	Italy	Caverna delle Fate [Manie]	??	ESR	Mousterian	40000	12000	MIS 3	F-85-2	S3P
Med	Italy	Gr. Romanelli	F	U-series	post-Mousterian	40000	3250	MIS 3	?	S3P

Med	Italy	Riparo Mochi	G	AMS C14	Dufour Aurignacian	40056	1003	MIS 3	OxA-3591	S3P
Central	Belgium	Maisieres-Canal	occup. Horizon	C14	Gravettian	40118	3604	MIS 3	Lv-305/1	S3P
Central	Germany	Das Geissenklosterle	II	C14	Aurignacian I	40129	3944	MIS 3	H-5315-4908	S3P
South	France	A. Combe Sauniere [Sarliac-sur-l'Isle]	X	AMS C14	Chatelperronian	40186	1129	MIS 3	OxA-6503	S3P
South	France	Le Moustier	J	TL	[Typical] Mousterian	40300	2600	MIS 3	Gif-	S3P
Central	Belgium	Trou Al'Wesse	L6 / Ch15 / F480 / -543 -647 cm	AMS C14	Aurignacian	40623	1249	MIS 3	OxA-7634 (Lyon-593)	S3P
South	France	A. Combe Sauniere [Sarliac-sur-l'Isle]	X	ESR*	Chatelperronian	40647	2994	MIS 3	**	S3P
Med	Spain	La Vina	XIII [lower]	C14	Aurignacian I	40879	586	MIS 3	Ly-6390	S3P
Med	Italy	Abri Fumane	A2 [inner]	AMS C14	Dufour Aurignacian	40891	498	MIS 3	UtC-2048	S3P
South	France	Isturitz [Isturits]	U27, 4d	AMS C14	Aurignacian	40896	502	MIS 3	GifA-98232	S3P
Central	Germany	Das Geissenklosterle	III	TL	Aurignacian 0	40900	4700	MIS 3	GK-3	S3P
South	France	Le Moustier	I	TL	Denticulate Mousterian [?sterile]	40900	5000	MIS 3	Gif-	S3P
South	France	Roche a Pierrot [St.-Cesaire]	10	TL	Mousterian	40900	2500	MIS 3		S3P
Med	Spain	Abric Romani	2	AMS C14	Archaic Aurignacian	40942	514	MIS 3	NZA-2311	S3P
Central	Germany	Sesselfelsgrotte	G2	C14	Mousterian	40966	674	MIS 3	GrN-6180	S3P
Med	Spain	Ermitons Cave	IV	C14	Mousterian	40989	2031	MIS 3	CSIC-197	S3P
South	France	Le Moustier	H[2a-7c]	ESR: LU	Mousterian [MTA B]	41000	2600	MIS 3	**	S3P
Med	Spain	Abric Romani	2	C14	Archaic Aurignacian	41056	1696	MIS 3	USGS-2839	S3P
Central	Germany	Das Geissenklosterle	III	C14	Aurignacian 0	41059	1887	MIS 3	H-5136-4909	S3P

Med	Spain	Abric Romani	2	AMS C14	Archaic Aurignacian	41183	807	MIS 3	AA-6608	S3P
South	France	Achenheim	loam GR2	C14	hearth [no industry!]	41261	2220	MIS 3	Ly-761	S3P
Central	Germany	Das Geissenklosterle	IIa [sq. 33]	AMS C14	Aurignacian I	41528	1151	MIS 3	OxA-4594	S3P
Med	Greece	Asprochaliko	19	C14	basal Mousterian	41544	4867	MIS 3	I-1958	S3P
Med	Italy	Abri Fumane	A2 [inner] [hearth S14, level A]	AMS C14	Dufour Aurignacian	41545	1308	MIS 3	UtC-2688	S3P
Med	Spain	Castillo	18B2	AMS C14	Archaic Aurignacian	41584	2428	MIS 3	OxA-2473	S3P
Central	Germany	Sesselfelsgrotte	E3	C14	Mousterian	41768	1188	MIS 3	GrN-7153	S3P
South	France	Pech de l'Aze II [Carsac]	4c2	ESR: EU	Typical Mousterian	41900	6000	MIS 3	629A	S3P
Med	Spain	Abric Romani	2	AMS C14	Archaic Aurignacian	41904	1198	MIS 3	AA-7395	S3P
North	U.K.	Windy Knoll		AMS C14	FAUNA	41928	1258	MIS 3	OxA-4579	S3P
Med	Spain	L'Arbreda	CE103[Level H?]	AMS C14	Aurignacian	41945	1209	MIS 3	OxA-3729	S3P
Med	Spain	Cueva Millan	1b	C14	Mousterian	41969	1044	MIS 3	GrN-11161	S3P
	France	Abri Caminade [Caneda]	G	AMS C14	Aurignacian [I]	42004	1609	MIS 3	GifA-97185	S3P
North	U.K.	Pin Hole Cave	69/6'-0" (Deeper than Upper Palaeolithic)	AMS C14	FAUNA/Early Upper Palaeolithic	42050	1259	MIS 3	OxA-3406	S3P
Central	Germany	Das Geissenklosterle	III [sq. 37]	AMS C14	Aurignacian 0	42054	1841	MIS 3	OxA-5163	S3P
Med	Spain	Cueva Millan	1a	C14	Mousterian	42116	1080	MIS 3	GrN-11021	S3P
South	France	Les Cottes [St. Pierre de Maille]	I2	C14	Mousterian	42116	1080	MIS 3	GrN-4421	S3P
South	France	Grotte du Renne, Arcy-sur-Cure	XII	C14	Late Middle Palaeolithic	42234	1661	MIS 3	Ly-2165	S3P
Med	Spain	L'Arbreda	B1*[Level H?]	AMS C14	Archaic Aurignacian	42302	1299	MIS 3	AA-3779	S3P

Med	Spain	L'Arbreda	B1*[Level H?]	AMS C14	Archaic Aurignacian	42302	1299	MIS 3	AA-3780	S3P
North	U.K.	Hyaena Den		AMS C14	FAUNA	42356	1427	MIS 3	OxA-5703	S3P
Central	Germany	Das Geissenklosterle	III [sq. 66]	AMS C14	Aurignacian 0	42372	1309	MIS 3	ETH-8267	S3P
Med	Spain	Castillo	18B2 [upper]	AMS C14	Archaic Aurignacian	42379	1782	MIS 3	AA-2407	S3P
South	France	Pech de l'Aze II [Carsac]	4c2	ESR: EU	Typical Mousterian	42400	3100	MIS 3	629C	S3P
South	France	Roche a Pierrot [St.-Cesaire]	12	TL	Mousterian	42400	4800	MIS 3		S3P
North	U.K.	Pin Hole Cave		AMS C14	FAUNA/Early Upper Palaeolithic	42440	1634	MIS 3	OxA-4754	S3P
Med	Spain	Abric Romani	2	AMS C14	Archaic Aurignacian	42451	1270	MIS 3	AA-8037B	S3P
Med	Italy	Gr. di Paina	9	AMS C14	Dufour Aurignacian	42483	1188	MIS 3	UtC-2042	S3P
South	France	Le Moustier	H2-H9	TL	Mousterian [MTA B]	42500	2000	MIS 3	Gif-	S3P
South	France	Pech de l'Aze II [Carsac]	3	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	42500	5200	MIS 3	636B	S3P
Central	Austria	Willendorf II	3 / C8	AMS C14	Aurignacian	42520	1163	MIS 3	GrA-896	S3P
South	France	A. Combe Sauniere [Sarliac-sur-l'Isle]	X	AMS C14	Chatelperronian	42585	1211	MIS 3	OxA-6503 (tripeptide)	S3P
South	France	Le Moustier	K	TL	[Typical] Mousterian / (Chatelperronian?)	42600	3700	MIS 3	Gif-	S3P
	France	Barbas III [Creysse]	4	C14	Mousterian [MTA]	42788	1006	MIS 3	Gif/LSM-9591	S3P
Med	Portugal	Oliveira Cave [Almonda cave system]	9	AMS C14	Mousterian	42825	986	MIS 3	GrA-9760	S3P
Med	Italy	Gr. di Paina	9	AMS C14	Dufour Aurignacian	42843	1311	MIS 3	UtC-2695	S3P
Med	Spain	Abric Romani	2	U-series	Archaic Aurignacian	43000	1000	MIS 3	*	S3P
Med	Italy	Gr. di Sant'Agostino	spit 1	ESR: LU	Mousterian	43000	9000	MIS 3	**	S3P

South	France	Le Moustier	G[1-4]	ESR: EU	Mousterian [MTA A]	43000	2300	MIS 3	**	S3P
North	U.K.	Pin Hole Cave	(Within Blade distribution - Jacobi et al. 1998).	AMS C14	FAUNA/Early Upper Palaeolithic	43127	2433	MIS 3	OxA-1470	S3P
South	France	Roc de Combe [Nadaillac]	10	AMS C14	early Chatelperronian	43127	2433	MIS 3	OxA-1443	S3P
South	France	Grotte XVI [Cenac-et-Saint-Julien]	B	AMS C14	Chatelperronian	43182	2176	MIS 3	AA-2997	S3P
North	U.K.	Kent's Cavern	cave earth A2	C14	Early Upper Palaeolithic	43285	2005	MIS 3	GrN-6324	S3P
Med	Spain	Castillo	18B2	AMS C14	Archaic Aurignacian	43487	1900	MIS 3	OxA-2474	S3P
Med	Spain	Castillo	18B1 [upper]	AMS C14	Archaic Aurignacian	43533	2265	MIS 3	AA-2406	S3P
Central	Belgium	Sclayn Cave	1A	C14	Mousterian	43569	2049	MIS 3	Lv-1377b	S3P
Med	Spain	Cueva Morin	10	C14	Chatelperronian	43594	10334	MIS 3	SI-951A	S3P
Central	Germany	Das Geissenklosterle	III	TL	Aurignacian 0	43600	5400	MIS 3	GK-12	S3P
North	U.K.	King Arthur's Cave	red clay	AMS C14	FAUNA	43600	2728	MIS 3	OxA-1565	S3P
South	France	Pech de l'Aze II [Carsac]	3	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	43600	4900	MIS 3	636A	S3P
Med	Italy	Castelcivita	tg.29-30	C14	Mousterian	43603	1713	MIS 3	GrN-13982	S3P
Med	Spain	L'Arbreda	B1*[Level H?]	AMS C14	Archaic Aurignacian	43638	1856	MIS 3	AA-3782	S3P
South	France	Pech de l'Aze II [Carsac]	3	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	43700	3700	MIS 3	636C	S3P
South	France	Grotte du Bison, Arcy-sur-Cure	I/J?	AMS C14	Late Middle Palaeolithic?	43727	1925	MIS 3	OxA-3461	S3P
Central	Austria	Willendorf II	3 / C8	C14	Aurignacian	43830	2082	MIS 3	GrN-17805	S3P
Med	Spain	Cova Beneito	basal [X (D1)]	AMS C14	Mousterian	43885	2423	MIS 3	?	S3P
South	France	Combe Grenal [Domme]	1 [12]	C14	Mousterian	43931	2092	MIS 3	GrN-4304	S3P

South	France	Combe Grenal [Domme]	1	C14	Denticulate Mousterian	43931	2092	MIS 3	GrN-4304	S3P
North	U.K.	Hyaena Den		AMS C14	FAUNA	43949	1972	MIS 3	OxA-5704	S3P
North	U.K.	Coygan Cave	deposit sealed below calcrete (breccia) layer in cave	C14	Mousterian ["MTA"]	43954	3302	MIS 3	BM-499	S3P
South	France	Combe Grenal [Domme]	20	TL	Mousterian	44000	4000	MIS 3	**	S3P
Med	Italy	Gr. di Sant'Agostino	spit 3	ESR: EU	Mousterian	44000	8000	MIS 3	**	S3P
Med	Italy	Gr. Guattari	surface deposit [GG IV]	ESR: EU	Neanderthal	44000	5000	MIS 3	**	S3P
Med	Portugal	Oliveira Cave [Almonda cave system]	9	AMS C14	Mousterian	44137	1777	MIS 3	Beta-111967	S3P
Med	Italy	Gr. Guattari	surface layer + stratum 1	ESR: EU	Mousterian	44200	5400	MIS 3	**	S3P
Med	Italy	Gr. del Broion	I [ca.5 m deep]	C14	final Mousterian	44224	1788	MIS 3	GrN-4638	S3P
	Italy	Gr. Guattari	G1	ESR: EU	Mousterian	44400	5900	MIS 3	**	S3P
South	France	Pech de l'Aze II [Carsac]	4c2	ESR: EU	Typical Mousterian	44600	2900	MIS 3	629B	S3P
Med	Spain	Castillo	20b2	AMS C14	Charentian Mousterian	44641	2806	MIS 3	GifA-89144	S3P
Central	Germany	Feldhofer Cave, Neandert[h]al	-	AMS C14	None	44658	5879	MIS 3	[Zurich]	S3P
Central	Germany	Das Geissenklosterle	III	TL	Aurignacian 0	44700	5600	MIS 3	GK-7	S3P
Med	Spain	Castillo	18C	AMS C14	Archaic Aurignacian*	44732	2826	MIS 3	GifA-89147	S3P
Med	Spain	L'Arbreda	BE116 [Level I?]	AMS C14	Late Mousterian	44742	2645	MIS 3	AA-3776	S3P
South	France	Grotte du Renne, Arcy-sur-Cure	XII	AMS C14	Late Middle Palaeolithic	44744	2663	MIS 3	OxA-3463	S3P
South	France	Grotte du Renne, Arcy-sur-Cure	RGS	C14	Late Middle Palaeolithic	44767	2768	MIS 3	Ly-2166	S3P
Central	Austria	Willendorf II	2? / D1 up. [*echantillon II, level 1-2]	C14	Aurignacian	44803	2689	MIS 3	GrN-11190	S3P

Med	Portugal	Figueira Brava Cave	2	Th/U	Mousterian	44806	15889	MIS 3	SMU-233E2	S3P
North	U.K.	Whaley 2		AMS C14	FAUNA	44856	2694	MIS 3	OxA-4434	S3P
Med	Spain	Castillo	18C	AMS C14	Archaic Aurignacian*	44947	2810	MIS 3	AA-2405	S3P
Med	Spain	Castillo	18C	AMS C14	Archaic Aurignacian*	44960	2679	MIS 3	OxA-2478	S3P
Med	Spain	Pena Miel 1	c	C14	Mousterian	44994	2694	MIS 3	UGRA-128	S3P
Med	Spain	Banyoles	travertine lake deposit at 5 m depth	U-series	-	45000	4000	MIS 3	-	S3P
Med	Italy	Gr. di Sant'Agostino	spit 2	ESR: EU	Mousterian	45000	6000	MIS 3	**	S3P
Med	Spain	L'Arbreda	B1*[Level H?]	AMS C14	Archaic Aurignacian	45013	2666	MIS 3	AA-3781	S3P
Med	Spain	Reclau Viver	T III	AMS C14	Archaic Aurignacian	45047	2677	MIS 3	OxA-3727	S3P
North	Germany	Das Geissenklosterle	IIIa [sq. 66]	AMS C14	Aurignacian 0	45106	2692	MIS 3	OxA-4595	S3P
North	U.K.	Hyaena Den		AMS C14	Mousterian	45194	2669	MIS 3	OxA-4782	S3P
South	France	Abri du Ranc de l'Arc [Lagorce]	Level 5	AMS C14	Mousterian	45244	2652	MIS 3	GifA-	S3P
North	U.K.	Ash Tree Cave		AMS C14	FAUNA	45244	2652	MIS 3	OxA-4580	S3P
North	U.K.	Banwell Bone Cave		AMS C14	FAUNA	45244	2652	MIS 3	OxA-4581	S3P
Med	Spain	Castillo	18B2 [base]	AMS C14	Archaic Aurignacian	45369	2591	MIS 3	OxA-2475	S3P
Med	Spain	Castillo	18C	AMS C14	Archaic Aurignacian*	45410	2550	MIS 3	OxA-2476	S3P
Central	Belgium	Trou Al'Wesse	L5 / Ch17 / F507 / -758 cm	AMS C14	Mousterian	45487	2788	MIS 3	OxA-7497 (Lyon-591)	S3P
South	France	Pech de l'Aze II [Carsac]	2g	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	45500	4800	MIS 3	789B	S3P
Med	Spain	Castillo	18C	AMS C14	Archaic Aurignacian*	45630	2461	MIS 3	OxA-2477	S3P

South	France	Abri du Ranc de l'Arc [Lagorce]	Level 5	AMS C14	Mousterian	45701	2496	MIS 3	GifA-	S3P
North	U.K.	Brean Down		AMS C14	FAUNA	45730	2390	MIS 3	OxA-4582	S3P
Central	Belgium	Trou Magrite	3 mid	AMS C14	early Aurignacian	45760	2399	MIS 3	CAMS-10352	S3P
Med	Spain	Kurtzia	"lower level (a)"	C14	Mousterian	45771	2888	MIS 3	UGRA-293	S3P
Med	Spain	L'Arbreda	BE116 [Level I?]	AMS C14	Late Mousterian	45851	2335	MIS 3	AA-3778	S3P
Med	Spain	Cariguela	??	TL	Mousterian	46000		MIS 3	TB-3	S3P
Med	Italy	Abri Fumane	A2 [outer] [hearth S10]	AMS C14	Dufour Aurignacian	46287	5649	MIS 3	UtC-1774	S3P
South	France	Le Moustier	H1	TL	Mousterian [MTA B]	46300	3000	MIS 3	Gif-	S3P
Med	Gibraltar	Vanguard Cave	unit 55	AMS C14	Mousterian	46315	2001	MIS 3	OxA-6998	S3P
Central	Germany	Sesselfelsgrotte	G2	C14	Mousterian	46395	1930	MIS 3	GrN-6848	S3P
Med	Italy	Castelcivita	tg.29-30	C14	Mousterian	46414	1510	MIS 3	GrN-13984	S3P
South	France	Abri du Ranc de l'Arc [Lagorce]	Level 5	AMS C14	Mousterian	46471	2052	MIS 3	GifA-	S3P
Central	Germany	Das Geissenklosterle	IV	ESR	Mousterian	46600	6900	MIS 3	92126b	S3P
Med	Gibraltar	Gorham's Cave	context 18, combustion zone	AMS C14	Transitional [Middle Palaeolithic-Upper Palaeolithic]	46602	1842	MIS 3	OxA-7791	S3P
	France	[Gr.] Neron [Soyons]	IV [sq. 1]	C14	Mousterian	46854	1926	MIS 3	Gif/LSM-9132	S3P
South	France	La Chapelle-aux-Saints	bed 1 [yellow clay with limestone fragments]	ESR: EU	Mousterian	47000	3000	MIS 3	**	S3P
South	France	Le Moustier	G[1-4]	ESR: LU	Mousterian [MTA A]	47000	2500	MIS 3	**	S3P
North	U.K.	Pin Hole Cave	37/9'-6" (Deeper than Upper Palaeolithic)	AMS C14	FAUNA/Early Upper Palaeolithic	47210	2720	MIS 3	OxA-4431	S3P
Med	Spain	Abric Romani	4	AMS C14	Mousterian	47437	2474	MIS 3	?	S3P

North	U.K.	Pin Hole Cave	48/8'-6" (Deeper than Upper Palaeolithic)	AMS C14	FAUNA/Early Upper Palaeolithic	47628	3166	MIS 3	OxA-4428	S3P
Med	Spain	Cariguela	??	TL	Mousterian	48000		MIS 3	TB-9a	S3P
Med	Italy	Gr. di Gosto	D [base]	U-series	Mousterian	48000	4000	MIS 3	?	S3P
	France	Ioton [Beaucaire]	Ag	TL	Quina Mousterian	48000	3000	MIS 3	Gif-	S3P
North	U.K.	Paviland Cave [Goat's Hole]		AMS C14	FAUNA/Early Upper Palaeolithic	48320	12552	MIS 3	OxA-140	S3P
North	U.K.	Whaley 2		AMS C14	FAUNA	48322	3887	MIS 3	OxA-4433	S3P
North	Germany	Feldhofer Cave, Neandert[h]al	-	AMS C14	None	48360	8102	MIS 3	[Zurich]	S3P
Central	Germany	Das Geissenklosterle	IV	ESR	Mousterian	48500	7700	MIS 3	92130a	S3P
Med	Portugal	Gruta do Escoural	test 3a [60-70]	U-Th	Mousterian	48900	5800	MIS 3	SMU-250	S3P
Med	Italy	Gr. Guattari	stratum 4	ESR: EU	Mousterian	49600	21400	MIS 3	**	S3P
South	France	Pech de l'Aze II [Carsac]	2g	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	49600	7600	MIS 3	789A	S3P
	France	Fonseigner [Bourdeilles]	D [upper]	TL	Typical Mousterian	50200	5300	MIS 3	Gif-	S3P
South	France	Le Moustier	G4	TL	Mousterian [MTA A]	50300	5500	MIS 3	Gif-TL-570	S3P
North	U.K.	Soldier's Hole	spit 20	AMS C14	FAUNA	50554	7771	MIS 3	OxA-1957	S3P
North	U.K.	Pin Hole Cave		AMS C14	FAUNA/Early Upper Palaeolithic	50597	7064	MIS 3	OxA-1448	S3P
Central	Austria	Willendorf II	2? / D1 mid. [*echantillon I, level 2]	C14	Aurignacian	50962	8259	MIS 3	GrN-11195	S3P
Med	Italy	Gr. Guattari	G0 [surface, southern chamber]	U-series	Mousterian	51000	3000	MIS 3	-	S3P
Med	Portugal	Vilas Ruivas	B	TL[/OSL]	Mousterian	51000	13000	MIS 3	BM-VRU1	S3P
Central	Austria	Willendorf II	2? / D1 up.	C14	Aurignacian	51260	8825	MIS 3	GrN-17806	S3P

Central	Germany	Das Geissenklosterle	IV	ESR	Mousterian	52700	7300	MIS 3	92124b	S3P
South	France	Pech de l'Aze II [Carsac]	2f	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	52700	4500	MIS 3	638D	S3P
	France	Fonseigner [Bourdeilles]	D [mid]	TL	Typical Mousterian	52800	5500	MIS 3	Gif-	S3P
	France	Barbas III [Creysse]	4	AMS C14	Mousterian [MTA]	52843	7849	MIS 3	GifA-93050	S3P
Med	Italy	Gr. di Sant'Agostino	spit 2	ESR: LU	Mousterian	53000	7000	MIS 3	**	S3P
Med	Portugal	Oliveira Cave [Almonda cave system]	Mousterian cone	U-Th	Mousterian	53000	5600	MIS 3	SMU-247E2	S3P
South	France	Pech de l'Aze II [Carsac]	3	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	53100	6500	MIS 3	636B	S3P
Med	Spain	Castillo	20b2	AMS C14	Charentian Mousterian	53166	8369	MIS 3	GifA-92506	S3P
Central	Germany	Konigsaue	culture layer A [horizon Ib]	AMS C14	Mousterian	53220	8031	MIS 3	OxA-7124	S3P
North	U.K.	Pin Hole Cave	68/6'-0" (Deeper than Upper Palaeolithic)	AMS C14	FAUNA/Early Upper Palaeolithic	53561	8234	MIS 3	OxA-3408	S3P
South	France	Pech de l'Aze II [Carsac]	2a	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	53800	3900	MIS 3	633C	S3P
Med	Italy	Gr. di Sant'Agostino	spit 3	ESR: LU	Mousterian	54000	11000	MIS 3	**	S3P
	France	Gr aux Ours [Gondenans les Moulins]	4 [base]	C14	Mousterian	54039	7772	MIS 3	GrN-4557	S3P
Med	Italy	Gr. Guattari	G1	ESR: LU	Mousterian	54200	4100	MIS 3	**	S3P
Central	Belgium	Sclayn Cave	1A	TL	Mousterian	54220	9730	MIS 3	OxTL230a 1	S3P
South	France	Pech de l'Aze II [Carsac]	2f	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	54300	6500	MIS 3	638B	S3P
South	France	Pech de l'Aze II [Carsac]	2f	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	54300	4600	MIS 3	638C	S3P
Med	Portugal	Columbeira, Gruta Nova	7	Th/U	Mousterian	54365	22240	MIS 3	SMU-238E1	S3P

South	France	Pech de l'Aze II [Carsac]	3	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	54500	4900	MIS 3	636C	S3P
South	France	Pech de l'Aze II [Carsac]	2f	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	54600	4800	MIS 3	638D	S3P
Med	Spain	L'Arbreda	BE116 [Level I?]	AMS C14	Late Mousterian	54607	8179	MIS 3	OxA-3731	S3P
South	France	Pech de l'Aze II [Carsac]	2f	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	54800	4700	MIS 3	638A	S3P
North	U.K.	Pin Hole Cave	50/8'-0" (Deeper than Upper Palaeolithic)	AMS C14	FAUNA/Early Upper Palaeolithic	55039	8253	MIS 3	OxA-4430	S3P
South	France	Pech de l'Aze II [Carsac]	3	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	55200	6200	MIS 3	636A	S3P
South	France	Grotte du Renne, Arcy-sur-Cure	IX	AMS C14	Chatelperronian/"Early Upper Palaeolithic"*	55232	8213	MIS 3	OxA-3465	S3P
Med	Spain	Roca dels Bous	S1	AMS C14	Mousterian	55232	8687	MIS 3	?	S3P
Med	Gibraltar	Gorham's Cave	context 22/22D [?=G], combustion zone	AMS C14	Mousterian	55243	7881	MIS 3	OxA-6075	S3P
Med	Gibraltar	Vanguard Cave	base spit 3 [top section]	AMS C14	Mousterian	55276	8067	MIS 3	OxA-7389	S3P
South	France	Le Moustier	G1	TL	Mousterian [MTA A]	55800	5000	MIS 3	Gif-	S3P
Med	Spain	Pena Miel 1	c	C14	Mousterian	55914	7225	MIS 3	GrN-12123	S3P
	France	Regourdou [Montignac]	4	C14	Mousterian	55978	7349	MIS 3	GrN-4308	S3P
	France	La Chapelle-aux-Saints	bed 1 [yellow clay with limestone fragments]	ESR: LU	Mousterian	56000	4000	MIS 3	**	S3P
Med	Italy	Gr. La Cala	R	AMS C14	Mousterian	56130	7079	MIS 3	OxA-7405	S3P
South	France	Pech de l'Aze II [Carsac]	2f	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	56200	6800	MIS 3	638B	S3P
South	France	Pech de l'Aze II [Carsac]	2f	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	56300	4900	MIS 3	638C	S3P
	France	Fonseigner [Bourdeilles]	E	TL	Typical Mousterian	56400	6800	MIS 3	Gif-	S3P
South	France	Pech de l'Aze II [Carsac]	2f	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	56400	4900	MIS 3	638A	S3P

Med	Italy	Gr. del Broion	I [ca.5 m deep]	C14	final Mousterian	56452	7138	MIS 3	GrN-4637	S3P
Central	Germany	Sesselfelsgrotte	G4	C14	Mousterian	56653	6934	MIS 3	*5114/5024/5026	S3P
Med	Spain	Los Moros I [Gabasa]	e	C14	Mousterian [Typical]	56740	8276	MIS 3	GrN-12809	S3P
Med	Italy	Gr. Guattari	surface layer + stratum 1	ESR: LU	Mousterian	56800	6000	MIS 3	**	S3P
South	France	Pech de l'Aze II [Carsac]	2e	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	56800	5800	MIS 3	637B	S3P
South	France	La Roquette II [Conquerac]	2 & 3	TL	Quina Mousterian	57200	4300	MIS 3	Gif-	S3P
Central	Belgium	Trou de l'Abime, Couvin	II [base]: zone A [squares G6/7 & H6/7]	C14	Late Middle Palaeolithic [/Early Upper Palaeolithic]	57283	7434	MIS 3	Lv-1559	S3P
South	France	Pech de l'Aze II [Carsac]	2a	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	57400	5800	MIS 3	633B	S3P
Med	Gibraltar	Vanguard Cave	unit 53	AMS C14	Mousterian	57436	6593	MIS 3	OxA-6892	S3P
Med	Italy	Gr. Guattari	layer 7 [beach deposit]	ESR: EU	?FAUNA	57500	2200	MIS 3	**	S3P
North	U.K.	La Cotte de St-Brelade	lower industry	C14	Mousterian	57522	6554	MIS 3	GrN-2649	S3P
South	France	Pech de l'Aze II [Carsac]	2e	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	57600	5900	MIS 3	637B	S3P
South	France	Pech de l'Aze II [Carsac]	3	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	57700	6400	MIS 3	634A	S3P
South	France	Pech de l'Aze II [Carsac]	4c2	ESR: LU	Typical Mousterian	57900	4300	MIS 3	629C	S3P
Med	Gibraltar	Gorham's Cave	G	C14	Mousterian	58084	6340	MIS 3	GrN-1473	S3P
	France	A. Brugas [?O/A] [Vallabrix]	4	TL	Quina Mousterian	58200	7500	MIS 3	Gif-	S3P
South	France	Pech de l'Aze II [Carsac]	2e	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	58300	4800	MIS 3	637C	S3P
Central	Germany	Konigsaue	culture layer B [horizon Ib] - below culture layer A.	AMS C14	Mousterian	58497	7420	MIS 3	OxA-7125	S3P
	France	Gr aux Ours [Gondenans les	2	C14	Mousterian	58557	6628	MIS 3	GrN-4629	S3P

		Moulins]								
South	France	Pech de l'Aze II [Carsac]	3	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	58600	7100	MIS 3	634B	S3P
South	France	Pech de l'Aze II [Carsac]	4c2	ESR: LU	Typical Mousterian	59000	8400	MIS 3	629A	S3P
South	France	Pech de l'Aze II [Carsac]	2e	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	59000	6500	MIS 3	637A	S3P
South	France	Pech de l'Aze II [Carsac]	3	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	59100	6700	MIS 3	634A	S3P
Med	Gibraltar	Gorham's Cave	G	C14	Mousterian	59161	7130	MIS 3	GrN-1556	S3P
Med	Italy	Gr. Guattari	layer 7 [beach deposit]	ESR: EU	?Mousterian	59600	5500	MIS 3	**	S3P
South	France	Pech de l'Aze II [Carsac]	2e	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	59600	5000	MIS 3	637C	S3P
South	France	Pech de l'Aze II [Carsac]	2e	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	59700	6600	MIS 3	637A	S3P
South	France	Pech de l'Aze II [Carsac]	4c2	ESR: LU	Typical Mousterian	60900	4000	MIS 4	629B	S3P
Med	Portugal	Columbeira, Gruta Nova	8	Th/U	Mousterian	60927	27405	MIS 4	SMU-236E1	S3P
South	France	Combe Grenal [Domme]	55	TL	Mousterian	61000	7000	MIS 4	**	S3P
Med	Gibraltar	Gorham's Cave	context 22D [?=G], combustion zone	AMS C14	Mousterian	61031	7594	MIS 4	OxA-7790	S3P
South	France	Pech de l'Aze II [Carsac]	2g	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	61500	6400	MIS 4	789B	S3P
Central	Germany	Das Geissenklosterle	III	TL	Aurignacian 0	61600	3800	MIS 4	GK-5	S3P
South	France	Pech de l'Aze II [Carsac]	3	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	61600	7600	MIS 4	634B	S3P
South	France	Combe Grenal [Domme]	50	TL	Mousterian	62000	7000	MIS 4	**	S3P
Med	Italy	Gr. Guattari	surface deposit [GG IV]	ESR: LU	Neanderthal	62000	6300	MIS 4	**	S3P
	France	A. Brugas [?O/A] [Vallabrix]	4	TL	Quina Mousterian	63000	5800	MIS 4	**	S3P
Med	Gibraltar	Vanguard Cave	unit 53	AMS C14	Mousterian	63004	7925	MIS	OxA-6891	S3P

South	France	Pech de l'Aze II [Carsac]	2g	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	63200	5700	4 MIS	788A	S3P
South	France	Pech de l'Aze II [Carsac]	3	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	63800	5900	4 MIS	634C	S3P
South	France	Pech de l'Aze II [Carsac]	4c2	ESR: LU	Typical Mousterian	65500	5500	4 MIS	630D	S3P
	France	A. Brugas [?O/A] [Vallabrix]	4	TL	Quina Mousterian	65900	9900	4 MIS	Gif-	S3P
Med	Italy	Gr. dei Moscerini	35	ESR: LU	Mousterian [& FAUNA]	66000		4 MIS	MO-35	S3P
South	France	Pech de l'Aze II [Carsac]	3	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	66800	6300	4 MIS	634C	S3P
South	France	Pech de l'Aze II [Carsac]	2g	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	67000	10300	4 MIS	789A	S3P
	France	Pie[d] Lombard [cave] [Tour[r]ettes-sur-Loup]	4c-4a	TL	[Typical] Mousterian	67000	8100	4 MIS	??	S3P
South	France	Pech de l'Aze II [Carsac]	4c2	ESR: LU	Typical Mousterian	67500	5700	4 MIS	630D	S3P
	France	[Gr.] Aldene [Cesseras]	A1	?TL	Mousterian	68000	3000	4 MIS	??	S3P
Med	Portugal	Vilas Ruivas	B	TL[/OSL]	Mousterian	68000	35000	4 MIS	BM-VRU2	S3P
	France	A. Brugas [?O/A] [Vallabrix]	4	TL	Quina Mousterian	69000	10800	4 MIS	Gif-	S3P
Med	Spain	Castillo	21	ESR: EU	sterile	69000	9200	4 MIS	90CST3A/4A	S3P
Med	Italy	Gr. Guattari	layer 7 [beach deposit]	ESR: LU	?FAUNA	69000	2400	4 MIS	**	S3P
Med	Spain	Castillo	21	ESR: LU	sterile	69300	9100	4 MIS	90CST3A/4A	S3P
South	France	Pech de l'Aze II [Carsac]	3	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	69500	6600	4 MIS	635B	S3P
South	France	Pech de l'Aze II [Carsac]	3	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	69800	8200	4 MIS	635A	S3P
South	France	Pech de l'Aze II [Carsac]	2g	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	69900	6700	4 MIS	788B	S3P
Med	Spain	Castillo	22	ESR: EU	Charentian Mousterian	70100	9400	4 MIS	90CST1/2	S3P

								4		
	Portugal	Oliveira Cave [Almonda cave system]	Mousterian cone	U-Th	Mousterian	70250	9000	MIS 4	SMU-247E1	S3P
Med	Spain	Castillo	22	ESR: LU	Charentian Mousterian	70400	9600	MIS 4	90CST1/2	S3P
South	France	Pech de l'Aze II [Carsac]	4c2	ESR: EU	Typical Mousterian	70500	5400	MIS 4	630A	S3P
Central	Germany	Salzgitter-Lebenstedt	[fluviatile sediments]	C14	Mousterian	70813	1013	MIS 4	GrN-2083	S3P
Med	Italy	Gr. Guattari	stratum 4	ESR: LU	Mousterian	71100	27600	MIS 4	**	S3P
South	France	Pech de l'Aze II [Carsac]	4c2	ESR: EU	Typical Mousterian	71300	5600	MIS 4	630C	S3P
South	France	Pech de l'Aze II [Carsac]	3	ESR: EU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	71500	6400	MIS 5a	635C	S3P
South	France	Pech de l'Aze II [Carsac]	3	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	72300	6900	MIS 5a	635B	S3P
South	France	Pech de l'Aze II [Carsac]	2a	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	72400	5400	MIS 5a	633C	S3P
South	France	Pech de l'Aze II [Carsac]	3	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	72500	8600	MIS 5a	635A	S3P
South	France	Pech de l'Aze II [Carsac]	4c2	ESR: LU	Typical Mousterian	72600	5700	MIS 5a	630A	S3P
South	France	Pech de l'Aze II [Carsac]	3	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	72800	6600	MIS 5a	635C	S3P
Med	Italy	Canale delle Acque Alte	E2	C14	post-Mousterian	72990	1569	MIS 5a	GrN-2572	S3P
South	France	Pech de l'Aze II [Carsac]	4c2	ESR: LU	Typical Mousterian	73300	5900	MIS 5a	630C	S3P
	France	Les Canalettes [12 - Nant]	2	TL	Typical [MTA] Mousterian	73500	6000	MIS 5a	??	S3P
South	France	Pech de l'Aze II [Carsac]	2a	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	73700	7700	MIS 5a	633B	S3P
South	France	Pech de l'Aze II [Carsac]	4c2	ESR: EU	Typical Mousterian	73800	6700	MIS 5a	630B	S3P
Med	Italy	Gr. dei Moscerini	26	ESR: LU	Mousterian [& FAUNA]	74000	7000	MIS 5a	MO-26*	S3P
Med	Portugal	Conceicao	E	TL/OSL	[pre-Mousterian: sterile]	74500	11600	MIS	QTLS-CNC-12	S3P

South	France	Pech de l'Aze II [Carsac]	2g	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	74600	6800	MIS 5a	788A	S3P
South	France	Pech de l'Aze II [Carsac]	4	ESR: EU	Typical[/Denticulate] Mousterian	74800	11600	MIS 5a	627B	S3P
Med	Italy	Caverna delle Fate [Manie]	??	231Pa/235U	??	75000	21000	MIS 5a	??	S3P
Med	Italy	Gr. del Principe	E [hearth]	U-series	Mousterian	75000	21000	MIS 5a	?	S3P
	France	Montagne de Girault [Genay]	tranchee 2 (red series: levels 3 & 4)	Pa-231/U-235	?Mousterian	75000	6000	MIS 5a	-	S3P
South	France	Pech de l'Aze II [Carsac]	4	ESR: LU	Typical[/Denticulate] Mousterian	75300	11700	MIS 5a	627B	S3P
South	France	Pech de l'Aze II [Carsac]	4	ESR: EU	Typical[/Denticulate] Mousterian	76400	11100	MIS 5a	628B	S3P
South	France	Pech de l'Aze II [Carsac]	4c2	ESR: LU	Typical Mousterian	76600	7100	MIS 5a	630B	S3P
South	France	Pech de l'Aze II [Carsac]	4	ESR: EU	Typical[/Denticulate] Mousterian	76800	8900	MIS 5a	627A	S3P
South	France	Pech de l'Aze II [Carsac]	2a	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	77000	8000	MIS 5a	633A	S3P
South	France	Pech de l'Aze II [Carsac]	2g	ESR: LU	Ferrassie Mousterian [or Typical Mousterian enriched in racloirs]	77400	7300	MIS 5a	788B	S3P
Med	Italy	Gr. Guattari	layer 7 [beach deposit]	ESR: LU	?Mousterian	77500	9500	MIS 5a	-	S3P
Med	Italy	Caverna delle Fate [Manie]	??	ESR	Mousterian	78000	13000	MIS 5a	F-85-9	S3P
Med	Italy	Caverna delle Fate [Manie]	??	ESR	Mousterian	78000	13000	MIS 5a	F-85-10	S3P
South	France	Pech de l'Aze II [Carsac]	4	ESR: EU	Typical[/Denticulate] Mousterian	78500	6600	MIS 5a	628A	S3P
South	France	Pech de l'Aze II [Carsac]	4	ESR: LU	Typical[/Denticulate] Mousterian	78800	11600	MIS 5a	628B	S3P
Med	Italy	Gr. dei Moscerini	25	ESR: LU	Mousterian [& FAUNA]	79000	??	MIS 5a	MO-25	S3P
South	France	Pech de l'Aze II [Carsac]	4	ESR: LU	Typical[/Denticulate] Mousterian	79900	9400	MIS 5a	627A	S3P
Med	Portugal	Furninha	3rd ossiferous layer	Th/U	Mousterian	80880	42420	MIS 5a	SMU-??	S3P

								5a		
South	France	La Salpetriere [Remoulins]	SL C4	C14	Ancient Aurignacian	8174	209	MIS 5a	MC-1300	S3P
Med	Italy	Caverna delle Fate [Manie]	??	230Th/234U	??	82000	36000	MIS 5a	??	S3P
Med	Italy	Gr. del Principe	E [hearth]	U-series	Mousterian	82000	36000	MIS 5a	?	S3P
South	France	Montagne de Girault [Genay]	tranchee 2 (red series: levels 3 & 4)	Th-230/U-234	?Mousterian	82000	20000	MIS 5a	-	S3P
South	France	Pech de l'Aze II [Carsac]	4	ESR: LU	Typical[/Denticulate] Mousterian	82700	7100	MIS 5a	628A	S3P
South	France	Pech de l'Aze II [Carsac]	4c2	ESR: EU	Typical Mousterian	84700	7900	MIS 5b	631B	S3P
South	France	Pech de l'Aze II [Carsac]	4c2	ESR: LU	Typical Mousterian	86400	8200	MIS 5b	631B	S3P
South	France	Pech de l'Aze II [Carsac]	4c2	ESR: EU	Typical Mousterian	89500	7200	MIS 5b	631C	S3P
South	France	Pech de l'Aze II [Carsac]	4c2	ESR: EU	Typical Mousterian	91000	7700	MIS 5b	631A	S3P
South	France	Pech de l'Aze II [Carsac]	4c2	ESR: LU	Typical Mousterian	92800	8000	MIS 5c	631A	S3P
South	France	Pech de l'Aze II [Carsac]	4c2	ESR: LU	Typical Mousterian	93700	7700	MIS 5c	631C	S3P
Med	Italy	Gr. dei Moscerini	39 [top]	ESR: LU	Mousterian [& FAUNA]	96000	1000	MIS 5c	MO-39*	S3P
MP	South Iberia	Laouza		AMS	Aurignacian	8110	140	MIS 3	Wk 3222	d'Errico/Goñi (2003)
South	France	Vanguard Cave		14C	Aurignacian	10000	480	MIS 3	Ly 991	d'Errico/Goñi (2003)
MP	South Iberia	Grotte du Renne		AMS	Mousterian	10170	120	MIS 3	OxA-7191	d'Errico/Goñi (2003)
South	France	Grotte du Renne		14C	Mousterian	10500	190	MIS 3	BM 1818	d'Errico/Goñi (2003)
South	France	Ferrassie		14C	Aurignacian	10900	250	MIS 3	L 340B	d'Errico/Goñi (2003)
South	France	Canecaude		14C	Aurignacian	11150	120	MIS 3	Gif 4263	d'Errico/Goñi (2003)
South	France	Cottes		14C	Aurignacian	12300	600	MIS	Gif 3448	d'Errico/Goñi

							3		(2003)
South	France	Ferrassie	14C	Mousterian	14360	150	MIS 3	GrN 4457	d'Errico/Goñi (2003)
South	France	Morin	14C	Aurignacian	15180	130	MIS 3	Gif 2428	d'Errico/Goñi (2003)
MP	North Iberia	Reclau Viver	14C	Aurignacian	15683	1800	MIS 3	WSU-500	d'Errico/Goñi (2003)
MP	North Iberia	Aitzbitarte	14C	Aurignacian	16560	600	MIS 3	M 1015	d'Errico/Goñi (2003)
MP	North Iberia	Caldeirao	14C	Aurignacian	17970	110	MIS 3	GrN 5993	d'Errico/Goñi (2003)
MP	South Iberia	Salpetriere	AMS	Mousterian	18060	140	MIS 3	OxA 5541	d'Errico/Goñi (2003)
South	France	Regismont le Haut	14C	Aurignacian	18550	500	MIS 3	Ly 2312	d'Errico/Goñi (2003)
South	France	Lezetxiki	14C	Aurignacian	18670	600	MIS 3	Ly 4815	d'Errico/Goñi (2003)
MP	North Iberia	Roc en Pail	14C	Aurignacian	19340	780	MIS 3	I 6144	d'Errico/Goñi (2003)
South	France	Salpetriere	14C	Mousterian	19510	620	MIS 3	NY 543	d'Errico/Goñi (2003)
South	France	Moula	14C	Aurignacian	19600	400	MIS 3	Gif 6019	d'Errico/Goñi (2003)
South	France	Moula	14C	Mousterian	20060	320	MIS 3	Ly 2902	d'Errico/Goñi (2003)
South	France	Pech de l Aze	14C	Mousterian	20100	310	MIS 3	Ly 2217	d'Errico/Goñi (2003)
South	France	Flageolet	14C	Mousterian	20240	770	MIS 3	GrN 6785	d'Errico/Goñi (2003)
South	France	Ferrassie	14C	Aurignacian	20270	1760	MIS 3	Ly 1749	d'Errico/Goñi (2003)
South	France	La Roche a Pierrot	14C	Aurignacian	21100	170	MIS 3	Gif 4267	d'Errico/Goñi (2003)
South	France	Villefranche sur Saone	14C	Aurignacian	21100	540	MIS 3	Ly 2192	d'Errico/Goñi (2003)
South	France	Anecrial		Mousterian	21330	240	MIS 3		d'Errico/Goñi (2003)
MP	South	Anecrial	14C	Aurignacian	21560	680	MIS	ICEN 964	d'Errico/Goñi

MP	Iberia South	Labeko Koba	AMS	Aurignacian	21560	220	3 MIS	OxA 5526	(2003) d’Errico/Goñi
MP	Iberia North	Peyrehaute	14C	Aurignacian	21660	300	3 MIS	Ua 3323	(2003) d’Errico/Goñi
South	Iberia France	Ferrassie	14C	Aurignacian	21700	1500	3 MIS	Ly 1150	(2003) d’Errico/Goñi
South	France	Ferrassie	14C	Aurignacian	22200	650	3 MIS	Gif 4265	(2003) d’Errico/Goñi
South	France	La Roche a Pierrot	14C	Aurignacian	22700	240	3 MIS	Gif 4268	(2003) d’Errico/Goñi
South	France	Canecaude	14C	Chatelperronian	22960	840	3 MIS	Ly 2193	(2003) d’Errico/Goñi
South	France	Ferrassie	14C	Aurignacian	22980	330	3 MIS	Gif 2709	(2003) d’Errico/Goñi
South	France	Caldeirao	14C	Aurignacian	23000	240	3 MIS	Gif 4270	(2003) d’Errico/Goñi
MP	South	Bidon	AMS	Mousterian	23040	340	3 MIS	OxA 5521	(2003) d’Errico/Goñi
South	Iberia France	Flageolet	14C	Mousterian	23260	370	3 MIS	Ly 2861	(2003) d’Errico/Goñi
South	France	Labeko Koba	14C	Aurignacian	23280	670	3 MIS	Ly 1608	(2003) d’Errico/Goñi
MP	North	Jarama	14C	Aurignacian	23360	300	3 MIS	Ua 3035	(2003) d’Errico/Goñi
MP	Iberia South	Anecrial	AMS	Mousterian	23380	500	3 MIS	Beta 56640	(2003) d’Errico/Goñi
MP	Iberia South	Le Raysse	14C	Aurignacian	23450	1240	3 MIS	ICEN 963	(2003) d’Errico/Goñi
South	Iberia France	Ferrassie	14C	Aurignacian	23630	480	3 MIS	Ly 2783	(2003) d’Errico/Goñi
South	France	Ferrassie	14C	Aurignacian	23700	250	3 MIS	Gif 4264	(2003) d’Errico/Goñi
South	France	Grotte de la Baume	14C	Aurignacian	23700	240	3 MIS	Gif 4269	(2003) d’Errico/Goñi
South	France	Bidon	14C	Mousterian	24180	840	3 MIS	Ly 550	(2003) d’Errico/Goñi
South	France	Cal Coix	14C	Mousterian	25000	0	3 MIS	Ly 2901	(2003) d’Errico/Goñi

MP	North	Grotte du Renne		Aurignacian	25000	0	3 MIS		(2003) d’Errico/Goñi
South	Iberia France	Theillat	AMS	Chatelperronian	25280	280	3 MIS	OxA 8450	(2003) d’Errico/Goñi
South	France	Theillat	14C	Chatelperronian	26060	460	3 MIS	Ly 2919	(2003) d’Errico/Goñi
South	France	Gatzarria	14C	Chatelperronian	26060	460	3 MIS	Ly-2929	(2003) d’Errico/Goñi
South	France	Baume de Gigny	14C	Aurignacian	27000	270	3 MIS	GrN 4346	(2003) d’Errico/Goñi
South	France	Morin	14C	Mousterian	27500	0	3 MIS		(2003) d’Errico/Goñi
MP	North	Morin	14C	Aurignacian	27607	540	3 MIS	SI 952B	(2003) d’Errico/Goñi
MP	Iberia North	Pataud	14C	Aurignacian	28350	540	3 MIS	SI 952	(2003) d’Errico/Goñi
South	Iberia France	Cova Negra	14C	Aurignacian	28510	280	3 MIS	GrN 6273	(2003) d’Errico/Goñi
MP	South	Cova Negra	14C	Mousterian	28700	0	3 MIS	C 848	(2003) d’Errico/Goñi
MP	Iberia South	Cova Negra	14C	Mousterian	28700	0	3 MIS	C 849	(2003) d’Errico/Goñi
MP	Iberia South	Tournal	14C	Mousterian	28900	5600	3 MIS	C 847	(2003) d’Errico/Goñi
SP	Iberia France	Gorham s Cave	14C	Aurignacian	29000	0	3 MIS	Ly 1895	(2003) d’Errico/Goñi
MP	South	Roc aux Sorciers	AMS	Aurignacian	29250	750	3 MIS	OxA 7110	(2003) d’Errico/Goñi
South	Iberia France	Gatzarria	14C	Mousterian	30000	0	3 MIS	Ly 2755	(2003) d’Errico/Goñi
South	France	La Rochette	14C	Aurignacian	30080	590	3 MIS	GrN 4363	(2003) d’Errico/Goñi
South	France	Ferrassie	14C	Mousterian	30700	400	3 MIS	GrN 4345	(2003) d’Errico/Goñi
South	France	Pecheurs	14C	Aurignacian	30970	395	3 MIS	GrN 5750	(2003) d’Errico/Goñi
South	France	Pataud	14C	Mousterian	31000	0	3 MIS	Ly 2343	(2003) d’Errico/Goñi

							3		(2003)
South	France	Ermita (Ermittia)	14C	Aurignacian	31080	290	MIS 3	GrN 6274	d'Errico/Goñi (2003)
MP	North Iberia	Grotte du Renne	AMS	Mousterian	31100	500	MIS 3	OxA 4603	d'Errico/Goñi (2003)
South	France	Baume de Gigny	AMS	Chatelperronian	31300	600	MIS 3	OxA 8533	d'Errico/Goñi (2003)
South	France	Baume de Gigny	14C	Mousterian	31500	0	MIS 3	Ly 3063	d'Errico/Goñi (2003)
South	France	Flageolet	14C	Mousterian	31500	0	MIS 3	Ly 804	d'Errico/Goñi (2003)
South	France	Montagne de Girault	14C	Aurignacian	31500	0	MIS 3	Ly 2727	d'Errico/Goñi (2003)
South	France	Zafarraya	14C	Mousterian	31500	0	MIS 3	Ly 3038	d'Errico/Goñi (2003)
MP	South Iberia	Grotte des Hyenes	14C	Mousterian	31800	500	MIS 3	Gif/LSM 9140 I	d'Errico/Goñi (2003)
South	France	Dubalen	14C	Aurignacian	31820	550	MIS 3	Gif 8568	d'Errico/Goñi (2003)
South	France	Brugas	14C	Chatelperronian	31900	530	MIS 3	Gif-8171	d'Errico/Goñi (2003)
South	France	Grotte du Renne	14C	Mousterian	32000	0	MIS 3	Ly 2038	d'Errico/Goñi (2003)
South	France	La Roche Cotard	14C	Chatelperronian	32000	1200	MIS 3	Ly-5062	d'Errico/Goñi (2003)
South	France	Flageolet	14C	Mousterian	32000	0	MIS 3	Gif 4383	d'Errico/Goñi (2003)
South	France	Trou du Renard	AMS	Aurignacian	32040	850	MIS 3	GifA 95560	d'Errico/Goñi (2003)
South	France	Grotte des Hyenes	14C	Mousterian	32100	0	MIS 3	Ly 1579	d'Errico/Goñi (2003)
South	France	Baume de Gigny	14C	Aurignacian	32190	620	MIS 3	Gif-8174	d'Errico/Goñi (2003)
South	France	Jarama	14C	Mousterian	32300	0	MIS 3	Ly 971	d'Errico/Goñi (2003)
MP	South Iberia	Bajondillo	AMS	Mousterian	32600	1800	MIS 3	Beta 56639	d'Errico/Goñi (2003)
MP	South	Baume de Gigny	AMS	Aurignacian	32770	1065	MIS	Ua 18050	d'Errico/Goñi

South	Iberia France	Montagne de Girault	14C	Mousterian	33000	0	3 MIS	Ly 2526	(2003) d'Errico/Goñi
South	France	Ferrassie	14C	Mousterian	33000	0	3 MIS	Ly 3037	(2003) d'Errico/Goñi
South	France	Chenelaz		Aurignacian	33200	0	3 MIS		(2003) d'Errico/Goñi
South	France	Grotte du Renne	14C	Mousterian	33380	860	3 MIS	Ly 6762	(2003) d'Errico/Goñi
South	France	Theillat	AMS	Chatelperronian	33400	600	3 MIS	OxA 9122	(2003) d'Errico/Goñi
South	France	Arbreda	14C	Chatelperronian	33440	1000	3 MIS	Ly 2918	(2003) d'Errico/Goñi
MP	North	Bajondillo	14C	Aurignacian	33500	0	3 MIS	Beta 46690	(2003) d'Errico/Goñi
MP	Iberia South	Bize (grande grotte)	AMS	Aurignacian	33690	1195	3 MIS	Ua 17150	(2003) d'Errico/Goñi
South	Iberia France	Grotte du Renne	14C	Aurignacian	34200	0	3 MIS	Ly 1031	(2003) d'Errico/Goñi
South	France	Castanet	AMS	Chatelperronian	34450	750	3 MIS	OxA 8452	(2003) d'Errico/Goñi
South	France	Ferrassie	AMS	Aurignacian	34800	1100	3 MIS	GifA 97312	(2003) d'Errico/Goñi
South	France	Le Mas Viel	14C	Mousterian	35000	0	3 MIS	Gif 4584A	(2003) d'Errico/Goñi
South	France	Le Mas Viel	14C	Mousterian	35000	0	3 MIS	Gif 3934	(2003) d'Errico/Goñi
South	France	Henin sur Cojeul	14C	Mousterian	35000	0	3 MIS	Gif 3935	(2003) d'Errico/Goñi
South	France	Tournal	14C	Mousterian	35600	1,100	3 MIS	Gif 8868	(2003) d'Errico/Goñi
South	France	La Rochette	14C	Mousterian	35800	0	3 MIS	Ly 1898	(2003) d'Errico/Goñi
South	France	Pendo	14C	Mousterian	36000	550	3 MIS	GrN 4362	(2003) d'Errico/Goñi
MP	North	Millan		Aurignacian	36960	6580	3 MIS		(2003) d'Errico/Goñi
MP	Iberia North	Henin sur Cojeul	14C	Mousterian	37450	650	3 MIS	GrN 11661	(2003) d'Errico/Goñi

South	Iberia France	La Roche Cotard	14C	Mousterian	37900	1,800	3 MIS	Gif 8869	(2003) d’Errico/Goñi
South	France	Barbas	14C	Mousterian	37900	0	3 MIS	Gif 4384	(2003) d’Errico/Goñi
South	France	Grotte du Renne	14C	Mousterian	38300	500	3 MIS	Gif/LSN 9591	(2003) d’Errico/Goñi
South	France	La Roche Cotard	AMS	Chatelperronian	38300	1300	3 MIS	OxA 8451	(2003) d’Errico/Goñi
South	France	Arbreda	14C	Mousterian	38400	0	3 MIS	Gif 4447	(2003) d’Errico/Goñi
MP	North	Beneito	14C	Aurignacian	38500	1000	3 MIS		(2003) d’Errico/Goñi
MP	Iberia South	Roca Dels Bous	AMS	Mousterian	38800	1900	3 MIS	AA 1387	(2003) d’Errico/Goñi
MP	Iberia North	Esquilleu	AMS	Mousterian	38800	1200	3 MIS	AA 6481	(2003) d’Errico/Goñi
MP	Iberia North	Grotte XVI	AMS	Mousterian	39000	300	3 MIS	Beta 149320	(2003) d’Errico/Goñi
South	Iberia France	Le Loup (La Gaillardie)	AMS	Chatelperronian	39800	0	3 MIS	AA 2674	(2003) d’Errico/Goñi
South	France	Le Mas Viel	14C	Chatelperronian	40000	0	3 MIS	Gif 2414	(2003) d’Errico/Goñi
South	France	Pena Miel	14C	Mousterian	40000	0	3 MIS	GIF 3559	(2003) d’Errico/Goñi
MP	North	Pech de l Aze	14C	Mousterian	40000	0	3 MIS	CSIC 546	(2003) d’Errico/Goñi
South	Iberia France	Baume Neron	14C	Mousterian	42230	1340	3 MIS	GrN 6784	(2003) d’Errico/Goñi
South	France	Arrillor	14C	Mousterian	43000	1100	3 MIS	Gif 9132	(2003) d’Errico/Goñi
MP	North	Vanguard Cave	AMS	Mousterian	43100	1700	3 MIS	OxA 6250	(2003) d’Errico/Goñi
MP	Iberia South	Carihuela	AMS	Mousterian	44100	0	3 MIS	OxA 7078	(2003) d’Errico/Goñi
MP	Iberia South	Arrillor	AMS	Mousterian	45200	1200	3 MIS	Beta 74381	(2003) d’Errico/Goñi
MP	Iberia North	Arrillor	AMS	Mousterian	45400	1800	3 MIS	OxA 6251	(2003) d’Errico/Goñi

	Iberia								3		(2003)
MP	North Iberia	Roca Dels Bous			AMS	Mousterian	45700	1200	MIS 3	OxA 6084	d'Errico/Goñi (2003)
MP	North Iberia	Vanguard Cave			AMS	Mousterian	46900	0	MIS 3	AA 6480	d'Errico/Goñi (2003)
MP	South Iberia				AMS	Mousterian	49400	0	MIS 3	OxA 7127	d'Errico/Goñi (2003)
CP		Sclayn Cave	1A		14C	M	38.6	1.5	MIS 3		Huxtable, 1998
CP		Sclayn Cave	1a		TL	m	44	5.5	MIS 3		Huxtable, 1998
CP		Burgtonna			U series	Taubachian	101		MIS 3		Svoboda 1989
CP		Ehringsdorf			U series	MP	102-244		MIS 5?		Brunnacker et al 1983
CP		Burgtonna			U series	Taubachian	104		MIS ?		Svoboda 1989
CP		Tabauch			U series	Taubachian	110		Eem		Svoboda 1989
CP		Burgtonna			U series	Taubachian	111		Eem		Svoboda 1989
CP		Weimar			U series	Taubachian	115		Eem		Svoboda 1989
CP		Tabauch			U series	Taubachian	116		Eem		Svoboda 1989
CP		Weimar			U series	Taubachian	118		Eem		Svoboda 1989
CP		Sclayn Cave (Belgium)	Layer 5b		TL	Levallois	130	20	MIS 5e/6		Huxtable, 1998
CP		Ehringsdorf			U series	MP	150-250		MIS 5e/6		Schwartz 1982
CP		Weimar			U series	Taubachian	151		MIS 5e/6		Svoboda 1989
MP		L' Arbreda	E2BE 116-3		14C AMS	M	34.1	0.75	MIS 3		Bischoff et al., 1989
MP		El Castillo		8	14C AMS	EUP	37.7	1.8	MIS 3		Cabera Valdes & Bischoff, 1989
MP		L' Arbreda	E2BE 111-1		14C AMS	EUP	37.7	1	MIS 3		Bischoff et al., 1989
MP		L' Arbreda	E2BE 111-2		14C AMS	EUP	37.7	1	MIS 3		Bischoff et al., 1989
MP		L' Arbreda	E2BE-114-4		14C AMS	EUP	38.7	1.2	MIS 3		Bischoff et al., 1989
MP		L' Arbreda	E2BE 116-1		14C AMS	M	39.4	1.4	MIS		Bischoff et al.,

MP	L' Arbreda	E2BE 113-3		14C AMS	EUP	39.9	1.3	3 MIS	1989 Bischoff et al.,
MP	L' Arbreda	E2BE 116-3		14C AMS	M	41.4	1.6	3 MIS	1989 Bischoff et al.,
MP	Banyolas			U series	?	45	4	3 MIS	1989 Julia & Bischoff,
MP	Guattari (Italy)		5	ESR	Pontinian	76	13	3 MIS	1991 Schwarz et al
MP	Abri Laborde	29-32		TL	Ferrassie	78.5	7.5	4/5 MIS	n.d. [kuhn 1991] Huxtable, 1998
MP	El Castillo	lev 23 flowstone		U series	L/MP	89	1	4/5 MIS	Bischoff et al.,
MP	Asprochaliko (Greece)		18	TL	Moust typ	98.5	12	4/5 MIS	1989 Huxtable, 1998
SP	Combe Grenal		49	TL	Moust typ	68	7	4/5 MIS	Bowman &
SP	Abri Pie-Lombard			TL	Moust typ	70	7.7	4 MIS	Sieveking, 1983 valledas et al
SP	La Chaise	7		U series	MP	71	6	4 MIS	1987 Laville et al.,
SP	La Chaise	7		U series	MP	89.5	5	4 MIS	1986 Laville et al.,
SP	Seclin	7		TL	Levallois	93	9	5 MIS	1986 Huxtable, 1998
SP	La Chaise	Upper Stalagmite		U series	MP	94	22	5 MIS	Laville et al.,
SP	La Chaise	Upper Stalagmite		U series	MP	101	7	5 MIS	1986 Laville et al.,
SP	La Chaise	7		U series	MP	101	12	5 MIS	1986 Laville et al.,
SP	Pech de l' Aze II	3		U series	M	103	27	5 MIS	1986 Laville et al.,
SP	Combe Grenal	60		TL	Acheulean	105	14	5 MIS	1986 Bowman &
SP	Abri Pie-Lombard			TL	Moust typ	108.4	9.8	5 Eem	Sieveking, 1983 valledas et al

								1987
SP	La Chaise	11 upper	U series	MP	112	5	Eem	Laville et al., 1986
SP	Combe Grenal	60	TL	Acheulean	113	13	Eem	Bowman & Sieveking, 1983
SP	La Chaise	7	U series	MP	114	7	Eem	Laville et al., 1986
SP	La Chaise	11 upper	U series	MP	117	8	Eem	Laville et al., 1986
SP	Abri Vaufrey	layer 1V K11 & 12	TL	M	120	13	Eem	Huxtable, 1998
SP	La Chaise	Level 11 upper	U series	MP	123	17	Eem	Laville et al., 1986
SP	La Chaise	Level 51	TL	MP	126	15	Eem	Laville et al., 1986
SP	Pech de l' Aze II	Layer 6-9	ESR	Acheulean	130-162		MIS 5e/6	Huxtable, 1998
SP	La Chaise	Level 11	U series	MP	146	16	MIS 5e/6	Laville et al., 1986
SP	La Chaise	level 11	U series	MP	151	15	MIS 5e/6	Laville et al., 1986