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Radiocarbon Evidence for the Late Upper Palaeolithic Recolonisation of Central Europe

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ABSTRACT

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RADIOCARBON EVIDENCE FOR THE LATE UPPER PALAEOLITHIC RECOLONISATION OF CENTRAL EUROPE

By Cheryl Anne Ross

In recent years the development of new approaches to the understanding of prehistoric human colonisation has been at the forefront of Palaeolithic Archaeology (Housley et al. 1997; Anderson and Gillam 1999; Bouquet-Appel and Demars 2000). Two main topics of debate have centred on the reliability of radiocarbon data, and the applicability of predictive modelling procedures. In this thesis I examine both in an attempt to build on existing theoretical perspectives and methodological applications to provide new insights into the Late Upper Palaeolithic recolonisation of Central Europe. Radiocarbon evidence is correlated with the palaeo-environmental record to question the timing of abandonment and recolonisation of Central Europe during Oxygen Isotope Stage 2. Questions about the rates and directions of population dispersal, and possible refugia are also addressed. Using GIS predictive modelling methods, and radiocarbon data as primary archaeological indicators, I propose a general model of late Upper Palaeolithic colonisation processes from 25000 cal BC – 11000 cal BC.

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CHAPTER ONE

INTRODUCTION

1.1 PURPOSE AND OBJECTIVES

Archaeologists generally agree that the challenge in colonisation research is to seek to understand the relationships between social behaviour, space and time (Chapman 1998b, 138). This is not an easy task for Palaeolithic studies where the database is often limited by both sparseness and the quality of preservation of the material record. Moreover, there are no comparable ethnographic examples of such processes at large chronological and spatial distances. Yet, advances in technology and improved radiocarbon dating and spatial modelling techniques have enabled archaeologists to approach colonisation studies with new vigour in recent years.

The work presented here seeks to examine, quantify and synthesize the radiocarbon evidence for late glacial hominid colonisation processes during the Central European late glacial, broadly equivalent to Oxygen Isotope Stage 2 (OIS-2). It investigates the use of archaeological radiocarbon dates as a primary source for the investigation of these processes. Of particular interest are the human choices about occupation and movement during the cold phases of the European Last Glacial Maximum (LGM). A spatial and chronological model for the late Upper Palaeolithic colonisation of Central Europe is developed and evaluated against empirical data, and current colonisation reconstructions for the period.

The research aims to build on existing theoretical perspectives and methodological applications to provide new insights into Palaeolithic archaeology, European hominid expansions and hunter-gatherer world constructs. It is hoped that this research will not only contribute to our understanding of our ancestors, but to the development of our discipline.

This work is essentially a two-part project. The first part evaluates the use of archaeological radiocarbon data as an indicator of colonisation processes. The objectives are as follows:

1) To compile a database of all available archaeological radiocarbon dates for sites within the study area;
2) To develop a means of determining an acceptability threshold for these control data by invoking some form of quality assessment criteria.
3) The development of a working database comprised of single characterised dates representing individual culture layers.

This first part of the research is developed in Chapter Two.

The second part investigates various approaches to modelling these control data both chronologically and spatially, to allow the following objectives of this research to be met:

1) To establish the timing and location of colonisation and/or abandonment of human populations in Central Europe for the period approximately 25000 – 11000 years ago;
2) To determine the rate(s) and direction(s) of population spread;
3) To determine the role that the Carpathian Basin may have played as potential refugium for hunter-gatherers during the cold phases of the late glacial;
4) To place the colonisation of Central Europe and the Carpathian Basin within the context of greater Europe.

It is proposed that these objectives can be achieved through the quantification of radiocarbon data, and spatial modelling techniques.

This research will address three additional queries. The first is the potential for site prediction in areas of poor archaeological visibility (i.e. the extent to which a chronology might be established where sites are assumed to be buried). The Carpathian Basin provides an ideal setting for addressing this question. Post-glacial sedimentation is extensive here and despite significant contributions to research (Dobosi 1983; Dobosi and Vörös 1987; Kozlowski 1996b) the archaeological record can be considered too sparse to provide satisfactory conclusions about the role this region may have played at the LGM. The application of a predictive model may shed clues toward this end.

The second query is to assess the potential for predicting Palaeolithic hunter-gatherer decision-making processes with respect to movement. It can be shown that the determination of population spread may be derived through simple modelling of data (in this case radiocarbon dates and site location). The potential for predicting population movement into regions where data is limited is assessed using statistical and spatial modelling. It is suggested that the results of such analyses reflect the decision-making processes of the Palaeolithic peoples that directed this movement.

Finally, the work presented here will assess the extent to which radiocarbon data can be used to interpret and model the behavioural and social factors involved in colonisation processes.

The assumption that colonisation processes can be traced and explained, but not predicted, is taken (Jochim, Herhahn and Starr 1999, 129). It is further assumed that human colonisation processes are systematic (Gamble 1995, 6; Housley, Gamble, Street and Pettitt 1997, 49-50), with purposeful hunter-gatherers acting on choices, as opposed to random dispersal too often assumed in spatial modelling attempts of this nature (e.g. Ammerman and Cavalli-Sforza 1979).

1.2 THE CHARACTER OF COLONISATION

The term *colonisation* takes on a dual meaning. On the one hand, it represents an action, which must therefore be determined and hopefully explained. On the other hand, colonisation as a concept represents a framework for research that enables prehistoric archaeologists to address hunter-gatherer research in new and innovative ways.

Hominids as a colonising species, time and space as colonising surfaces, behaviour/social actions as a means to colonisation, and the variability therein, form a colonisation framework. The processes of colonisation are determined through the systematic execution of human decisions, governed by the factors that lead individuals or populations to colonise new niches. Of course the challenge to determine the character of colonisation in a prehistoric hunter-gatherer landscape, and the processes involved is, to say the least, difficult.

Certainly Chapman's (1997b, 138) view that the social and ecological landscapes hold similar truths, can be reflected in the variability of colonisation processes - dependent on time, space and social conceptual frameworks of human perspectives of their world. This view of landscape is supported by Jochim, who answers Wobst's (1990) concerns, in an examination of the Palaeolithic and Mesolithic in Southwest Germany. He suggests that hunter-gatherer archaeology has begun to recognise "Variation within culture areas and natural habitats, by focusing on individual behaviour rather than that of entire groups, and by borrowing and adapting mathematical models of decision-making and behaviour... " (Jochim 1998, 2). Such innovations have encouraged archaeologists to take up the challenges colonisation research has to offer. Recent work in Moravia (Svoboda, Ložek and Vlček 1996), Northwest Europe (Housley et al. 1997) and Greece (Bailey, ed. 1997) provide excellent examples of efforts to determine the character and processes of colonisation in late glacial Europe.

1.2.1 Colonisation

> "As yet, no theory or methodology allows us to accommodate a changeable environment, changeable humans, and a long period of time within the same hypotheses. Their implications for our data would be so equifinal that virtually any scenario would be plausible" (Wobst 1990, 329-330).

Contrary to the above statement, this research argues that the evolving character of colonisation provides a framework for research that enables archaeologists to strive for the resolution of such concerns.

The study of human colonisation has only recently reached the forefront of Palaeolithic archaeology. Bringing into new context the well-debated concepts of migration and diffusion (Gamble 1993), colonisation, by definition, has emerged to provide a useful framework for the study of large-scale human dispersals.

> "A process occurring on a larger scale both temporally and geographically. Major extension of species habitat or range to include established occupation of areas previously unoccupied and use of ecological niches. This may occasionally be due to the removal of environmental barriers but more likely to behavioural and biological changes. If the latter, then adaptive and exaptive explanations need to be investigated" (Gamble 1995, 7).

A discussion about colonisation during the Upper Palaeolithic is generally regarded as a discussion about the movement of small groups of hunter-gatherers across a large spatial landscape and large expanse of time (Gowlett 1993, 10-11; Jochim 1998, 2). Migration and diffusion are differentiated from colonisation in terms of both scale (temporally and spatially) and interaction between groups and individuals. Migration is defined by Gamble (1993, 45) as "a discrete event, involving directed or intentional, though not necessarily calculated, movement from one type of place to another ... Short timescales or even singular events, though not necessarily short geographical distances. One-off events that may or may not have lasting consequences for colonisation... " The concept of migration has been the favoured explanation, whether understood in terms of this definition or another, for human movement and dispersals (Jochim et al. 1999, 129). In fact, Jochim et al. (1999, 129) point out that the attitude that "wherever dramatic changes in the archaeological record occur in areas previously unoccupied, immigration seems often to still be viewed as an explanation of last resort". That migration is considered density dependent, reactive rather than purposeful, and that material remains are equated with ethnic identity, led to its rejection as a valid explanation.

While migration remains a useful concept, *colonisation* does not provide an explanation of process but rather a framework for the resolution of a set of inter-related and changing processes that lead to large-scale expansion. The character of colonisation is such that these processes can be examined and interpreted using a social archaeology of hunter-gatherers, encompassing change and continuity in both large-scale spatial and temporal ranges.

1.2.2 Refugium

The concept of refugium is also important to the understanding of colonisation processes. Jochim (in keeping with the ecological theoretical connotations inherent in colonisation research) provides a definition.

> "A refugium is a place of shelter, an area of relatively favorable conditions to which animals retreat under adverse conditions. It assumes a special role by virtue of its *relative* richness" (Jochim 1987, 320).

While colonisation accounts for species movement into new ecological niches and the use of those niches (Gamble, 1993, 1995), it also allows for the examination of refugia as explanation. The process of achieving this determination however, is not as simple as it may first appear.

In an exploration of refugium in Europe during the LGM, Jochim refers to rare or nonexistent settlement in Poland and Moravia at this time. He suggests that "if these peoples did not simply die out or become archaeologically invisible, then they must have moved into refuge areas... " (Jochim 1987, 322).

There is an eminent danger however, that refugia can be used to explain discontinuity in colonisation processes (Gamble 1993, 50-51). Soffer's work in Eastern Europe reflects this concern (1987). Here she remarks that, "though the data suggest some shifts in population... we have no unequivocal way of evaluating either decimation of local populations or the issue of hunter-gatherer refugia" (Soffer 1987, 344). Street and Terberger propose that there is increasing evidence to support the view that "regions peripheral to proposed Pleniglacial refugia were also occupied sporadically or at low intensity... " (1999, 259).

Perhaps it is the character of refugia which needs to be less rigidly defined rather than the depiction by Jochim that refugium, given assumptions about resource abundance, should be visible in hunter-gatherer terms as a "bounded area of high population density" (Jochim 1987, 324). More to the point, refugium, in the context of colonisation processes, should be considered bounded only in terms of hunter-gatherer mobility and behaviour. Of course, ecological niches and range extension are assumed to exist, but the boundaries of these are flexible. This may indeed account for issues of continuity and discontinuity in the archaeological record. The role of refugium in colonisation research is one that also belongs to a spatial, temporal and social landscape.

1.2.3 The Character of Hunter-gatherer Archaeology of the Upper Palaeolithic

Gowlett (1993, 11) and others (e.g. Kozlowski 1986; Bailey 1997; Jochim 1998) recognise that while it is dangerous to make broad generalisations about prehistoric groups based on any one hunter-gatherer society, there are fundamental characterisations that we can draw on in our efforts to explain past hunter-gatherer behaviour. These include low population density, high mobility and small home ranges. Since this impression of prehistoric hunter-gatherers may not "fit" every local scenario, prehistoric archaeologists look to modern hunter-gatherer societies for additional insight. Arguably, ethnographic analyses can be used cautiously as an effective means of interpreting prehistoric hunter-gatherer behaviour (Newell and Constandse-Westermann 1996, Binford, 1998).

Hunter-gatherer archaeology of the Palaeolithic has traditionally been one of "stones and bones" (Jochim 1998, 3), evidence of which is usually limited and thinly spread over a large landscape. As Jochim points out, "Sites with unusual conditions of preservation may dominate the archaeological record because of their richness, but they are not likely to be "typical" or representative of more than a fraction of the activities carried out" (1998, 2). More often than not, the degree of preservation is less than desirable for radiocarbon dating as material remains are subject to environmental or contaminated factors that adversely affect the accuracy of results.

The Upper Palaeolithic archaeology of hunter-gatherers then, is faced with a difficult circumstance. Despite considerable regional variation (e.g. see Svoboda et al. 1996), there has been a tendency to make sweeping categorisations over the larger landscape. For example, the term Gravettian has been applied to a broad lithic typological grouping that is spread across western, central and Eastern Europe, and across a time span of approximately 12000 years (see Kozlowski 1986). Of course this is not to presume that regional variations are not recognised or studied, rather they are ignored in favour of the sweeping categorisations that tend to dominate large-scale research. The nature of Palaeolithic hunter-gatherer archaeology often includes variable preservation conditions, limited material culture and a radiocarbon dating program that is not always considered dependable. In light of this, archaeologists often find themselves grouping very different archaeological sites (open-air sites and rockshelters for example) and considering sites hundreds of years apart as contemporary (Jochim 1998, 1-3).

Even so, hunter-gatherer archaeology of the Upper Palaeolithic is beginning to look beyond the traditional "stones and bones" analyses (e.g. Dobosi 1990; Srejović (ed.) 1996), beyond inter and intra-site comparisons (e.g. Abramova 1993; Grigoriev 1993) and beyond the assumed characterisations of the Palaeolithic "hunter-gatherer" (i.e. Binford 1998). These peoples are now recognised as dynamic individuals and groups, adaptive and flexible in space and time (Wobst 1990, 333). Within the context of colonisation research, the character of Upper Palaeolithic hunter-gatherer archaeology is changing.

1.2.4 Problematic Concerns for Colonisation Research in Hunter-Gatherer Archaeology

In this chapter, I have previously alluded to the fact that hunter-gatherer archaeology in the Palaeolithic can be particularly frustrating. In colonisation research, problematic concerns such as inconsistency in the data due to variable preservation of the archaeological record, lead to intensive criticism of data quality, methodology, and also to renewed theoretical debates. The following discussion outlines the major problems faced in hunter-gatherer archaeology by colonisation researchers.

Colonisation modelling is prone to environmental determinism (e.g. Binford 1998; Ray et al. 1999). Wobst remarks on this phenomenon, suggesting that,

> "nature is easier to measure than human behaviour... Both nature and behaviour will vary if measured at points far enough apart... [and] differing measurements invite the jump from associated change in nature and behaviour, to correlated change and to causation in which all human behavioural change and variation are attributed to environmental stress or to avoid environmental risk" (Wobst 1990, 326).

This is particularly relevant to large-scale colonisation studies that envelop large-scale environmental events such as glaciations or volcanic eruptions, providing readily acceptable explanations (or justifications for explanation) for interpreting population dispersal and consequently social behaviour. An example attempting to incorporate an ecological approach to an environmentally deterministic scenario is provided by Bang-Andersen (1996) whose examination of colonisation in Southwest Norway is referenced to palaeo-environmental research. While the character of colonisation is such that hunter-gatherers are given the primary active role in the space - time - social relationship, modelling this relationship in a fashion more suitable to current theoretical constraints for human dispersal, requires a cautious approach. Arguably, that approach must distance itself from the "cause and effect" implied in environmental determinism.

> "... the problem of scale is manifest in Upper Paleolithic regional analysis [of hunter-gatherers] that unquestionably employs some of the traditional typological units, which collapse time, space and/or variation" (Conkey 1987, 69).

This argument is reflected in colonisation research and the conceptualisation of the region and regional variability (Conkey 1987; Wobst 1990). Wobst (1990, 323) in fact argues "to analyse worldwide variations in hunter-gatherer behaviour, we need information about change and variation along spatial scales of behavioural relevance to hunter-gatherers". Certainly in colonisation research where the subject matter occurs in a "larger" framework, there are multiple and variable levels of scale within a single study. Given the concerns mentioned here, this indeed presents a problem.

As I have previously discussed, the grouping of sites spatially, temporally and culturally, can be problematic in hunter-gatherer research and can result in misrepresentations of the past. Conkey (1987, 9) suggests that the resolution to this problem rests in changing the way we view the archaeological record - away from assuming that the investigated archaeological record comprises the past regional patterning, toward the development of models "for a particular prehistoric context that then structures our archaeological inquiry... " It is therefore considered acceptable, and even appropriate, that largely variable cultural complexes are grouped according to broader classifications in an effort to maintain a more manageable research framework (Kozlowski 1986; Bouquet-Appel and Demars 1998).

Conkey (1987, 10) further comments that modelling large-scale regional landscapes "does not usually allow for small scale regional variation in local geographic features..." This, she suggests, raises concerns about post-depositional processes inferring an evolutionary bias in long temporal studies. This is certainly an issue to be addressed (particularly in terms of potential refugium) in the Carpathian Basin of Central Europe where post-glacial sediment has accumulated rapidly and to a much greater extent than in the regions peripheral to it (Kozlowski 1986, figure 1).

1.3 THE PROCESSES OF COLONISATION

> "It is not only important to the archaeologist that monuments A, B and C were in place before the construction of droveway D and field-system E - it was of ideological and social significance to the inhabitants of the later period" (Chapman 1997a, 16).

Chapman's reference to the relationship between space, time and behaviour comes in a discussion within the theoretical perspectives of landscape archaeology, which additionally refers to colonisation as a metaphor for archaeological practice (see Chapman 1997a, 1-21). Here however, these words not only highlight this relationship, but illustrate the importance of attempts to take on the challenge of modelling the processes of colonisation, spatially and chronologically. The advent of radiocarbon dating as a means to establishing chronology, and new developments in computer applications and modelling techniques have paved the way to address the need to produce models that could describe the processes by which "colonists" moved. Among the first promising models of this nature was one by Ammerman and Cavalli-Sforza (1979), in *The Wave of Advance Model for the Spread of Agriculture in Europe*.

Modelling is most often understood in terms of being a predictive methodology. In fact, models are produced to describe, and (in the case of colonisation) to explain the archaeological record (Jochim et al. 1999, 132). Attempts to use them in a predictive manner occur after, for example in the manipulation of the data in various ways that produce results that can be tested empirically. These are often the result of simulation studies. Examples of predictive modelling in colonisation research can be found on North American (Steele, Adams and Sluckin 1998) and African data (Young and Bettinger 1995; Ray, Schneider and Excoffier 1999).

Modelling the processes of colonisation is certainly not an easy task. Inherent in the process is the risk of either over-simplifying, or attempting to include so many variables that the complexity of the generated model is prone to increased error. Yet there are important considerations that must be addressed.

Most models stemming from colonisation research are governed in terms of palaeo-demography (Bouquet-Appel and Demars 2000), hunter-gatherer range and mobility (Kelley 1995) and human dispersals (Steele et al. 1998; Ray et al. 1999). Recently new innovations in genetic archaeology have led to new models of human origins and colonisation through DNA analyses, as well as from within the framework of colonisation research (Wallace et al. 1998). Soffer (1999, 160) states "The disparate regional European Upper Paleolithic record for colonization, abandonment, refuging, and demographic shifts, calls for the development of models of gene flow and of genetic *drift,* and the impact of environmental change upon the expansion/contraction and admixture/isolation of different European populations".

The contribution of molecular data studies to understanding the population history of the Upper Palaeolithic is becoming increasingly impressive. Probably the two main advantages to such studies are 1) the reconstruction of palaeo-population histories to include temporal and geographic distribution, and 2) the ability to correlate the results with climatalogical, archaeological and the radiocarbon evidence that is so important to Palaeolithic exploration. In this section, the mtDNA evidence is described in conjunction with archaeological regional colonisation studies to place the recolonisation of Central Europe within the context of Europe as a whole.

In "Tracing European Founder Lineages in the Near Eastern mtDNA Pool", Richards et al. (2000, 1251-1276) analyse "nonrecombining" DNA sequence data to identify and date human migrations with respect to the colonisation of Europe. By exploring the geographic distribution of genetic variation markers, such as mtDNA, the "phylogeographic approach" is used to investigate population expansion and migration. In their conclusions, the authors' suggest that "(i) there has been a substantial back migration into the Near East, (ii) the majority of extant mtDNA lineages entered Europe in several waves during the Upper Palaeolithic, (iii) there was a founder effect, or bottleneck, associated with the Last Glacial Maximum, 20,000 years ago, from which derives the larges fraction of surviving lineages, and

(iv) the immigrant Neolithic component is likely to comprise less than one-quarter of the mtDNA pool of modern Europeans" (Richards et al. 2000, 1251).

The most desirable way to model the processes of colonisation would be the development of a model where hunter-gatherer palaeo-demography and behaviour are derived or traced from archaeological source material (Welinder, 1979) that can be weighed against evidence obtained from like-minded research. Additionally, the identification of "diagnostic indicators" in the archaeological record, which can be used as control data in the development of analytical methods for the production of a colonisation model, is advantageous (Williams 1998, 5).

In this thesis, radiocarbon dates derived from archaeological source material are used as diagnostic indicators to determine processes of colonisation. The data are first assessed for acceptability according to a given set of quality control criteria. Then, for each culturally stratified location represented in the radiocarbon database, a single date is assigned using statistical methods. The resulting database is input into a Geographic Information System (G I S) for temporal/spatial analysis. The assumption is that the radiocarbon database is sufficiently representative chronologically and spatially of Upper Palaeolithic populations such that acceptable interpretations of colonisation processes may be determined.

1.3.1 Radiocarbon Dates as Indicators of Colonisation Processes

While proper caution governing the use of radiocarbon data continues to be expressed (Sinitsyn and Praslov 1997; Housley et al. 1997; Charles 1996), there is no argument about the value these data have to Palaeolithic archaeology. Sinitsyn and Praslov (1997, 111) highlight the goal of these for assessing this value. The first consideration is the extent to which the data can define age and duration of sites. The second is the extent to which local periodisation can be determined and compared against archaeological assemblages used to construct relative chronologies and sequences defined by technocomplex groupings. Housley et al. (1997, 26-27) suggest that a sound appreciation for the value of radiocarbon dates, the potential problems with quality and assessment of the data, and the limits to what the data can provide are the foundations for acceptable use of radiocarbon dates in modelling colonisation processes.

Traditionally, the use of radiocarbon data in archaeology has been to refine our knowledge of chronological sequencing, and if need be, to question such chronologies. The use of radiocarbon dates as indicators on which to model colonisation processes both temporally and spatially however, is a relatively recent application.

In European Upper Palaeolithic archaeology the application of radiocarbon dates to colonisation modelling in this manner has been implemented primarily in Northwest Europe. In their paper, *Radiocarbon evidence for the Lateglacial Human Recolonisation of Northern Europe*, Housley *et al.* (1997) used uncalibrated AMS dates to examine the late glacial recolonisation of Northern Europe to resolve similar questions of those addressed in this research. The authors used the dates as data points to not only determine occupation and hiatus (chronologically and spatially) but the rates at which colonisation took place. Similarly, Street and Terberger (1998) in *The Last Pleniglacial and the human settlement of Central Europe: new information from the Rhineland site of Wiesbaden-Igstadt*, compared new radiocarbon dates obtained from Wiesbaden-Igstadt, Germany, to the Northwest European radiocarbon database to suggest that the colonisation process may have been more continuous than previously presumed. In this case, the authors note that the Aurignacian technocomplex (ca. 32000 – 29000 BP) at the site does not match consistent dates for the site, which place it between 20000 – 17000 BP. They suggest that this indicates that areas adjacent to presumed refugia were occupied at low intensity much earlier than previously assumed (Street and Terberger 1998, 259). Excluding Northwest Europe however, radiocarbon dates have not been used in such a bold manner in the rest of Europe. Sinitysn and Praslov (1997) and Dolukhanov (1999) have addressed the problematic issues surrounding establishing sound chronological sequencing in Eastern Europe. But while the radiocarbon database is used extensively as supporting evidence, its application as the primary indicator in colonisation studies of Central and Eastern Europe has yet to be explored.

1.4 CENTRAL AND EASTERN EUROPE IN THE LATE GLACIAL

During the initial planning stages of this research, the Carpathian Basin was selected as the focus for research for a good reason. With the exception of its inclusion as a peripheral entity to various regional studies (West 1997; Svoboda et al. 1996; Kozlowski 1986), or alluded to in site specific archaeological research (Williams 1998; Dobosi 1983), little attention has been paid to the Carpathian Basin as a discreet unit. Its place and role in the reconstruction of European colonisation in the late Upper Palaeolithic has not been established. Yet, the very nature of the physical landscape and archaeological history of this region demands its inclusion for the significant part it must have played in the colonisation of Europe. The region therefore presents itself as an excellent case study for testing colonisation models, theories about refugia and archaeological visibility.

These same conditions however, are also a source of methodological problems. Post-glacial sediment deposition and data inconsistency are only two concerns. The limitations placed on the study of the Carpathian Basin as a discreet unit as a result of such concerns led to the expansion of the study area to include peripheral regions.

In this study the whole of Central and most of Eastern Europe have been included, ignoring for the moment topological boundaries, in order to provide an archaeological database of significant size from which to draw reasonable conclusions. This expansion also enables the use of current regional studies both as source material, and comparative analyses. Variable modes of human dispersal may be examined and the bias inherent in these typically direction-oriented studies can be minimized.

1.4.1 Geography

Figure 1.1: National borders within Central and Eastern Europe. Countries whose borders are represented within the geographic study region are identified.

At the centre of Europe lies the Carpathian Basin. The selected study area is bounded by latitude and longitude and defined as 55N, 35N, 10E and 45E. Within the landscape, the Carpathian Basin stands out as a prominent geographic feature, encircled by four major mountain ranges. To the northeast are the Carpathians and the southeast the Transylvanian Alps. The Balkan range borders the south end of the basin, the Dinaric Range separates the western side of the basin from the Adriatic Sea, and the Alps lie to the northwest. The North German Plain stretches north to the Baltic Sea, and east into the East Russian Plain. Between the Transylvanian Alps and the Balkan Range lies the Valachian Plain that borders the Black Sea.

The major rivers of the region include the Danube, which flows east, north of the Alps, south through the centre of the Carpathian Basin and east, draining into the Black Sea. The Dnester and Dnieper rivers flow in a southerly direction through the Russian Plain and into the Black Sea. The Vistula and the Oder rivers flow north through to the Baltic Sea and drainage into the Adriatic and Aegean Seas come from water flows from the surrounding mountains or smaller rivers off the Danube. Figure 1.1 outlines the political borders included in the study. Figure 1.2 shows the major geographical features of the study area.

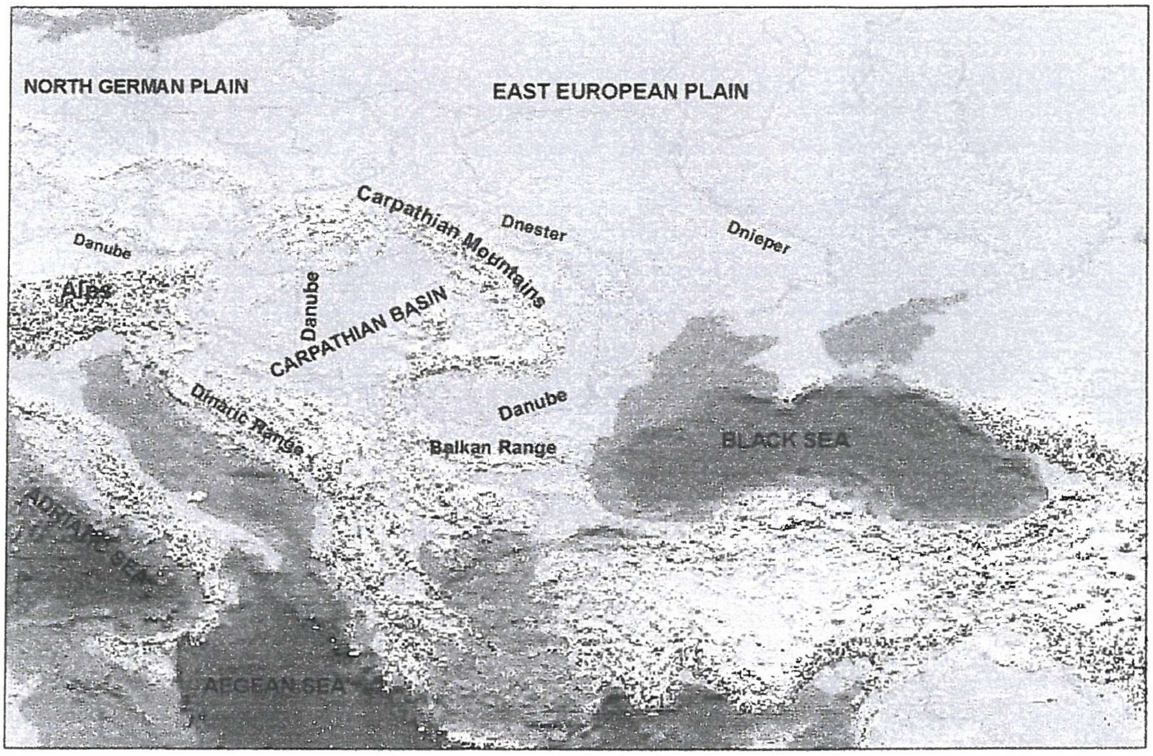


Figure 1.2: Major geographic features within the study area (Adapted from United States Geological Survey GTOPO30 relief map).

1.4.2 Climate

Isotopic evidence from the Greenland ice cores (Figure 1.3) places the Upper Pleniglacial, and the beginning of OIS-2, at ca. 24000 BP (Street and Terberger 1998, figure 1; Djindjian et al. 1999, figure 2.3). Climate fluctuations during OIS-2 are clearly visible in the Summit ice core (Figure 1.4) and described by Djindjian et al. (1999, 45-47). Climate changes occurring between 26000 and 24000 BP are associated with major changes in the Gulf Stream. The first clearly marked climate episode however is the Lascaux interstadial, occurring about 18000 BP. It is contemporary with the climate deterioration of the LGM (Djindjian et al. 1999, 46), characterised by Jochim (1987, 321) as having "low average temperatures, long winters, permafrost, and high winds, and consequently were increasingly harsh environments marked by decreasing vegetational and faunal abundance and diversity". Sea level was approximately 120m below present and ice flows and mountain glaciers reached their maximum extent.

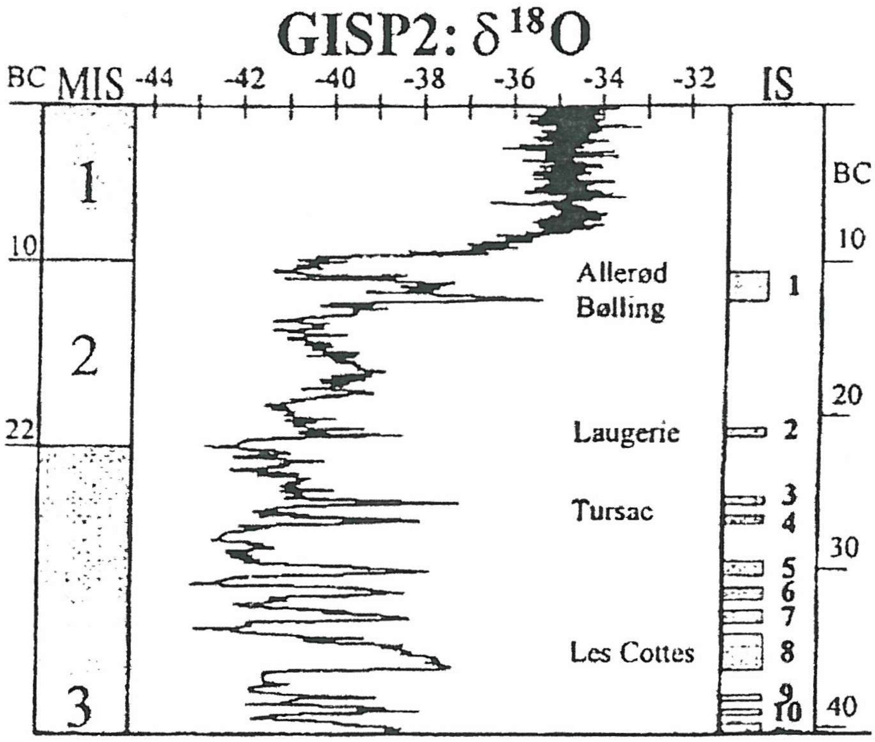


Figure 1.3: GISP2 (Greenland Ice Sheet Project Two) $\delta^{18}O$ curve. Calendrical age is in thousands of years BC. IS = Interstadial, MIS = Marine Isotope Stage. After Street and Terberger (1998, figure 1).

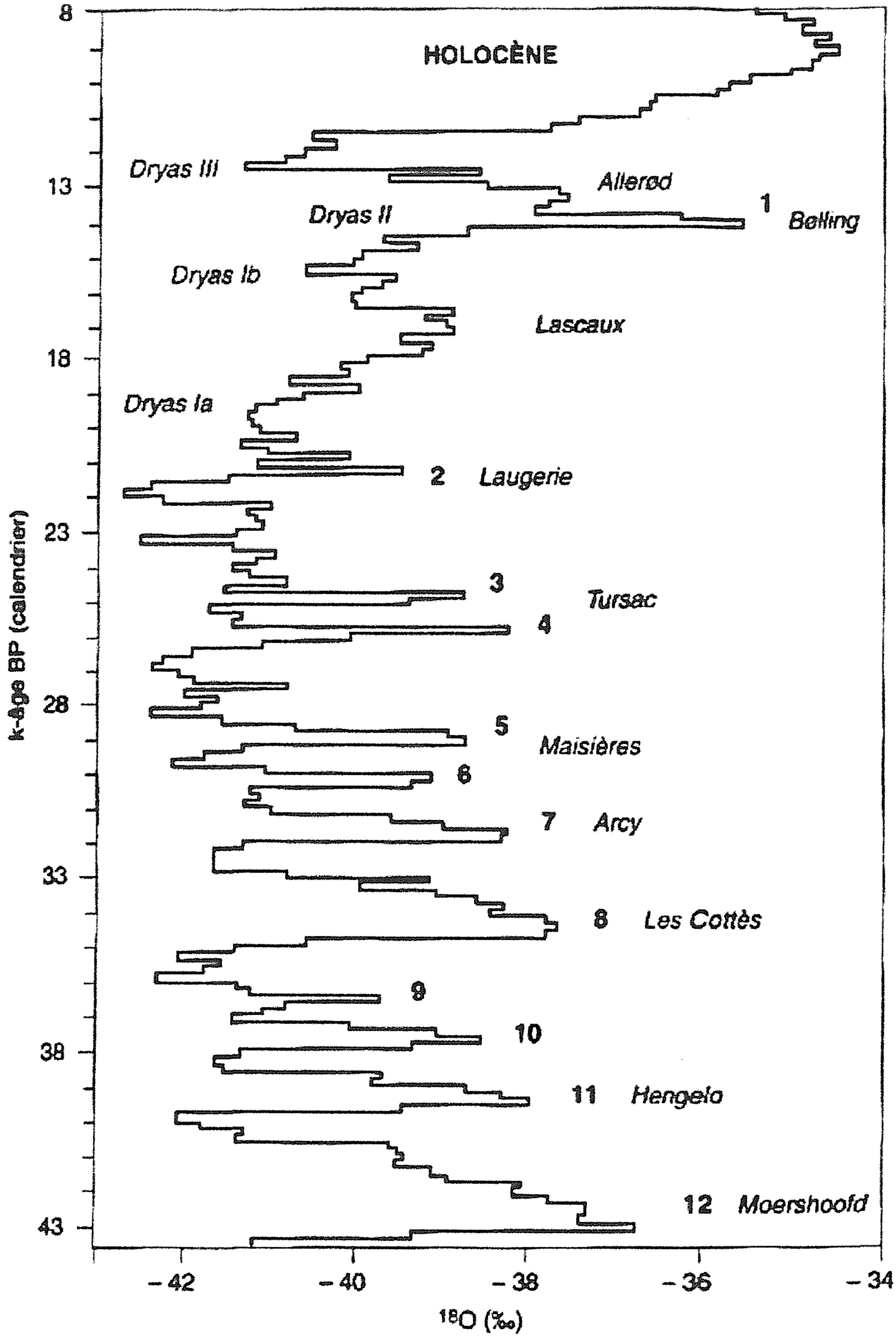


Figure 1.4: Summit ice core. Interstadials are numbered as defined in core data. After Djindjian *et al.* (1999, figure 2.3).

Loess and palynological sequences show the Dryas I phase as the signalling of the retreat of the glaciers and a return to a dryer, warmer climate and the progressive amelioration (Djindjian et al. 1999, 46). Ložek (1967, 388-390) who suggests that a cold "loess" phase occurred during the decline of the Late Glacial Maximum, points out that climate during this phase differed considerably from most present conditions, leaving "few analogies on which to base a reconstruction of the climatic zones". Figure 1.3 shows the stratigraphic sequencing of palaeo-environmental factors for significant sites in Central Europe (Kozlowksi 1986, figure 3.2).

The Bölling oscillation is also well marked on the Summit core (Djindjian et al. 1999, 50). It is characterised by hot summers and cold winters and is considered to mark the beginning of climate amelioration to the Holocene. In Northwest Europe, arbutus tundra dominated as opposed to the park tundra with pine of Northeast Europe. The rest of Europe consisted of a juniper steppe environment.

The Alleröd oscillation is considered to mark the introduction of the pine forest to the plains of Northern latitudes. Further south, pine and fir, and increased temperatures and precipitation are descriptive of the onset of the Holocene. Djindjian et al. (1999, 52) note that in the vertical zones of mountain regions, temperature and precipitation facilitated vertical displacement, causing bathymetric and topographic changes.

Kozlowski (1986, 132) notes that environmental conditions of the Upper Pleniglacial, throughout Central and Eastern Europe, were mild and unglaciated regions of mid-latitude Europe consisted of various forms of periglacial open vegetation. The climate change facilitated the sedimentation of loess, typical of a cold and dry periglacial environment, in Northwest Europe and the Carpathian Basin (Kozlowski 1986, 132; Frechen et al. 1999, 1467; Djindjian et al. 1999, 50). North of the Carpathian Basin, the environment was "an inhospitable zone of arctic desert" with a mean annual temperature of -8°C (Kozlowski 1986, 133).

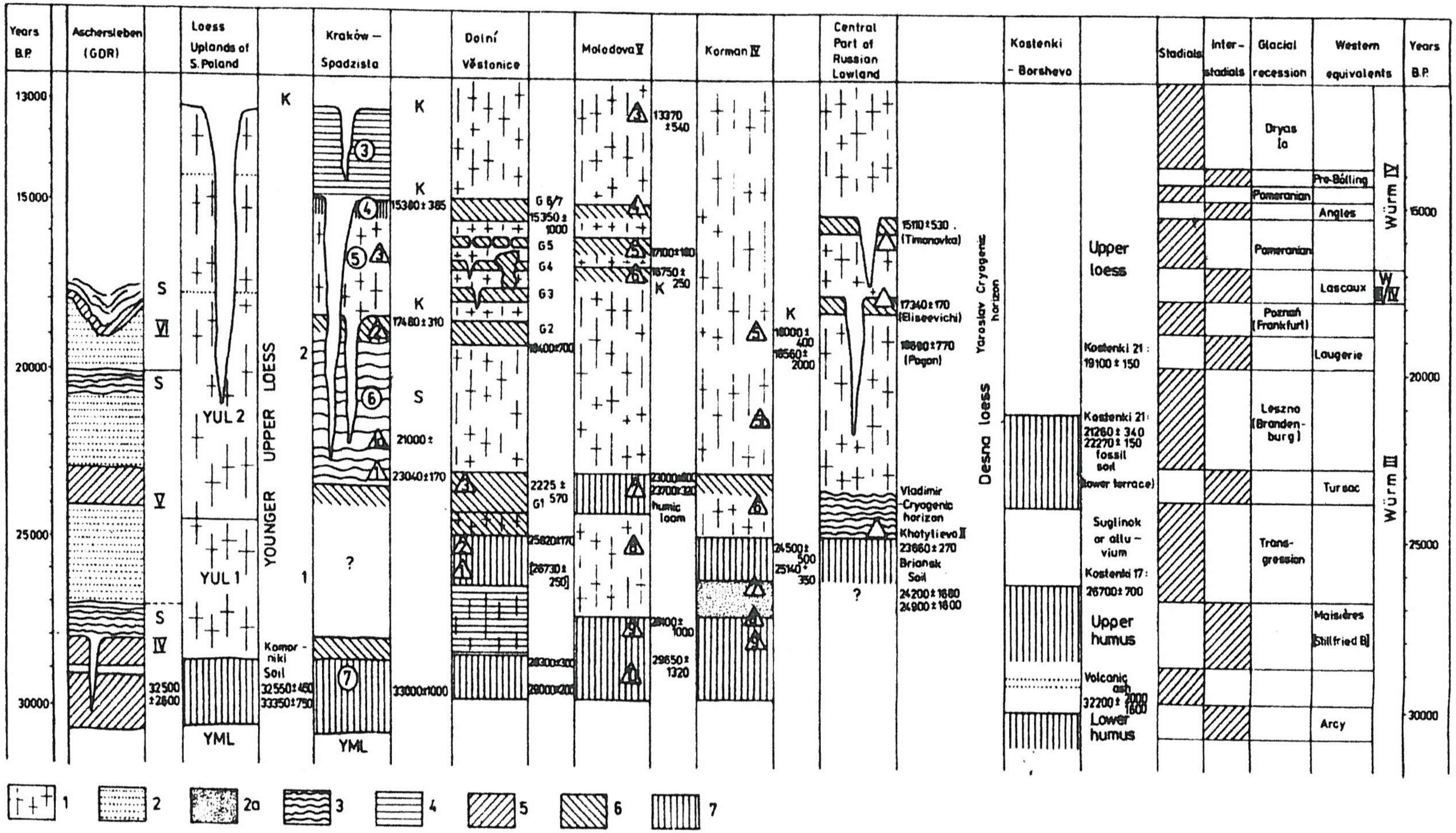


Figure 1.3: Schematic stratigraphy of the principal multilayer sites in Central and Eastern Europe with reference to paleoclimatic cycles during the Upper Pleniglacial: 1, loess; 2, sandy lacustrine formations; 2a, sandy beds; 3, solifluction layers; 4, diluvial formations; 5, limnic beds; 6, buried initial soils; 7, buried well-developed soils or humic beds; S, solifluction; K, cryogenic horizon; △, cultural layers. (Kozlowski, 1986: Figure 3.2)

In the Balkans and the Mediterranean, conditions at the LGM were milder. Evidence from cave stratigraphy shows increased warming and humidity between 17000 and 16000 BP (Djindjian et al. 1999, 55). Kozlowski (1996a, 319) cites stratigraphic evidence from Temnata Cave, Bulgaria, to suggest a more "uniform" climate where changes are more noticeable in humidity rather than temperature through the period of 30000 – 10000 BP. He further notes differences in changes in the landscape between Northern Greece, the Dinaric Mountains and the ridge of the Central Balkans and the Lower Danube Basin, particularly at the LGM, leading to very different biomes over short distances.

In Northeast Europe temperatures and humidity were slightly higher and despite extremely cold winters, favoured steppe and steppe forest conditions in the valleys. Stadial conditions and humid oscillations followed until the abrupt onset of glacial interstadial warming at about 14700 years ago. In Eastern Europe the Lascaux interstadial is consistent with the Brandenberg-Leszno-Bologovo stadial (Kozlowski 1986, 132; Djindjian et al. 1999, 45). Dryas I corresponds to the Louga stadial, represented by tundra and associated vegetation on the Russian plains.

1.5 SUMMARY

The goal of this research is to determine the human colonisation processes in Central Europe, and the role the Carpathian Basin may have played as refugia at the LGM. Radiocarbon dates are used as spatial and temporal indicators of these processes. The large chronological and geographic scale of this work leaves it subject to the problems and concerns addressed in this chapter. Given the ecological perspective inherent in colonisation theory however, the objectives of this research can be achieved without necessarily falling victim to weaknesses in the material database, or to the cause and effect explanations of environmental determinism.

Chapter Two outlines the problems and perspectives of radiocarbon dates as chronological indicators for colonisation. The compilation of a complete database of archaeological radiocarbon dates is presented followed by a discussion of quality control criteria to be used in the determination of an acceptability threshold for uncalibrated radiocarbon dates. Radiocarbon calibration methods are applied and critiqued. Methods for addressing problematic concerns, such as multiple, wide-ranging dates for single occupation levels are also addressed. The methodology for producing a working database acceptable for use in spatial/temporal modelling is discussed.

Chapter Three provides the analyses and discussion for chronological/temporal resolution of the processes of colonisation in Central Europe. The timing and rates of population dispersal are addressed here. The moving sum method (Holdaway and Porch 1995; Housley et al. 1997) is applied.

Chapter Four provides the analyses and discussion for spatial resolution of colonisation processes in Central Europe. In this chapter, spatial modelling techniques are used along with the moving sum method to determine the directions and spatial patterning of population dispersal. The radiocarbon data are evaluated for the purpose of assessing potential areas of refugia and archaeological visibility.

Chapter Five presents the method of development, and final output, of GIS spatial modelling techniques to determine archaeological visibility and produce a predictive model that can be applied to determine and interpret colonisation in Central Europe. This model is evaluated against the results of the analysis in Chapters Three and Four.

Chapter Six provides a synthesis of the results obtained in Chapters Three to Five. These are evaluated against empirical archaeological and environmental data, and against comparative regional studies.

Chapter Seven summarises the work presented in this thesis and places the colonisation of Central Europe within the context of greater Europe. The results of this research are weighed against current DNA studies in the Upper Palaeolithic human colonisation of Europe. Directions for future research are outlined in the concluding discussion.

CHAPTER TWO

THE RADIOCARBON DATABASE

In this chapter the application of radiocarbon data as diagnostic indicators to be used in the chronological and spatial analysis of colonisation processes is examined. The advantages and constraints of such an application are considered. Improved dating technology, and an increased number and spread of available dates, makes the data a viable means of analysis. The implications of that analysis however, are constrained by qualitative issues (Newell and Constandse-Westermann 1999, 2-4; Housley et al. 1997; Charles 1996). One of the principal components of this research is the compilation of a detailed database of Upper Palaeolithic - Oxygen Isotope Stage II (OIS-2) - radiocarbon dates for Central and Eastern Europe. In this chapter the dates are assessed for their acceptability for the work presented in this thesis. A methodology for developing quality control criteria is developed and applied to achieve this goal.

Three main groupings of dates are considered for quantitative and qualitative control. These are a) when there is only a single available date for a given cultural level, b) a series of dates for a single sample, and c) a series of multiple dates from multiple samples for a single cultural level. Finally, successful application of radiocarbon data as chronological and spatial data points for analytical purposes requires that a single date characterize each stratigraphic spatial locality (Dolukhanov 1999, 11). The problems and perspectives associated with this undertaking are discussed and a methodology for achieving this subsequent *working* database is developed. This working database is used to meet the objectives of this research. The original database and the subsequent working database can be found in Appendixes A and B respectively.

2.1 COMPILING THE DATABASE

The radiocarbon database used in this research consists of a largely variable set of dates ranging from conventional dates obtained early in the history of radiocarbon dating to those obtained by accelerator mass spectrometry (AMS) - a more recent and more accurate means of measurement (Taylor 1994, 35). A total of 36 separate radiocarbon laboratories (Table 2.1) have produced dates present in the compiled database. All have been published in various literature forms and were obtained via these sources. The database consists of 727 dates, from 165 sites and 260 cultural levels, gathered up to May 2000 (Appendix A).

Table 2.1: Radiocarbon laboratories represented in the compiled database and their lab codes.

Radiocarbon laboratories referenced in the compiled database	
A	Laboratory of Isotope Geochemistry, Arizona, United States
AA (AMS)	NSF, United States
Bln	Archaeological Institute, Berlin, Germany
CAMS (AMS)	Center for Accelerator Mass Spectrometry, Lawrence Livermore, United States
CU	Department of Hydrogeology, Prague, Czech. Rep.
Deb	Debrecen, Hungary
Gd	Gliwice, Poland
GIN	Geological Institute, Russian Academy of Sciences, Russia
GrA (AMS)	Groningen Accelerator, The Netherlands
GrN	Groningen, The Netherlands
Gro	Groningen, The Netherlands (changed code to GrN)
GX	Geochron Laboratories, United States
H (Hd)	Heidelberg, Germany
Hv	Hannover, Germany
I	Teledyne Brown Engineering Environmental Services, United States
IGAN	Institute of Geography, Russian Academy of Sciences
ISGS	Illinois State Geological Survey, United States
Ki	Kiev Radiocarbon Laboratory, Ukraine
KN	Köln, Germany
LE	Institute of the History of Material Culture, Russian Academy of Sciences
LOD	Lodz, Poland
LU	St. Petersburg State University, Russia
Lv	Louvain-la-Neuve, Belgium
Ly	University of Lyon, France
Mo	Verdanski Institute of Geochemistry, Moscow, Russia
Ox	USDA Oxford, Mississippi, United States
OxA (AMS)	Oxford Radiocarbon Accelerator Unit, United Kingdom
P	University of Pennsylvania, United States
QC	Queens College, United States
R	Rome, Italy
SOAN	Institute of Geology and Geophysics, Russia
TA	Tartu, Estonia
VRI	Vienna Radium Institute, Austria
Z	Zagreb, Croatia

2.1.1 Setting the Boundaries

The temporal boundaries used in the selection of the radiocarbon database have been set to include 25000 uncal bp to 11000 uncal bp. This closely approximates the terminal points for OIS-2 from the Greenland ice cores (figure 2.1), encompassing the onset of the Last Glacial Maximum, and the warming to the Holocene. These dates also represent suitable and acceptable temporal "cut-off points" for the full inclusion of late glacial technocomplexes in the study area – the broadly categorised Gravettian phase (Otte 1981, v.1).

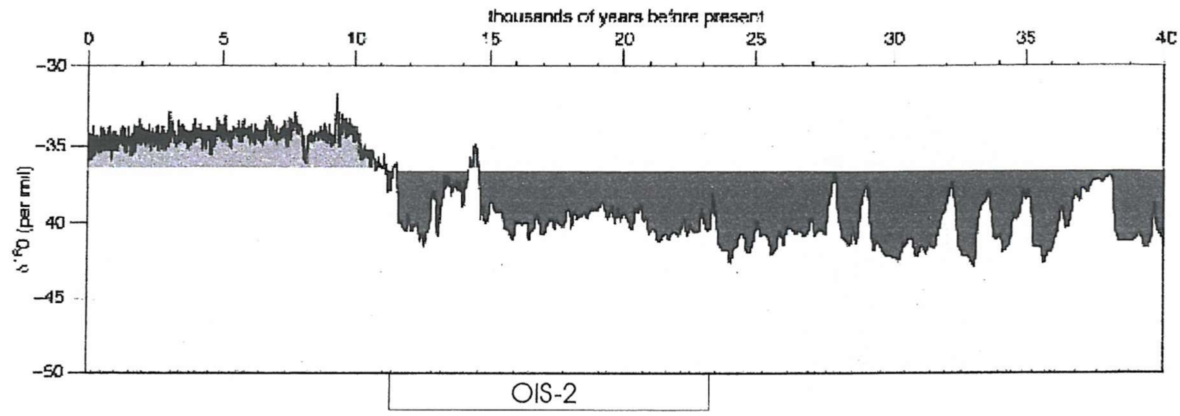


Fig. 2.1: Ice-core record from Greenland Ice Sheet Project Two (GISP-2) showing oxygen-18 concentration. Dating is calibrated BP (After Taylor 1999).

The physical boundaries of the region are defined as 10 degrees east and 35 degrees north (SW corner) to 45 degrees east 55 degrees north (NE corner) as shown in Figure 1.2, and encompass all of Central Europe and most of Eastern Europe. Collection of all available radiocarbon dates from this region enables not only the compilation of a large enough sample of dates for detailed analytical purposes, but provides suitable data from which to draw comparative conclusions between well documented sites from both Central and Eastern Europe. This in turn will enable the placement of the recolonisation of Central Europe within the context of greater Europe.

2.2 PROBLEMS AND PERSPECTIVES

Radiocarbon dating is often considered proof of an absolute chronology - age correct at death - of a given dated material. But, as archaeologists, we consider it as only one aspect of the archaeological record. We must consider the radiocarbon date both in terms of comparable similar data and comparable chronological information. Its acceptability is then judged within the framework of our own "expert estimation" (Sinitsyn and Praslov 1997, 111), biased by our own interpretations and knowledge of the data.

Among the primary issues of concern which influence our judgement of the data are

1) quality control that must somehow define the degree of confidence by which we set the acceptability threshold of the radiocarbon date;
2) variability within the dataset which must include the procedures by which samples were retrieved and dated, and the question of a series of dates vs. the single date;
3) variability from the dating laboratory (i.e. the methodology by which samples are dated at different labs).

2.2.1 Quality Control and Data Acceptability

It is well known that radiocarbon data of variable quality are susceptible to error. This can occur naturally, or at any point in the process of obtaining the radiocarbon date. Natural contamination can occur when the quality of the sample to be dated may be compromised by post-depositional intrusion, weathering or handling at some point prior to excavation. One example of contamination occurring is when organic material such as plant roots, intrude on the sample to be dated. When this happens, the resulting date may be too old or too young because the amount of carbon (the substance measured to determine the date) present is altered. During the data gathering process, the sample may be contaminated during excavation, or during the dating process itself.

In this thesis the arrival at a judgement of acceptability of the data is invoked through some means of quality control. This is usually done through the verification of radiocarbon dates against chronological information derived from palaeo-climatological sources and other archaeological evidence (i.e. typological information), and in terms of the context of the dated material (e.g. in situ or disturbance?). Agreement between the data, both between dates in the dataset and dates versus palaeo-climate information, is often a function of method. This means that the goodness of fit of the data to the desired result is dependent on quality control criteria. Quality control criteria and the method used to achieve results must therefore be carefully developed.

Inconsistency in the Data

By comparing the available information obtained for two sites, it is possible to explore the differences in the quality of data sources used in the database. In the following example the data from Oelknitz, Germany and Zolotovka, Russia are used.

Detailed information obtained on samples from Oelknitz in Germany (Table 2.2, p.26) includes the geographic locality and coordinates of the site, the condition of the site, faunal representation, the type of sample dated, stratigraphical and climatological information, and bibliographic sources. The dates were obtained primarily via AMS from the Oxford Radiocarbon Accelerator Unit (Hedges et al. 1998, 233-234) and each date inspires a significant level of confidence. This can be compared to the more limited information presented for dated samples from Zolotovka where there is less information available on the conditions of the site, and the dates derived show considerably less confidence. Without firsthand knowledge of excavation and conservation procedures for obtaining samples in either case, assumptions about the quality of data can be made only on the basis of the available information. As a result, there is potential for error. This is an important consideration when the database to be used in work such as that presented here, is derived from secondary sources. Where dates in the compiled database are attributed to unknown sample material and occasionally, the sample's laboratory number is not known, they are identified in Appendix A.

Table 2.2: Comparison of dates from Oelknitz and Zolotovka. p/m = plus/minus.

Site	Uncal BP	p/m	Lab Ref. No.
Oelknitz	12270	120	OxA-5709
Oelknitz	12080	110	OxA-5710
Oelknitz	12050	110	OxA-5711
Oelknitz	12270	110	OxA-5712
Oelknitz	12740	120	OxA-5713
Oelknitz	12620	120	OxA-5714
Oelknitz	12790	110	OxA-5716
Zolotovka	17400	700	GIN-1968
Zolotovka	13600	1000	GIN-8002

Quality and acceptability are also potentially affected during the handling procedure of the sample at the time of excavation or conservation, and/or during the preparation and dating process. This is likely in situations where environmental, typological and stratigraphical data are consistent, but where the resulting dates show larger deviations and wider ranges. This is pointed out by Housley et al. (1997, 28), who suggested that a date from a sample composed of a number of bones, which "is subsequently identified as having mixed age material" will be suspect.

An example of such bulk sampling is provided by Kostenki 14, Layer II (Table 2.3) which has 7 dates ranging from 19300 ± 200 uncal bp (LE-1400) to 28500 ± 420 uncal bp (OxA-4115B), a span of 9000 years (Sinitsyn and Praslov 1997). Of the seven dates however, 5 fall within a range of less than 3000 years. LE-1400 has been dated twice yielding a range of approximately 6000 years. While the earlier date, when compared with the remaining 5 samples, appears on the surface to be a good quality date, it may (speculatively) have been derived from a sample that was obtained out of archaeological context, or contaminated at some point, yielding poor results. This is an assumption that is invariably based not only on what can be gained from the knowledge base, but, on the interpretations of the researcher. The dates derived from this sample can be considered poor quality.

Table 2.3: Raw radiocarbon data from Kostenki 14, Layer II (after Sinitsyn and Praslov 1997). p/m = plus/minus.

Site	Level	Uncal BP	p/m	Lab Ref. No.	Sample
Kostenki 14 (Markina gora)	II	19300	200	LE-1400	bone
Kostenki 14 (Markina gora)	II	25090	310		same sample as LE-1400; lab. LU
Kostenki 14 (Markina gora)	II	25600	400	GIN-8030	bone
Kostenki 14 (Markina gora)	II	26400	660	LU-59a	bone fragment 'A'
Kostenki 14 (Markina gora)	II	28200	700	LU-59b	bone fragment 'B'
Kostenki 14 (Markina gora)	II	28380	220	GrN-12598	charcoal
Kostenki 14 (Markina gora)	II	28580	420	OxA-4115B	bone

Furthermore, the dates were obtained from 6 different radiocarbon laboratories, including Geographic Research Institute, Saint Petersburg State University (LU), Geological Institute of Russia (GIN), Institute of History of Material Culture, Saint Petersburg (LE), Groningen Center for Isotopic Research (GrN) and the Oxford Radiocarbon Accelerator Unit (OxA). This suggests concern for error due to variability in the dating procedures used by different laboratories – a concern that will be addressed in section 2.2.3.

It is easy to see why quality control can be a difficult objective. These concerns will be addressed in a practical manner in sections 2.3 and 2.4, when quality control methodology is applied toward the derivation of the working database.

2.2.2 Variability Between the Radiocarbon Data

Considerable variability between radiocarbon dates can occur within a dataset despite efforts to obtain a level of acceptability for the data. This can occur when there are a series of dates obtained for a single layer based on a number of archaeological samples, or when there is a series of different dates obtained from a single sample. This is a problematic concern yet to be resolved to any degree of satisfaction when trying to place that single layer within a chronology useful to colonisation research on the larger scale.

Series of Multiple Dates from Multiple Samples

Grouping together bulk material from a single layer can have consequences for the integrity of the sample and archaeological interpretation. Dating bulked samples "can only give an average of all the individual ages", or, they "can be highly misleading, bearing little relationship to the 'real' age of apparently associated archaeological residues" (Charles 1996, 3-4). This is a problem where there is repeated occupation of a site over a long period. An example can be found in Eastern Europe at the site of Kostenki I, layer I. Here, there are 42 dated samples in this database, comprising of bone, tooth and charcoal samples (Table 2.4).

Sinitsyn and Praslov (1997, 111) use Kostenki 1, Layer I as a test case to address the variability problem. These authors stress an importance on looking for quality control and results, not from single dates, but on the basis of a series of dates.

At Kostenki 1, Layer I, the level has produced multiple dates ranging from 18230 ± 620 uncal bp to 24570 ± 3930 uncal bp (Sinitsyn and Praslov 1997, 114). The authors apply a modal method of analysis to estimate variability in a series of "statistically representative" sites (those where more than 10 dates are present in a given layer) by computing the dispersion of dates, and analysing the confidence level obtained through statistical measures. These measures suggest that in the case of sites where there are a large number of dates in the series, that "the ratio of variance of dates to their confidence interval is a constant value... " (Sinitsyn and Praslov 1997, 111). The authors suggest that while this method provides what appears to be a more "realistic value" for age evaluation (in terms of agreement with evidence from environmental data) the method remains problematic. They acknowledge that the variability of the range of dates is, in actuality, much wider than the applied statistical method showed (Sinitsyn and Praslov 1997, 114). Because of the wide range of absolute chronological data from Kostenki 1, Layer I, temporal accuracy remains elusive. Charles (1996, 4) however, suggests that while chronological accuracy may be difficult to come by, it can be accepted that the date will fall within a range, thus allowing for some temporal resolution to site chronology.

Table 2.4: Raw Radiocarbon data for Kostenki I, Layer I (after Sinitsyn and Praslov 1997). p/m = plus/minus.

Site	Uncal BP	p/m	Lab Ref. No.	Sample
Kostenki 1 (Poliakov site)	18230	620	LE-3280	burned bone
Kostenki 1 (Poliakov site)	18400	3300	LE-4351	mammoth tooth, sq. II-70
Kostenki 1 (Poliakov site)	19010	120	LE-2950	mammoth tooth, storage-pit, sq. IIP-72
Kostenki 1 (Poliakov site)	19540	580	LE-3292	burned bone, pit, sq. H-76
Kostenki 1 (Poliakov site)	19620	460	LE-3281	burned bone, sa. O-78
Kostenki 1 (Poliakov site)	19860	200	LE-2949	mammoth tooth
Kostenki 1 (Poliakov site)	20100	680	LE-3277	burned bone
Kostenki 1 (Poliakov site)	20315	200	AA-4800	burned bone
Kostenki 1 (Poliakov site)	20855	260	AA-4799	burned bone
Kostenki 1 (Poliakov site)	20800	300	GIN-4851	burned bone, pit, sq. O-73,74
Kostenki 1 (Poliakov site)	20950	100	GrN-17120	burned bone, sq. P-78
Kostenki 1 (Poliakov site)	21150	200	GIN-4231	burned bone, pit, sq. P-73
Kostenki 1 (Poliakov site)	21180	100	GrN-17119	burned bone, hearth sq. H-79
Kostenki 1 (Poliakov site)	21300	400	GIN-2534	burned bone, dugout "A", northern chamber
Kostenki 1 (Poliakov site)	21680	700	LE-3279	Mammoth tooth, sq. JI-77
Kostenki 1 (Poliakov site)	21800	200	LE-2801	Object (with a wall)
Kostenki 1 (Poliakov site)	21800	300	GIN-4230	burned bone, hearth, sq. H,O-72,73
Kostenki 1 (Poliakov site)	21950	250	GIN-8041	Mammoth tooth, cultural layer
Kostenki 1 (Poliakov site)	22020	310	LE-3282	Mammoth tooth, storage-pit, sq. K-78
Kostenki 1 (Poliakov site)	22060	500	LE-3290	Bone, sq. II-76
Kostenki 1 (Poliakov site)	22200	300	GIN-3634	Burned bone, pit B, 65-67
Kostenki 1 (Poliakov site)	22200	500	GIN-4903	burned bone, dugout T, Y, S-72-75
Kostenki 1 (Poliakov site)	22300	200	GIN-2533	burned bone dugout "A", central chamber
Kostenki 1 (Poliakov site)	22300	230	GIN-1870	burned bone, sq. N-M-5-6
Kostenki 1 (Poliakov site)	22330	150	GrN-17118	Charcoal, hearth, sq. H-79
Kostenki 1 (Poliakov site)	22600	300	GIN-6249	Mammoth tooth, sq. II-69
Kostenki 1 (Poliakov site)	22600	300	GIN-3633	burned bone, hearth, sq. H-62
Kostenki 1 (Poliakov site)	22700	250	LE-2969	Mammoth tooth, sq. II-69
Kostenki 1 (Poliakov site)	22760	250	LE-2800	Mammoth tooth, sq. K-70
Kostenki 1 (Poliakov site)	22800	200	GIN-2530	burned bone, dugout "K"
Kostenki 1 (Poliakov site)	22800	300	GIN-3632	burned bone, dugout "A"
Kostenki 1 (Poliakov site)	23000	500	GIN-2528	burned bone, dugout "A", central chamber
Kostenki 1 (Poliakov site)	23010	300	LE-3276	Mammoth tooth, sq. JI-78
Kostenki 1 (Poliakov site)	23260	680	LE-3289	Mammoth tooth, dugout "T-X-72-75"
Kostenki 1 (Poliakov site)	23490	420	LE-3286	Burned bone, dugout "T-X-72-75"
Kostenki 1 (Poliakov site)	23500	200	GIN-2527	Burned bone, dugout "A", central chamber
Kostenki 1 (Poliakov site)	23600	410	GrA-5244	Charcoal, dugout E-3-72-74, floor
Kostenki 1 (Poliakov site)	23640	320	LE-3283	Mammoth tusk, pit, sq. K-78
Kostenki 1 (Poliakov site)	23770	200	LE-2951	Mammoth tooth, dugout "T-X-72-75"
Kostenki 1 (Poliakov site)	24030	440	GrA-5243	Charcoal, pit. sq. II-74
Kostenki 1 (Poliakov site)	24100	500	GIN-2529	Burned bone, dugout "3"
Kostenki 1 (Poliakov site)	24570	3930	LE-4352	Mammoth tooth fragments, dugout "H"

Dolukhanov (1999, 11) also argues that temporal resolution can be found in these types of series. He applied a statistical method to four sites in Eastern Europe including Kostenki 1, layers 1 and 3, Avdeevo and Mezhirichi, to determine a new age estimate in the form of a single date (believed to be the most reliable) that could be used to "characterise" each site (the author's methodology is unpublished at the time of writing of this thesis and thus is not available for review). This resulted in the development of a datelist and database (Appendix D), which addressed late Pleistocene human colonisation in the East European Plain.

Efforts by Dolukhanov (1999, 7-23) toward the resolution of a working database, in which each occupation level could be characterized by a single date, support the widely perceived need to resolve problematic radiocarbon issues (Charles 1996; Sinitsyn and Praslov 1997; Housley et al. 1997) and the aims of the research presented here. His research is especially important to my work since there are significant overlapping spatial and chronological distinctions. These include archaeological data from the East European Plain, and the OIS2 chronology. Dolukhanov's results are presented in Appendix D.

A critique of the method used by Dolukhanov (1999) to produce the characterised dates is not possible for reasons already given. While the method used by Dolukhanov cannot be tested here, the results of his work can be used for comparison against those obtained using the methods applied in this research for the development of the working database in section 2.3 of this chapter.

Single Sample Series

Another problem arises when there is a series of dates that have been derived from the same sample. This is found at Pieny 1 in Eastern Europe (Table 2.5). A single bone sample, LE-1434, has produced dates of 21600 ± 350 uncal bp, 23100 ± 280 uncal bp and 25200 ± 350 uncal bp (Sinitsyn and Praslov 1997). This kind of variation is most likely a result of technical problems at the radiocarbon laboratory. Housley et al. (1997, 28) comment that this can occur due to an inappropriate chemical fraction during dating or failure to remove carbon of another age during pre-treatment. The authors also remind us that a simpler conclusion might be drawn from the scenario where the dating method and sample quality are highly acceptable, but do not reflect the results we may be looking for (Housley et al. 1997, 28).

Table 2.5: Radiocarbon dates for bone sample LE-1434 (after Sinitsyn and Praslov 1997). p/m = plus/minus.

Uncal bp	Uncal bp p/m	Lab Ref	Sample Type	AMS Date
23100	280	LE-1434	bone	no
25200	350	LE-1434	bone	no
21600	350	LE-1434	bone	no

Lone Date Scenario

Where few, or lone dates are available, control for quality becomes more constrained. An example is Skalisty Rockshelter layer III, horizon 3, where drastically different dates occur: 18380 ± 220 uncal bp (OxA-4889) and 12820 ± 140 uncal bp (OxA-4888) (Hedges et al. 1990). Despite the advantage that these dates were obtained using AMS, a lack of available supporting information reduces confidence in their value. In fact, there are a number of samples listed in the database that are quality-deficient as there is little detail available to shed light on the stratigraphic context from which they were collected or the archaeological association (see Charles 1996 for comparable concerns). Examples of this are provided from the sites of Madaras, Dunaföldvár and Estergom-Gyuurgyalag, in Hungary. These partially excavated sites have yielded single radiocarbon dates (Dobosi and Hertelendi 1993) of 18080 ± 405 uncal bp (Hv-1619), 12110 ± 315 uncal bp (Hv-1657) and 16160 ± 200 uncal bp (Deb-1160) respectively. As with most sites in this region, information is limited due to constraints on excavation. This can be for reasons such as depth from surface to the buried occupation layer, or industrial disturbance. Dobosi (1992, 7) recognises inconsistency in excavation documentation over time. This is not uncommon as sites are often excavated over a period of several seasons, and often by different researchers.

Enough archaeological association exists between the above sites and their radiocarbon dates, such that they may be placed within the context of Eastern Gravettian technoclomplex assemblages. Even so, Dobosi suggests that there remains some difficulty in establishing relationships *between* the living surfaces of these sites (Dobosi 1992, 7-8). This is complicated by the fact that on some sites, cultural layers are thin and often the artefacts recovered are scattered surface finds. The site of Pilismarót is indicative of this (Dobosi 1996, 7). Indeed, there are also a number of occurrences in the database where there is no indication that the sample being dated is directly associated with human activity (Appendix A). This is a concern supported by Housley et al. (1997, 32), who suggest that "it may be misleading to put too much confidence" in radiocarbon measurements derived from such samples. This is meant primarily with respect to chronological interpretation of cultural occupation. These authors used radiocarbon evidence to develop a model for the late glacial colonisation of Northern Europe, addressing similar questions to those asked in this research.

2.2.3 Variability Between Radiocarbon Data Sources

There are two fundamental concerns regarding variability between the sources from which radiocarbon data are obtained. The first is inconsistency between radiocarbon laboratories performing the dating task (Sinitsyn and Praslov 1997, 112). Sinitsyn and Praslov noted a difference between dates obtain through laboratories in Western Europe as opposed to those of Eastern Europe.

The second is the important differentiation between AMS and conventional C^{14} dating which influences the quality criteria when assessing the dates. AMS dating has several advantages over the conventional procedure, which involves carbon decay counting. "Bulking" samples together, is often a necessity when dating via conventional methods, since the amount of sample material needed is significantly larger (Charles 1996, 2). AMS requires only 1-2 milligrams of carbon to date a large range of samples. Furthermore, AMS technology employs a significantly sturdier screening process for eliminating contaminants from the sample. Dating via Accelerator Mass Spectrometry allows for increased accuracy of the derived date, and in turn, increased confidence in the results (Bronk Ramsey 1995).

These concerns are supported by Haesaerts et al. (1998), in their examination of Upper Palaeolithic dates. Using data obtained from the site of Cosautsi, Moldavia, AMS dates were compared to conventional, and the variation between sample types and laboratories noted. Van der Plicht suggests that the success of AMS dating can be attributed to "an extreme sensitivity to the least contamination" (1997, URL: http://www.cio.phys.rug.nl/HTML-docs/Verslag/97/report_95-97.htm).

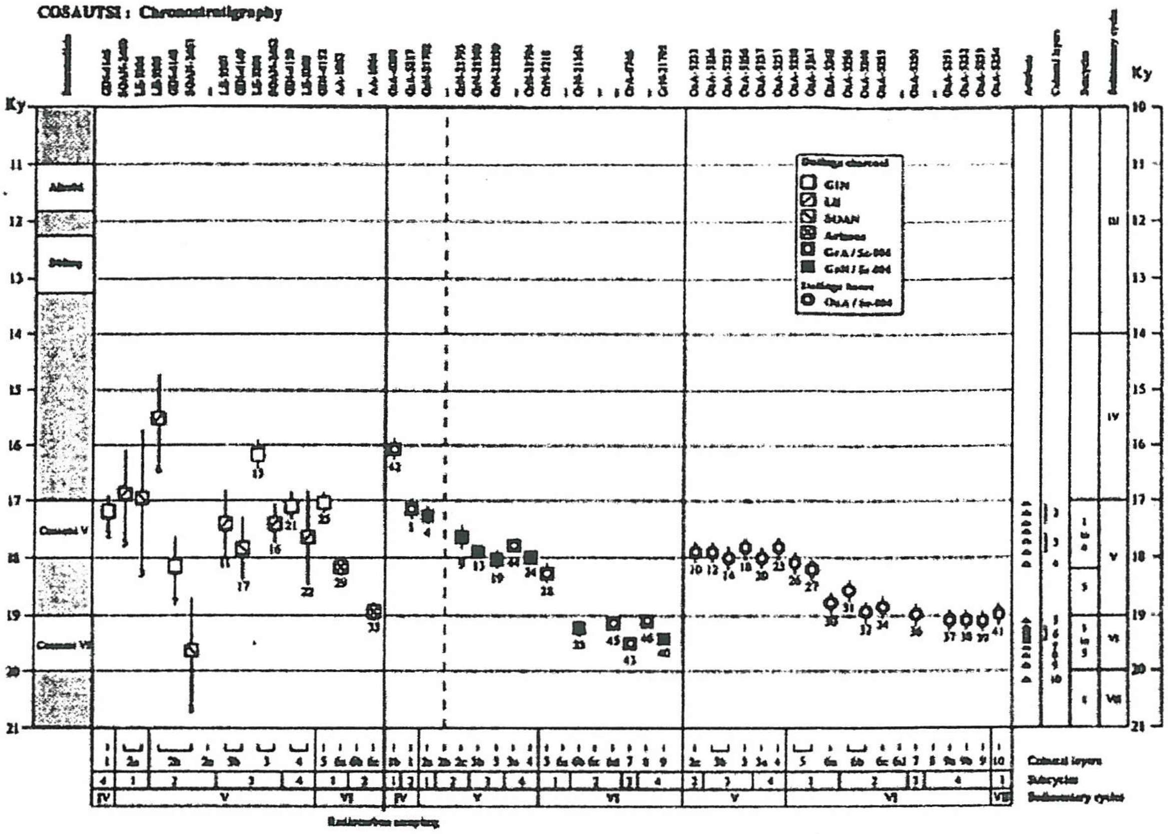


Figure 2.2: Comparison of radiocarbon dates from AMS and conventional laboratories. The data are plotted against climate events and chronostratigraphy (after Van der Plicht 1997, URL: http://www.cio.phys.rug.nl/HTML-docs/Verslag/97/report95-97.htm). Conventional dates are illustrated in the left column; GrN and GrA dates from Groningen are in the middle column and dates from the Oxford AMS lab (OxA) are in the right column.

Dates obtained from the Groningen Centre for Isotopic Research (GrN and GrA dates) also showed a tendency to produce older dates than Russian results "for various reasons probably including field collection and laboratory treatment". Figure 2.2 shows the comparative results produced by the study (van der Plicht 1997).

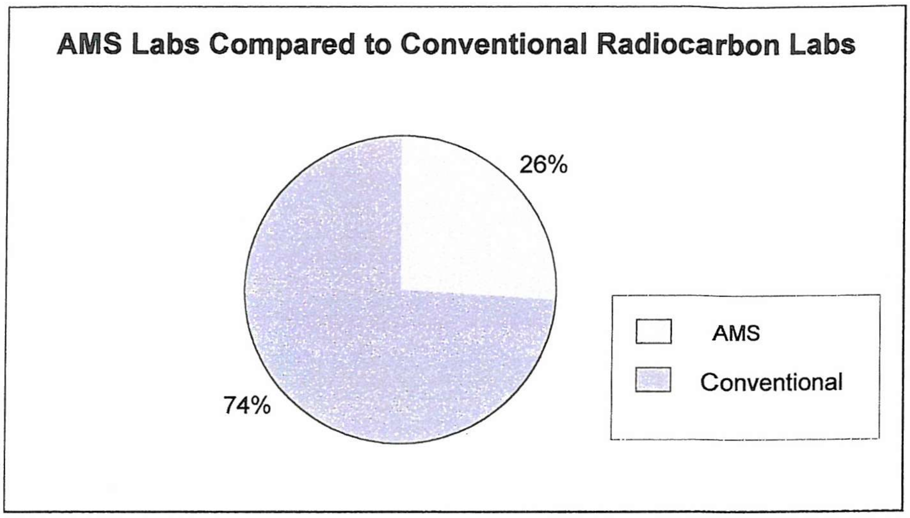


Fig 2.3: Percentage of radiocarbon dates in the database obtained from AMS and conventional laboratories.

There are 36 radiocarbon laboratories represented in the database compiled for this research (refer to table 2.1). These labs are situated worldwide and have a varied history (i.e. some are no longer in existence, or may be poorly equipped). Such a variable resource must automatically incite caution, however none may be discounted strictly on the basis of the radiocarbon dates it produces.

In the database used for this research, dates derived from those samples indexed according to the references of AMS laboratories can be assumed to be AMS ages. All others are assumed to be conventional C^{14} dates. 26%, of the total number of dates in the database, were obtained through AMS laboratories. Fig. 2.3 shows the percentage of dates obtained from each lab type (AMS or conventional).

2.3 SETTING THE QUALITY CONTROL CRITERIA

There are a number of considerations and/or problems that must be addressed, or at the very least acknowledged, prior to acceptance of any radiocarbon date. Confidence in the quality of a radiocarbon date is dependent on a number of factors:

1) The origin of the dated material - stratigraphy, provenience etc.

This type of information tells the researcher whether or not the dated sample was in situ, directly associated with cultural activity and whether or not it has been disturbed since its deposition. The stratigraphic information sheds clues as to environment, faunal and palynological associations and occupation history.

The site of Šandalja II provides an example where the stratigraphic context of the radiocarbon dates is sufficiently recorded (Table 2.6).

Table 2.6: Data for Šandalja II (after Paunovic and Jambresic 1999). p/m = plus/minus.

Layer	Uncal BP	Plus/Minus	Lab Ref. No.	Sample Type
B; top	10830	50	GrN-4976	charcoal or bone
B	10140	160	Z-2421	Unknown
B/C	13050	220	Z-2423	Unknown
C; top	13120	230	Z-2424	Unknown

In this case, the sequencing appears to represent an acceptable chronology (with respect to stratigraphy only). The appearance that both the top and the bottom of layer B have produced dates earlier than the date for the "middle" of layer B would suggest that the dates obtained may be less reliable.

2) Treatment of the dated material - during excavation, post-excavation and at the radiocarbon laboratory.

This knowledge is invaluable as it provides the necessary detail about the handling of the dated sample. This information can provide clues as to the potential degree of contamination the sample may have been exposed to.

3) The quality of the material itself in terms of usefulness for dating (i.e. is there sufficient collagen in the bone?)

This information concerns the physical sample itself. It provides detail about whether or not the sample has been humanly modified, and the fragility of the sample. Likewise, certain materials are more amenable to dating procedures than are others. Bone, for example will generally produce more accurate results than will shell (Higham 1999).

4) Where there is a range of dates from multiple samples derived from a single layer of a single site, how is the most acceptable date determined? Is there a difference in the acceptability of a single available date as opposed one derived from a series of dates?

These are theoretical questions that must be answered prior to attempting to address confidence issues about the radiocarbon date. They are included here because the answers to these questions are part of the justification for assigning a confidence level to the radiocarbon data. These questions form the basis of the methodology for quality control and the determination of an acceptability threshold as discussed later in this chapter and will be answered accordingly.

5) What is the correlation between the date derived from the sample (in light of the above) to other palaeo-climatological, palynological and archaeological evidence?

This involves weighing the relationships between the dated sample against available evidence for quality and temporal correlation. For example, the date may be assigned to a specific chronological event such as the correlation made in Table 2.7 where Garla Mare, GrN-12662 is placed within the Würm III Tardiglacial (Brudiu 1996).

Often in large-scale studies much of this information is not readily available as knowledge of the sites and relevant data comes from secondary sources. One example of this is found at the site of Garla Mare where the dated laboratory sample material, GrN-12662, is unknown (Brudiu 1996). The same can be said at Dunafoldvar for sample Hv-1657 (Dobosi and Hertelendi 1993, 141), where the archaeological context is unknown. This is most often simply a case of that specific data being unpublished. Due to time constraints and the nature of the large scope of research undertaken in this thesis, obtaining the necessary information to fill these gaps is impossible. This issue is addressed in section 2. 4.1; in the discussion that deals with the methodology for applying the quality control criteria to the data.

The 5 points discussed above represent important pieces of information, useful in evaluating and developing a degree of confidence in the quality of the radiocarbon date. The sites of Garla Mare, Romania (Table 2.7) and Dunafoldvar, Hungary (Table 2.8) are compared here to illustrate the value of the quantitative data for assessing the quality of a radiocarbon date for the purposes of judging its usefulness to analytical research.

Table 2.7: Raw data for Garla Mare, Romania (after Brudiu 1996). p/m = plus/minus.

Layer	Geography	Cultural Association	Site Type	Paleo Position	Uncal bp	Uncal bp p/m	Lab Ref. No.	Sample Type	Litho-stratigraphy	Faunal
level W	valley	Gravettian	intermittent occupation; very good cultural remains	Wurm III - Tardiglacial	20140	140	GrN-12662	unknown	loess	Large vertebrates: Rangifer, Bison, Equus; Small vertebrates: Marmota

Table 2.8: Raw data for Dunafoldvar, Hungary (after Dobosi and Hertelendi 1993, 141). p/m = plus/minus.

Layer	Uncal bp	Uncal bp p/m	Lab Ref. No.	Sample Type
upper	12110	315	Hv-1657	bone

The confidence level is dependent on a rank weight, given to the data according to a set of quality control criteria, dependent on the amount of available information on the five factors discussed above. These two single-date sites both provide acceptable dates assuming acceptability is dependent on small standard deviations. In both cases however, significant information pertaining directly to the quality of the dates obtained is missing from the data source. This is an example of one factor that must be taken into account when weighting the date against quality control criteria. So far then, the data for both sites yield equivalent confidence levels. The difference then, is in the amount of available empirical and contextual data.

There is no additional information presented for the date from the upper cultural layer of Dunafoldvar, limiting the confidence level to simple acceptance of the date based on minimal criteria. The confidence level for the date representing Garla Mare however, is increased on the basis of the additional information provided. Here, we can see that the site was occupied intermittently and has yielded "very good" cultural remains, suggesting that the date is more likely (although not conclusively) associated with such remains. It is also known that several faunal species are associated and which paleosols are present. Chronological sequencing has also been assigned. When all the data is put together and compared between sites, the assumption can be made that the radiocarbon data obtained from Garla Mare demands a higher degree of confidence.

In any case, the date must be deemed acceptable at some significant level, particularly in spatial studies. How best to approach weighting and resolving an acceptable working database for this research will be discussed in the following sections.

2.4 THE WORKING DATABASE

In this section, a methodology for classifying each radiocarbon date according to an acceptability threshold is presented.

2.4.1 The Acceptability Threshold and Quality Control

The acceptability threshold is characterised as a ranked level of acceptability given to each date according to a set of predetermined quality control criteria. The method takes separately into account, knowledge about the quality of the radiocarbon date as it pertains to the dating procedure, sample treatment and other concerns normally addressed by the radiocarbon laboratory, and knowledge about the archaeological associations of the dated sample (Housley 1998). In each case, a rank of 1, 2 or 3 is assigned where 1 is 'poor', 2 is 'good' and 3 is 'very good'. The two ranked variables, radiocarbon and archaeology, are then added together resulting in a 6-point rank scale where a total of 2 points is the minimum a date may receive and 6 is the maximum. Following this, each date is then placed relative to the acceptability threshold where a ranked total of 2 is deemed unacceptable and thus eliminated from the working database, a ranked total of 3-4 is deemed acceptable and a ranked total of 5-6 is counted as excellent, or very acceptable.

Radiocarbon Quality Control

The acceptability threshold for radiocarbon quality control is set on the basis of available knowledge about each radiocarbon date where each date is ranked according to the following criteria:

1) If the date was obtained via AMS it is given a +1 rank over the conventional radiocarbon date.

2) If the plus/minus deviation is greater than 1000 years, the date is deemed unacceptable. It is given a 0 rank.

3) If the plus/minus deviation is less than 1000 but greater than 500 years, the date is acceptable but with limited confidence. It is given a +1 rank.

4) If the plus/minus deviation is less than 500 years the date is acceptable with confidence. It is given a +2 rank.

In the case where the radiocarbon date is deemed excellent on the basis of the above criteria, but additional comments available from the literature (and pertaining directly to the date) cause reasonable doubt to the determination, the rank will be reduced by –1.

The minimum rank order is 0 and the maximum is 3. On the acceptability threshold, if the radiocarbon ranking is 0 the date is automatically discarded, a rank of 1 is considered poor, a rank of 2 is considered good and a rank of 3 is deemed very good.

An example of this method is provided below using radiocarbon data from the site of Anetovka 2 (Table 2.9).

Table 2.9: Radiocarbon data from Anetovka 2 showing the dated sample type, lab reference, date obtained and the plus/minus deviation (after Sinitsyn and Praslov 1997). p/m = plus/minus.

Dated Sample	Lab Ref	Uncal bp	Uncal p/m
burned bone	LE-4610	19090	980
bison bone	LE-4066	18265	1650
bison bone	LE-2424	18040	150
burned bone	LE-2947	19170	120
mammoth tooth	LE-2624	24600	150

In this case, note that LE-4066 has been dated at 18265 uncal bp with a plus/minus deviation of greater than 1000 years. This date is automatically discarded from the working database. LE-4610, possessing a plus/minus of 980 years, falls in the category of less than 1000 years but greater than 500. It is given a rank of 1. The remainder of the dates are considered good and ranked at 2. Since none of the dates were derived through the AMS technique, '2' is the maximum achievable rank. In this example, one date is removed, one is considered poor with an acceptability level of 1 and the rest are considered good (Table 2.10).

Table 2.10: The result of the radiocarbon quality control procedure for Anetovka 2. p/m = plus/minus.

Dated Sample	Lab Ref	Uncal bp	Uncal p/m	Ranked for Acceptability
burned bone	LE-4610	19090	980	1
bison bone	LE-2424	18040	150	2
burned bone	LE-2947	19170	120	2
mammoth tooth	LE-2624	24600	150	2

In this case LE-4610 remains a questionable date depending on the available knowledge about the archaeological associations of the dated sample. If there is no further available information on any of these samples, an archaeological acceptability of 1 is assumed. The rank total of 2 for acceptability then, would eliminate this sample from the working database, leaving three out of five dates that can be considered as usable in this research.

Archaeological Quality Control

The acceptability threshold for archaeological quality control is set as follows:

1) Where a definite cultural association (i.e. the sample shows evidence of cut marks or is in direct association with a cultural artefact such as a projectile point) the rank is +1.

2) Where cultural or archaeological association is known to be good, the rank is +1.

3) Where archaeological association is unknown, or is known to be poor, the rank is 1.

This method is applied to Skalisty Rockshelter, Ukraine in the following example (see Table 2.11 for raw data). The available information for this site provides an example of how the threshold for archaeological acceptability is derived and influenced on the basis of knowledge about the data. Hedges et al. (1996,188) note that the two bone samples, OxA-4888 and OxA-4889, were removed from the same location, layer 3, horizon 3, at the site. Since the resulting dates show a roughly 6000-year difference, the results are deemed to be archaeologically unsound. One other result was obtained from the same level. OxA-5165 yielded a date of 11750 ± 120. This is a much closer result to OxA-4888 and may indicate that the latter is the more acceptable of the two bone dates for this layer. In fact, Hedges et al. (1996,188) suggest that OxA-4889 more closely resembles the expected date for layer 7, whereas OxA-4888 does fall within broad expectations for layer 3. Archaeological rankings have been assigned with respect to this information.

Table 2.11: The archaeological rankings for each radiocarbon date at Skalisty Rockshelter assessed on an individual basis according to the given information (Otte 1996; Hedges et al. 1996,188). p/m = plus/minus.

Layer ID	Uncal bp	Uncal bp p/m	Lab. Ref. No.	Sample Type	Archaeological Acceptability
3\2	11620	110	OxA-5164	charcoal	2
3\3	11750	120	OxA-5165	charcoal	2
3\3	12820	140	OxA-4888	bone	1
3\3	18380	220	OxA-4889	bone	0
4	14570	140	OxA-5166	charcoal	2
6	14880	180	OxA-5168	charcoal	2
7	15020	150	OxA-5167	charcoal	2
unknown	15510	unknown	Leuven	charcoal	1

2.4.2 Case Examples Illustrating the Procedure for Determining the Acceptability Threshold

Acceptability for a Series of Dates From Multiple Samples

Using example of Skalisty Rockshelter as an example, a different picture of the quality of the data emerges. In each case, radiocarbon acceptability must be determined before the date can be ranked according to a final acceptability threshold. Immediately one can see that the date of 15510 uncal bp has, unlike the remaining dates, not been attributed to any cultural layer and has an unknown Radiometric Laboratory reference number. Since the standard deviation normally associated with a ^{14}C age determination is missing, the entry is incomplete. This date is given a rating of 1 (poor). The remaining dates were obtained via AMS from the Oxford Radiocarbon Accelerator Unit with a deviation of less than 500 years. This automatically assigns them the highest available ranking of 3. Again however, OxA-4888 and OxA-4889 must be questioned for the reasons discussed above. Hedges et al. (1996, 188) note that the "widely differing age determinations reveal quite graphically... the dangers of pooling bones to produce a date". On the grounds that these dates may well be the result of contamination in this manner, their radiocarbon acceptability is reduced to 2.

Table 2.12 shows the results of both the radiocarbon and archaeological acceptability ranking procedure and the resulting determinations for overall acceptance to the working database.

Table 2.12: Acceptability rankings for Skalisty Rockshelter. P/m = plus/minus.

Layer	Uncal bp	Uncal bp p/m	Lab Ref. No.	AMS	Radiocarbon Acceptability	Archaeological Acceptability	Total	Acceptability
3\2	11620	110	OxA-5164	yes	3	2	5	3
3\3	11750	120	OxA-5165	yes	3	2	5	3
3\3	12820	140	OxA-4888	yes	2	1	3	2
3\3	18380	220	OxA-4889	yes	2	0	2	1
4	14570	140	OxA-5166	yes	3	2	5	3
6	15020	150	OxA-5167	yes	3	2	5	3
7	14880	180	OxA-5161	yes	3	2	5	3
unknown	15510	unknown	Leuven	unknown	1	1	2	1

At Anetovka 2 (Table 2.13), both archaeological and radiocarbon quality control are ranked and the acceptability of the radiocarbon dates associated with this single occupation site are set accordingly.

Table 2.13: Archaeological information available for the site of Anetovka 2. CA=cultural association; AA=archaeological association; SI=stratigraphic information; FI=faunal information; PI=palynological information; E/O=Environmental and other information; ra=radiocarbon acceptability; aa=archaeological acceptability; ta=total acceptability; A=acceptability ranking. p/m = plus/minus.

Lab. Ref. No.	Uncal bp	Uncal bp p/m	AMS	Sample Type	CA	AA	SI	FI	PI	EIO	ra	aa	ta	A
LE-2424	18040	150	no	bison bone	0	0	0	1	0	1	2	1	3	2
LE-2624	24600	150	no	mammoth tooth	0	0	0	1	0	1	2	1	3	2
LE-2947	19170	120	no	burned bone	0	1	0	1	0	1	2	3	5	3
LE-4066	18265	1650	no	bison bone	0	0	0	1	0	1	0	1	1	0
LE-4610	19090	980	no	burned bone	0	1	0	1	0	1	1	3	4	2

In this case, where more than one date are available for the single occupation layer, one date, LE-4066, exceeds the 1000-year plus/minus limitation set out in the criteria as an unacceptable date and is therefore eliminated as a useable date and removable from the database. LE-4610 is considered to be poor in terms of radiocarbon acceptability, however it has been given equal ranking with the remaining dates based on it archaeological acceptability.

The remaining three dates were all given a radiocarbon acceptability of 2 (good) as the determinations were all below ± 500. Like LE-4610, LE-2947 has been assigned a slightly higher archaeological acceptability ranking due to the nature of the sampled material. The two carbonised samples produced very similar dates.

The quality control procedures implemented in this research are defended by the results from Anetovka 2. The mean date for the site is 20225 ± 350 uncal bp. The median date is 19130 ± 150 uncal bp. This is consistent with the typological assessment of Zaliznyak (1999, 337-338), which places Anetovka 2 between 20000 and 18000 years ago.

In a final working example, Amvrosievka, Ukraine, both archaeological and radiocarbon quality control procedures are put into practice, and the acceptability of the radiocarbon dates are set accordingly. The test site consists of a base camp and bone bed, and is assigned to the Eastern Gravettian technocomplex (Table 2.14).

Radiocarbon acceptability for Amvrosievka is as follows:

In this case, all but 3 of the dated samples were obtained via AMS, and all dates fall within the "accepted with confidence" level for radiocarbon acceptability. LE-1637 is assumed to be "clearly too young" (Krotova and Belan, 1993, 128), an unreliable date due to long-term curation. On the basis of this knowledge the radiocarbon ranking for this sample is reduced to '1'. All the AMS dates are considered to be excellent (ranked 3) and the remaining as good (ranked 2). Of the three non-AMS dates, Krotova and Belan (1993, 129) propose that LE-3403 represents the most accurate date for the Amvrosievka bone bed.

Table 2.14: Archaeological information available for the site of Amvrosievka (after Krotova 1996; Sinitsyn and Praslov 1997). P/m = plus/minus.

Layer ID	Sample Type	Lab Ref. No.	Uncal bp	Uncal bp p/m	AMS	Arch. Assoc.	Cultural Assoc.	Other Pertinent INFO
top of culture layer; bone bed	bison bone	LE-1805	20620	150	no	good	good-uncertain	exact occupation location uncertain due to erosion; faunal assoc. good; attributed to Late Mammoth Complex
culture layer; bone bed	bison bone	LE-1637	15250	150	no	poor	good-uncertain	exact occupation location uncertain due to erosion; faunal assoc. good; attributed to Late Mammoth Complex
horizon I	bone	OxA-4891	18860	220	yes		good-uncertain	exact occupation location uncertain due to erosion; faunal assoc. good; attributed to Late Mammoth Complex
horizon I	bone	OxA-4890	18700	240	yes		good-uncertain	exact occupation location uncertain due to erosion; faunal assoc. good; attributed to Late Mammoth Complex
horizon II; bone bed	bone	LE-3403	21500	340	no	good	good-uncertain	exact occupation location uncertain due to erosion; faunal assoc. good; attributed to Late Mammoth Complex
horizon II-III	bone	OxA-4892	18700	220	yes		good-uncertain	exact occupation location uncertain due to erosion; faunal assoc. good; attributed to Late Mammoth Complex
horizon II-III	bone	OxA-4893	18620	220	yes		good	exact occupation location uncertain due to erosion; faunal assoc. good; attributed to Late Mammoth Complex
horizon IV	bone	OxA-4894	18220	200	yes		good	exact occupation location uncertain due to erosion; faunal assoc. good; attributed to Late Mammoth Complex
horizon VI	bone	OxA-4895	18660	220	yes		good	exact occupation location uncertain due to erosion; faunal assoc. good; attributed to Late Mammoth Complex

Archaeological acceptability for Amvrosievka is as follows:

1) Cultural association is known to be good for OxA-4893, OxA-4894 and OxA-4895 and *assumed* to be good for the remainder of the samples. The three samples are given a +1 rank. The remainder will be further assessed on the basis of additional information. In the cases of LE-3403 and LE-1805, archaeological association is known to be good and can be given a rank of +1. LE-1637 however, is shown to have poor archaeological association and an uncertain cultural association. This sample is given a rank of 1 only. The archaeological history of the site indicates that the remainder of the dates can be assigned a '2' for this category. It is known that the site itself has been subject to extensive processes of erosion (Krotova 1996), though association with Pleistocene fauna is known to be good in all cases. The acceptance of the archaeological control as being 'good', is supported by Krotova and Belan (1993, 129), who note that cultural remains are better preserved in the bone bed.

The archaeological acceptability of the samples can be categorized where LE-1637 is considered as poor (rank 1), LE-3403 and LE-1805 are good (rank 2) and OxA-4893, OxA-4894 and OxA-4895 are considered very good (rank 3). The remainder must be given an automatic rank of 2. Table 2.15 shows the results of the ranked data for total acceptability.

Table 2.15: Acceptability of radiocarbon data for Amvrosievka. p/m = plus/minus.

Lab Ref. No.	Uncal BP	Uncal bp p/m	Radiocarbon Acceptability	Archaeological Acceptability	Total	Acceptability
LE-1805	20620	150	2	2	4	2 (good)
LE-1637	15250	150	1	1	2	1 (poor)
OxA-4891	18860	220	3	2	5	3 (very good)
OxA-4890	18700	240	3	2	5	3 (very good)
LE-3403	21500	340	2	2	4	2 (good)
OxA-4892	18700	220	3	2	5	3 (very good)
OxA-4893	18620	220	3	3	6	3 (very good)
OxA-4894	18220	200	3	3	6	3 (very good)
OxA-4895	18660	220	3	3	6	3 (very good)

Hedges *et al.* (1996:187-188) suggest "this is a consistent set of dates… [showing that] the pattern is as would be expected from a single event although theoretically multiple short occupations over a 400 year time period would produce a similar effect" [my parentheses].

Acceptability for a Series of Dates for a Single Sample

Two dates from Avdeevo (Table 2.16), GIN-1571a and GIN-1571b, were obtained from the same sample of burned bone (Sinitsyn and Praslov 1997; Grigoriev 1996). This would result in very different interpretations on the knowledge of these dates should they be evaluated separately. In this case, because it is known as fact that the dates come from the same sample, it can be assumed that the archaeological context is the same. This highlights the need for thorough background research when compiling the data and emphasises a difficulty that could affect the outcome of analysis drastically. Should these dates be evaluated separately, acceptability between them would vary considerably (Table 2.17). Even when evaluated together, GIN-1571b must be discarded due to its failure to meet the radiocarbon criteria, leaving a single acceptable date for this sample.

Table 2.16: Raw data for Avdeevo GIN-1571a and GIN-1571b (Reyniers and Helsen 1996). P/m = plus/minus.

Cultural Association	Site Type	Paleo Position	Uncal bp	Uncal bp p/m	Lab Ref. No.	Sample Type	Lithostratigraphy	Environs	Faunal
Upper Palaeolithic - Gravettian episode	permanent; very good cultural remains; excellent archaeological associations	Between two layers of the sand sealed by the upper one covered by loess; at the top of alluvial deposits of the 1st terrace	22700	700	GIN1571a	burned bone	surface of the deposits with cultural remains	cold enough climate, dwarf plants as Betula nana, Alnaster fruticosa, low percent of arboreal pollen	cold fauna; all parts of mammoth skeleton accumulated in pits and over the habitation area; full skeletons of wolves and polar foxes in pits
			17200	1800	GIN-1571b	same sample as GIN-1571a			

Table 2.17: Acceptance Ranking of Avdeevo GIN-1571a and GIN-1571b.

Uncal bp	Uncal bp p/m	Lab Ref. No.	AMS	Radiocarbon Acceptability	Archaeological Acceptability	Total	Acceptability
22700	700	GIN1571a	no	1	2	3	2
17200	1800	GIN-1571b	no	0	N/A	0	0

The site of Pieny 1 presents a very different problem (Table 2.18). Here there is little knowledge available on the single sample as it was obtained from the INQUA (International Union for Quaternary Research) database (Reyniers and Helsen 1996). LE-1400 has produced 3 very different dates. Evaluation for accepting each of these dates must therefore be limited to the radiocarbon quality control and an automatic ranking of 1 for archaeological acceptability according to the method. The result in this case is that all three dates are deemed equally acceptable with a ranking of 2 (good). The determination of a single date must be derived in the next stages of the working database development.

Table 2.18: Acceptability data for Pieny 1, LE-1400. p/m = plus/minus.

Uncal bp	Uncal BP p/m	Lab Ref. No.	Sample Type	AMS	Radiocarbon Acceptability	Archaeological Acceptability	Total	Acceptability
23100	280	LE-1434	bone	no	2	1	3	2
25200	350	LE-1434	bone	no	2	1	3	2
21600	350	LE-1434	bone	no	2	1	3	2

Acceptability for a Lone Date

One example comes from Stanistea in Romania (Table 2.19). The date was submitted to the INQUA database (Reyniers and Helsen 1996) by Brudiu. Though the archaeological data associated with the site is considered very good, the dated sample type is unknown. Without this knowledge consideration of sample quality cannot be undertaken. This leaves little alternative but to rank archaeological acceptability of the date as poor (rank 1). The radiocarbon date itself, however, can be ranked as good (rank 2) since the date has a deviation of less than 500 years and apparently good associations. Thus, the overall acceptability of this date is good.

Table 2.19: Data for Stanistea, Romania (Brudiu 1996). P/m = plus/minus.

Cultural Assoc.	Site INFO	Lithostratigraphy	Paleo Position	Uncal bp	Uncal bp p/m	Lab Ref. No.	Sample Type	Faunal INFO
Gravettian	intermittent occupation; very good cultural remains; excellent archaeological associations	loess	Wurm III tardiglacial	19460	220	Bln-144311	unknown	Rangifer, Bison, Equus

On the other hand, a single date exists for Balatonszabadi, Hungary (Dobosi and Hertelendi 1993, 141) of 21725 ± 660 uncal bp. There is little other information associated with this date that will aid the evaluation process. As a result, it is given a rank value for radiocarbon acceptability of 1 (poor) as it is useable (since it does not exceed the 1000 year deviation limit) but neither is it AMS derived, or below 500 years in deviation. The radiocarbon laboratory that dated the sample is unknown. The sample type itself is unknown and no data is readily available as to the context of the site this date is seen to represent. Unknown information demands a ranking of 1 (poor).

The total is 2 out of a possible 6. According to the criteria set in this methodology, this date is accepted for use in the working database, but ranked as poor.

2.5 CALIBRATING THE DATA

Inconsistency between environmental and radiocarbon data is a qualitative concern which archaeologists need to address.

Until recently, the Pleistocene climate record could not be compared to the Upper Palaeolithic radiocarbon record because of time-dependent differences (see Stuiver et al. 1998; van Andel 1998). Van Andel (1998: 30) refers to these differences as the "elastic" C^{14} time-scale and the "real time" calendrical time-scale. This "real" time can be viewed as a constant, while the radiocarbon time-scale is variable. The deviations occur at singular events shared by each time-scale, but because of the fluctuation of the radiocarbon time, the result is that the timing of this singular event is different for one than the other. Resolution of this problem is being addressed through studies of temporal variations in the earth's magnetic field, and chronological sequences derived from ice cores, marine data (e.g. coral) and tree rings. This has led to the development of calibration curves to allow for the correction from large deviations between the radiocarbon time-scale and the calendrical chronology of environmental data (van Andel 1998; Stuiver et al.1998). It also, however, now requires the researcher to decide on which calibration curve to use and which method of calibration is most appropriate.

2.5.1 The Calibration Curve

Calibration curves model the relationship between radiocarbon age and calendar years. They have been developed in response to the necessity to correct for the large deviations in the radiocarbon time-scale. One of the initial assumptions about radiocarbon dating was that the rate of production of radiocarbon is constant. This assumption is now known to be incorrect, meaning that radiocarbon years are not equivalent to calendar years. Long-term variations in the rate of production appear to correspond to fluctuations in the strength of the Earth's magnetic field (Stuiver et al. 1998; van Andel 1998, 26-29). "Because radioactive carbon mixes differently in different environments, a different calibration curve is required when calibrating material from organisms that metabolised in different carbon reservoirs" (Buck et al. 1999, URL: http://intarch.ac.uk/journal/issue7/buck/toc.html). Thus, a marine curve is normally used to calibrate the dates for material of marine origin such as shell or fish bones. An atmospheric curve is used to calibrate the dates for organic material of terrestrial origin such as deer, crop seeds etc. (van Andel, 1998; Buck et al. 1999).

Prior to the development of the working database for this research, two calibration curves and their association calibration programs have been compared and tested to determine the most applicable application to this work. An overview of the INTCAL98 curve (Stuiver et al. 1998) and the Oxcal Calibration Program (Bronk Ramsey 1999) will be addressed first followed by the CALPAL calibration procedure (Jöris and Weninger 2000).

2.5.2 INTCAL98 and the OxCal Calibration Program

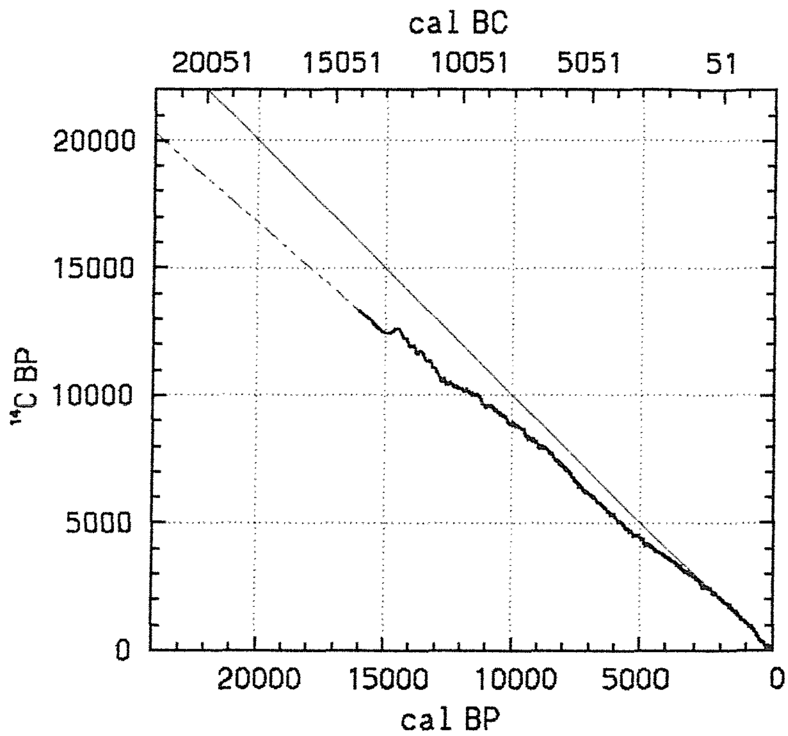
Radiocarbon Calibration and INTCAL98

The standard for calibrating radiocarbon dates in the past has been through dendrochronology, or tree ring dating (Baillie 1995). Some species of trees (e.g. Irish and German oak) grow one ring per year, carbon can be measured and compared, the rings counted, and a calendrical date derived. A dendrochronological sequence has been established that provides an absolute chronology to ca. 10300 cal BP (Stuiver et al. 1998, 1041). While this is acceptable for more recent Holocene chronologies because the dendro-database is readily available, it is not so useful for the Upper Palaeolithic (van Andel 1998, 26).

Another means of measurement are through uranium-thorium (U-Th) dating of corals. Housley has pointed out that these allow for calibration from the early Holocene to ca. 24000 (letter to the author 01 September 1999). "Whereas tree-ring ^{14}C, *via* the photosynthetic cycle, equilibrates with atmospheric carbon dioxide, corals equilibrate with mixed-layer ocean bicarbonate. The slightly lower ^{14}C activity (per gram of carbon) of the mixed layer, relative to the atmosphere, results in an offset (the ^{14}C reservoir age correction) between "atmospheric" and "oceanic" ^{14}C ages of samples with identical cal age" (Stuiver et al. 1998, 1041). The correction is 509 ± 25 radiocarbon years over the 12000 – 10000 cal BP time period. A marine varve sequence supports the curve from 11700 cal bp to 14500 cal BP (Stuiver et al. 1998) and ice core data provide additional correlating measurements (Housley, letter to the author, 01 September 1999). A combination of these data has been correlated by Stuiver et al. (1998) to produce the INTCAL98 calibration curve (Figure 2.4). The curve is considered acceptable to 24000 BP.

Correcting according to a given calibration curve involves more than one statistical procedure (Bronk Ramsey 1999; Buck et al. 1999) to correct for radiocarbon deviation, in order to 'fit' the data to the curve and to allow for degrees of confidence. These are often dependent on the needs of the researcher and certainly on the quality of the data being calibrated. There are now however, a number of computer-based programs that are structured to perform the necessary statistical calculations for correcting the radiocarbon age to the calibrated age.

Figure 2.4: The INTCAL98 Calibration Curve showing deviation of the INTCAL98 calibration curve from a one to one radiocarbon age versus calendar age. Dashed lines represent insufficient data. Obtained from the Quaternary Isotope Lab website (1999, URL: http://depts.washington.edu/qil/images/intcal.jpg)



The OxCal Radiocarbon Calibration Program, v.3.3

The OxCal calibration program provided by the University of Oxford Radiocarbon Accelerator Unit (Bronk Ramsey 1999), can be used in conjunction with INTCAL98 (Stuiver et al. 1998). OxCal allows for the calibration of multiple dates, alone or as a group, and for complex statistical procedures, including both long-range probability and bayesian (posterior distribution) calculations. Calibration is performed by a comparison of the measured radiocarbon age to the INTCAL98. The program integrates several calibration curves including INTCAL98. During the calibration process, OxCal performs chi-square testing for confidence. Both text and graphical output are available.

2.5.3 CALPAL

The CALPAL method, otherwise known as the Köln Radiocarbon Program Package (Jöris and Weninger 1999) is a combination of computer applications that provide for achieving objectives similar to those of OxCal (e.g. wiggle-matching). In addition, one advantage to the CALPAL package is the ability to graphically display comparative environmental data. The authors of this package have incorporated additional environmental data, which accommodates the extension of the INTCAL98 curve back to 45000 – 50000 BP, some 20 – 25 thousand years (kyr) longer than previous curves allowed.

Jöris and Weninger (2000, 1) suggest that marine and terrestrial records controlled by Uranium/Thorium ages on coral are in good agreement with the GISP-2 time-scale. As such, these data may be "synchronized" with the Vostok ice-core chronology, which is "astronomically tuned". In turn, similarities between these and the GRIP chronology used in INTCAL98 can be aligned to produce the temporal extension. The data has been further correlated with various other environmental data (e.g. marine varves and other ice-cores). Testing against radiocarbon data produced "strikingly good agreement" (Jöris and Weninger 2000, 8), suggesting that this newer methodology shows potential for enabling more accurate chronological conclusions for the Upper Palaeolithic.

Jöris and Weninger (2000, 8-9) are careful to reiterate the caution that calendar age conversions are inherently prone to error and thus interpretation remains difficult. The usefulness to Upper Palaeolithic research should this method prove fruitful under scrutiny, is evident.

2.5.4 A Comparison of Calibration Procedures

Comparing calibration methodologies can be difficult in light of the variable approaches available that will, when used, give varying results (sometimes vastly different). Here, the two methods are compared using the simplest calibration technique – straight across calibration of the dates with no regard to the possible influence of archaeological considerations.

In the following example, the single date of 17480 ± 150 uncal bp (GO-10212) for Descrowa Cave, Poland (Cyrek 1996) is used to illustrate simple calibration (i.e. data entry with no conditions or bounding parameters) using OxCal v.3.3 (Figure 2.5). Note that a total of 4 calibrated dates are given (top right corner of diagram); two for each of 68.2% (sigma 1) and 95.4% (sigma 2) confidence levels. These dates represent the deviation limits from the median for each confidence level. The date to be used in the working database for this example is the median (or mean) of the two range dates at the 95.4% (sigma 2) confidence level. In this case the working date is 20802 ± 732 cal BP.

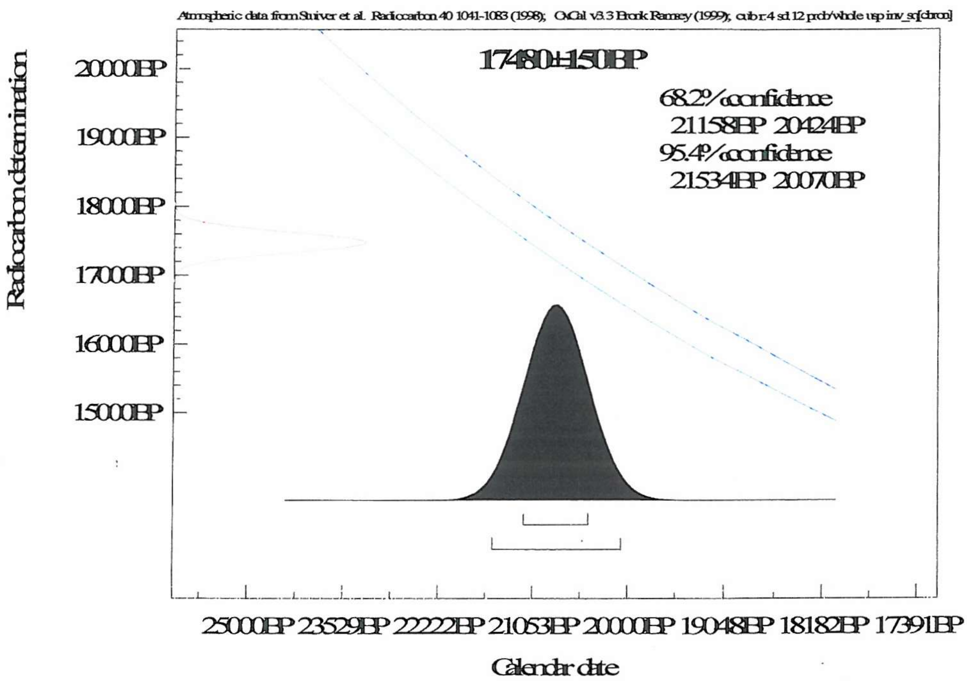


Figure 2.5: Calibration results determined by OxCal v.3.3 on the Descrowa Cave radiocarbon date 17480 ± 150 uncal bp (GO-10212).

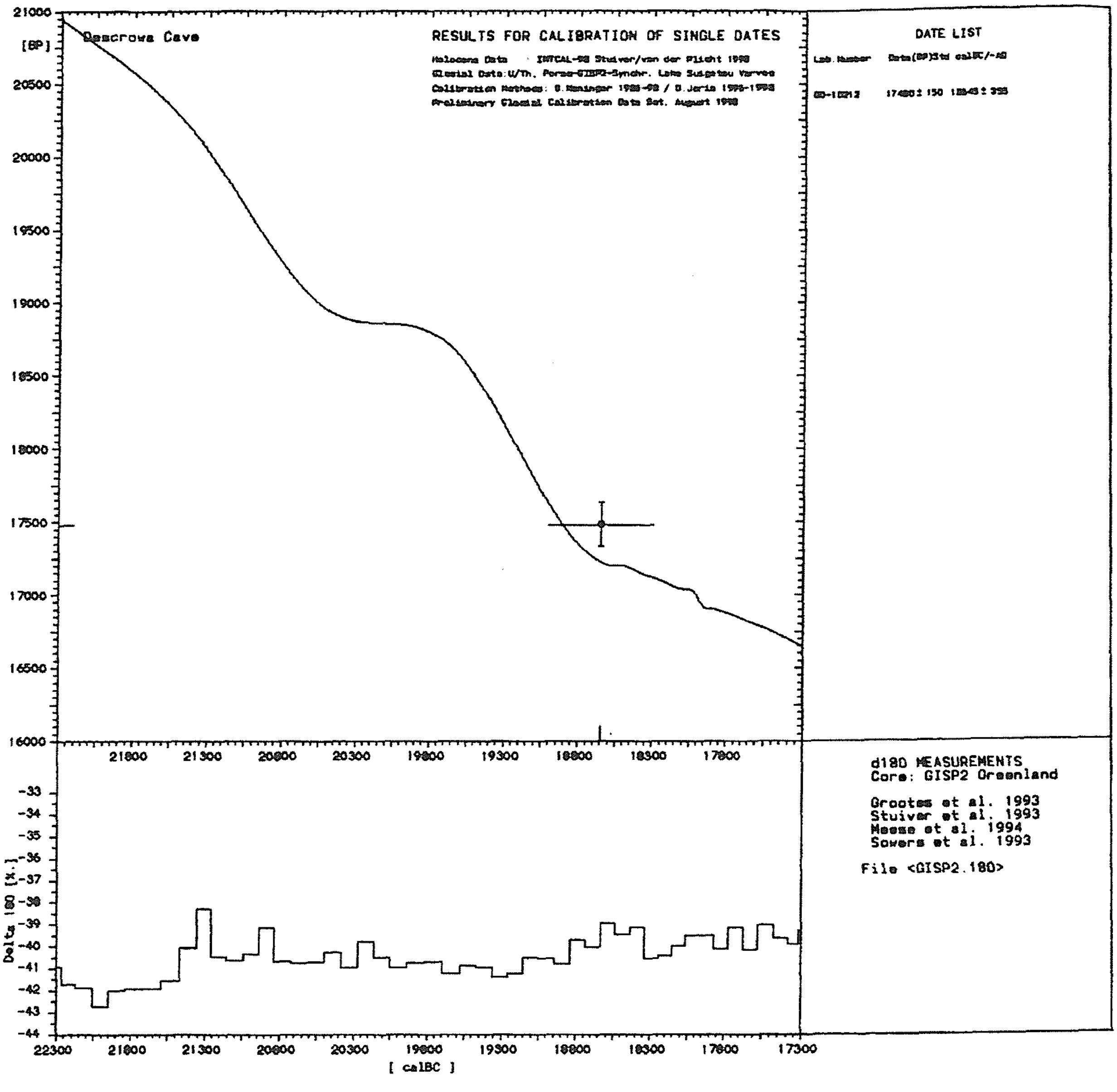


Figure 2.6: Calibration results determined by CALPAL on the Descrowa Cave radiocarbon date of 17480 ± 150 uncal bp (GO-10212). The date range is 17480 ± 150 to 18645 ± 355.

The same data are used achieve a calibrated date using CALPAL (Figure 2.6) at 99.7% confidence (sigma 3). Here the result is 18645 ± 355 cal BC. There is a difference of approximately 207 years once BC and BP are adjusted, and a reduced error margin by ± 377 years. There is a significant difference between the results of the OxCal method at sigma 2 and CALPAL at sigma 3.

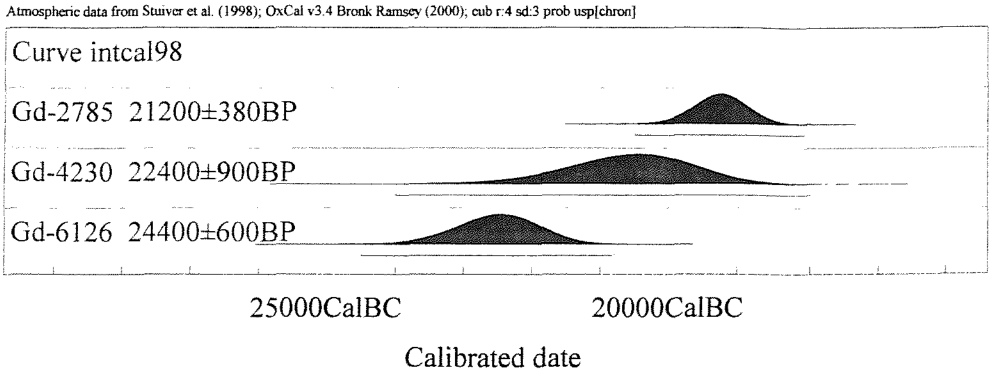


Figure 2.7: Results for Temnata Cave, 6\7a,b, using INTCAL98 and OxCal.

In this second example, a single occupation layer producing a series of dates representing the earliest extent of the INTCAL98 curve is used to compare the assumption that the INTCAL98 curve is less accurate than CALPAL at the 99.7% (sigma 3) confidence level. The dates representing Temnata Cave, Bulgaria, layers 6\7a,b (Bluszcz et al. 1992, 225), are used here following the same methodology.

Figure 2.7 shows the results of the OxCal calibration. The application of the program yielded an error message suggesting that the date was "out of range" and the option to retry was used. This tells the program to find a way around the problem, most likely a result of the limited range of the INTCAL98 curve. The mean calendar date is calculated to be 20983 cal BC, while the median is 21000 cal BC. Using the R-Combine (Bronk Ramsey, 1999) option in OxCal, the dates were re-worked to produce a median result of 20650 cal BC.

Figure 2.8: Results for Temnata Cave, 6\7a,b, using CALPAL. The results are as follows: Gd-2785 is given the range 21200 ± 360 to 23495 ± 475; Gd-4230 is given the range 22400 ± 800 to 23525 ± 825; Gd-6126 is given the range 24400 ± 600 to 25825 ± 975.

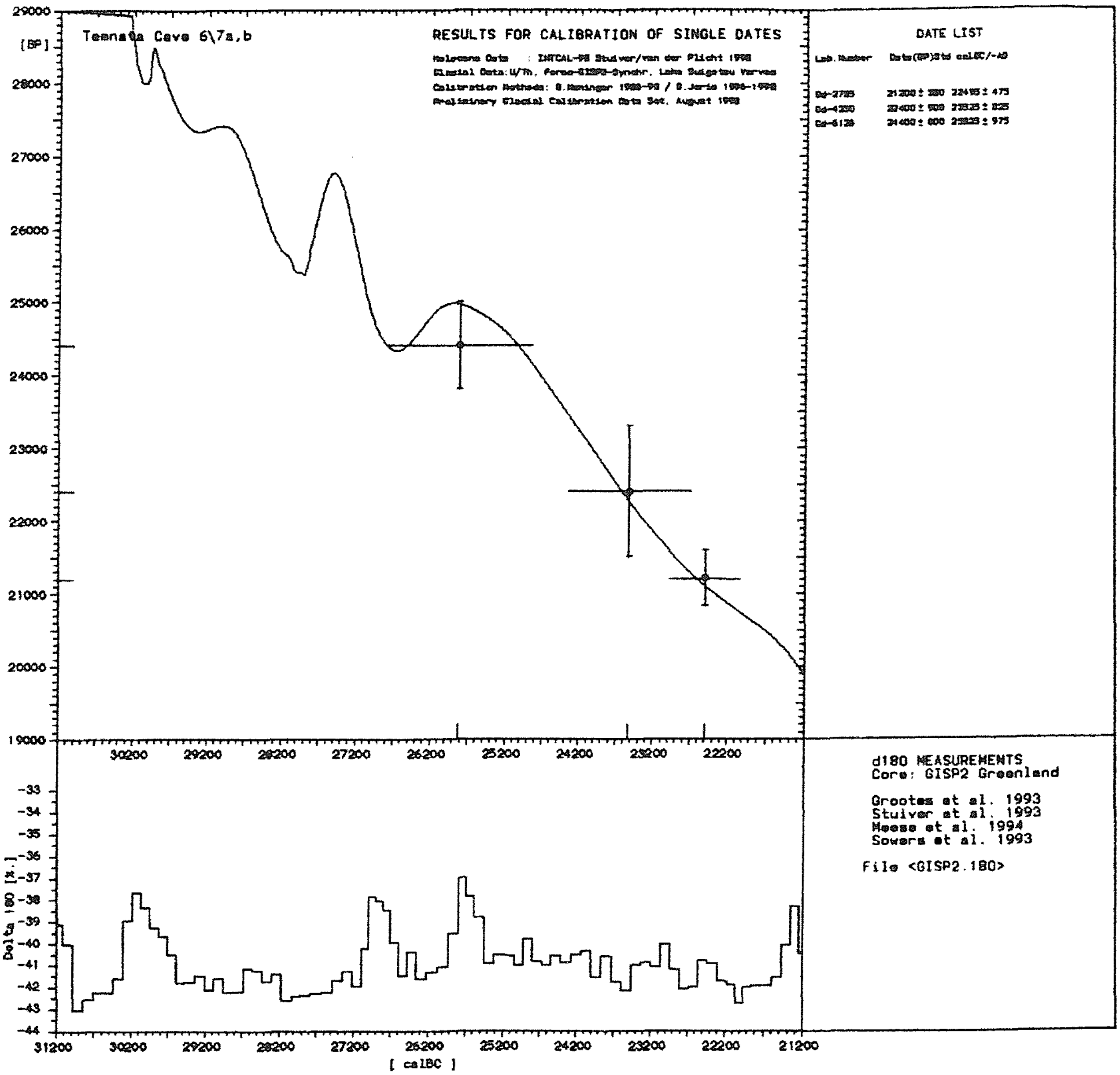


Figure 2.8 shows the results from the CALPAL calculations utilising sigma 3. There is a significant discrepancy noted in this case. In both scenarios, the INTCAL98 curve was used. Differences were noted in the application of each method. Within the CALPAL program, the extended time scale, INTCAL98 extended, from 25000 – 45000 cal BC as described in the previous section is applied. The shift during this time is 2000 calendar years earlier (Jöris and Weninger 1998, 4), accounting for the large difference in calibrated results. The mean result from CALPAL is 23948 cal BC, while the median is 23525 cal BC.

While the younger dates (roughly before 18000 cal BC) calibrate with very similar results using both methods, it is the difference in the earlier dates that will lead to the choice of application. When the result is compared to the expected chronology, based on typological assignments and palaeo-climatological evidence, the two calibration methods can be compared and assessed to determine the most appropriate application for this research.

The cultural level 6\7a,b at Temnata Cave corresponds to the lithostratigraphic unit 3d (Figure 2.9 as presented by Ginter and Kozlowski 1992, 292). The level has been TL-dated to 22900 ± 2100 (Gd-210; Ginter and Kozlowski 1992, 290). Kozlowski (1996a, 320-321) correlates cultural levels 6\7 at Temnata Cave to the Willendorf Gravettian sequence, suggesting a date of 24000 to 22000 years ago. This is supported by lithic typology; that Middle Danube type Gravettian backed points, dated between 23000 and 21000 years ago, are dominant in this level (Kozlowski 1996a, 321-323).Calibrated radiocarbon dates for the unit are shown in Figure 2.10 (OxCal) and Figure 2.11(CALPAL).

Calibrated dates using OxCal yielded an averaged result of 19300 ± 693 cal BC and 19200 cal BC using the R-Combine option. CALPAL produced an average of 22063 ± 633 cal BC and a median date of 22495 ± 475 cal BC. When compared to empirical data from Temnata Cave (Kozlowski et al. 1992), the results derived using CALPAL appear to be the most appropriate since the date produced using CALPAL correlates well with both the TL date and the Gravettian sequencing suggested by Kozlowski (1996a, 321-323). The date produced using the OxCal methodology appears to be too young.

Litho-logical units	Cultural levels	C14		TL
		charcoals	bones	burnt flints
3a (350-410)	I (-275) Ia (-280-290) II (-293-305) III (-305-317) several layers of scattered artefacts	10 480 ± 280 (Gd-4025) 10 880 ± 480 (Gd-4022) 20 100 ± 900 (Gd-4028)	16 600 ± 300 (Gd-2578) 24 800 ± 700 (Gd-2581)*	15400 ± 6100 (Gd-213) 19600 ± 3700 (Gd-212)
Hiatus	Hiatus			
3c (400–360)	IV + Va, b			
(450/365) 3d	VI + VIIa, b		22 400 ± 900 (Gd-4230) 21 200 ± 380 (Gd-2785) 24 400 ± 600 (Gd-6126)	23300 ± 5100 (Gd-214)
Hiatus	Hiatus			
3g	Upper Palaeolithic		> 33 100 (Gd-4595)	
3h	Upper Palaeolithic		> 32 200 (Gd-4693)	
3i	Aurignacian			
3j	Aurignacian			
4 a, b	Aurignacian			

* Bone from 3d.

Figure 2.9: Lithostratigraphic and cultural sequences of Temnata Cave, Trench TD-V (after Ginter and Kozlowski 1992, Table II).

Figure 2.10: OxCal calibration of lithostratigraphy unit 3d at Temnata Cave – sigma 3.

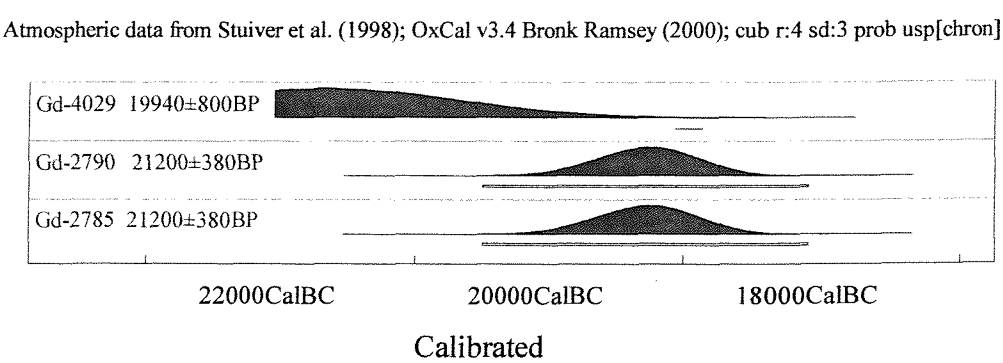
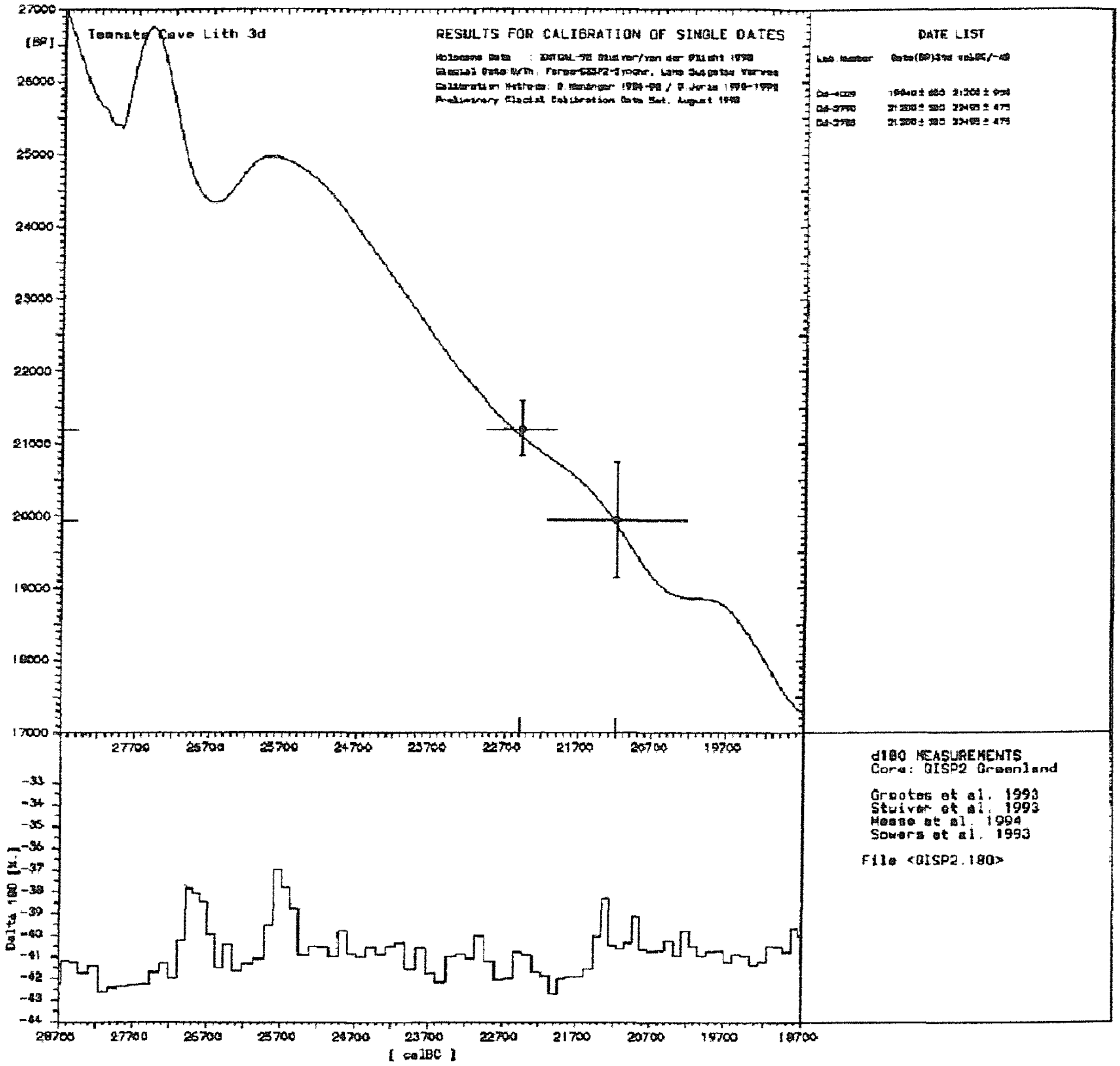


Figure 2.11: CALPAL calibration of lithostratigraphy unit 3d at Temnata Cave – sigma 3. Gd-4029 is given the range of 19940 ± 600 to 21200 ± 920; Gd-2790 is given the range of 21200 ± 580 to 22495 ± 475; Gd-2785 is given the range of 21200 ± 580 to 22495 ± 475.



OxCal vs. CALPAL: Comparing the Results

In this next example, a series of dates from a well-documented site, whose dates extend to the earliest limits of the INTCAL98 calibration curve, are used to compare the two methods. The site of Kraków Spadzista, Poland is interpreted as a seasonal base camp consisting of two or three dwellings of mammoth bones (Kozlowski 1990, 212). Table 2.20 describes the quality control results for uncalibrated radiocarbon dates obtained for the site.

Table 2.20: Quality control results for Kraków Spadzista. RA = radiocarbon acceptability, AA = archaeological acceptability, TA = total acceptability, A = acceptability threshold. B/p = plus/minus.

Site	Layer ID	Technocomplex	Lab Ref. No.	Uncal bp	Uncal bp p/m	AMS	Sample	RA	AA	TA	A
Kraków Spadzista St B	Level 6	Gravettian	GrN-6636	23040	170	no	charcoal	2	2	4	2
Kraków Spadzista St B	Level 6	Gravettian	Ly-631	20600	1050	no	ivory	0	2	2	0
Kraków Spadzista St C2	Level 6, Layer II	Epigravettian	Ly-2541	17400	310	no	bone	2	3	5	3
Kraków Spadzista St C2	Level 6, Layer III	Gravettian	GrN-11006	24380	180	no	charcoal	2	2	4	2
Kraków Spadzista St C2	Level 6, Layer III	Gravettian	Ly-2542	21000	900	no	bone	1	3	4	2
Kraków Spadzista St C2	Level 6, Layer III	Gravettian	OxA-635	20200	350	yes	ivory	3	3	6	3
KrakówSpadzista St F	Level 6	Gravettian	Ki-3712	22900	600	no	bone	1	3	4	2
Kraków Spadzista St F	Level 6, Layer II	Gravettian	Ki-3713	23600	1400	no	bone	0	3	2	0
Kraków Spadzista	lower	Gravettian	Ly-2544	21000	300	no	?	2	1	3	2
Kraków Spadzista	upper	Epigravettian	Ly-2545	17480	310	no	?	2	1	3	2

Note that two dates, Ly-631 and Ki-3713, exceed the radiocarbon cut-off of 1000 years in deviation and will be eliminated from the database immediately for that reason since both belong to stratigraphic units where more acceptable dates are available. This leaves ten dates for calibration. Figure 2.12 shows the calibration and chronology for the culture levels at Kraków Spadzista.

Table 2.21: Calibration of Kraków Spadzista. The mean of each range of dates is recorded. Dates are given in cal BC.

Site, Layer ID	Lab Ref. No.	OxCal sigma 1	OxCal sigma 2	OxCal sigma 3	CALPAL sigma 3
B, Level 6	GrN-6636	21095	21100	21150	24070
C2,Level 6, Layer II	Ly-2541	18750	18800	18800	18425
C2, Level 6, Layer III	GrN-11006	22435	22425	22450	25855
C2, Level 6, Layer III	Ly-2542	19100	19300	19500	22280
C2, Level 6, Layer III	OxA-635	21465	20925	20420	21595
F, Level 6	Ki-3712	20950	21050	21150	24000
lower	Ly-2544	19075	19050	19100	22315
upper	Ly-2545	18850	18850	18900	18515

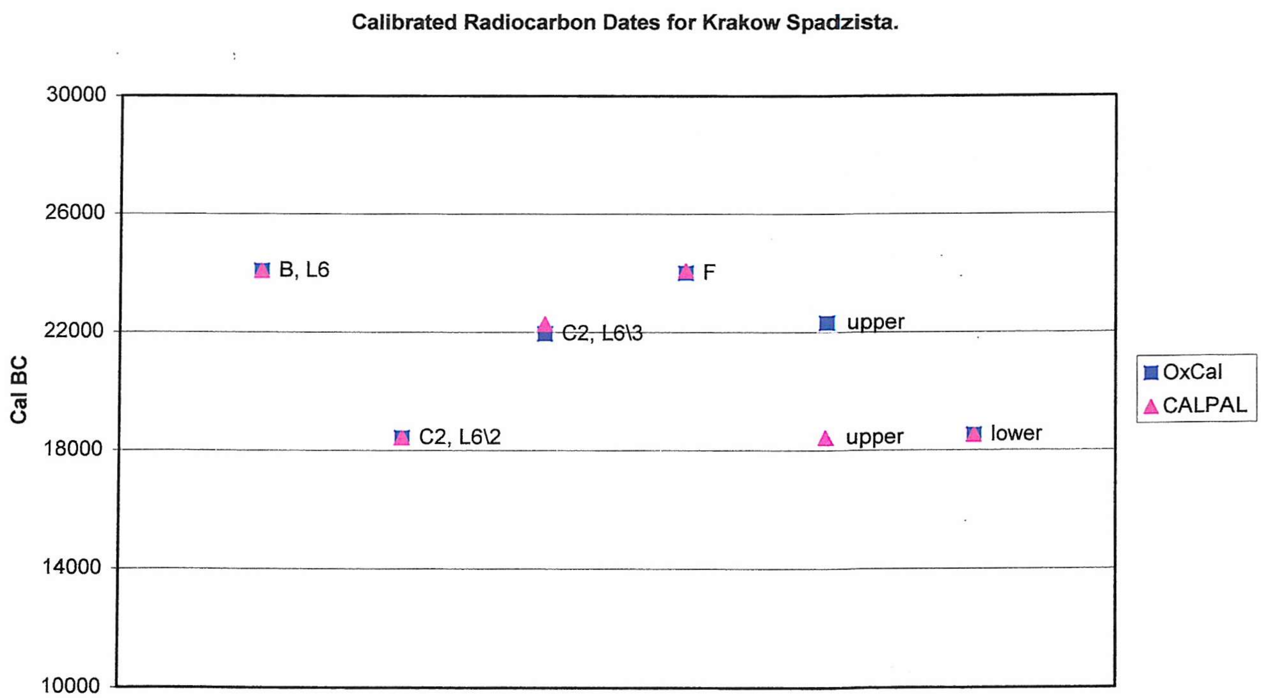
As the data illustrates, there is a significant difference in the outcome of calibration between the OxCal method and CALPAL beyond 18900 cal BC years. This is particularly problematic for Kraków Spadzista Level 6, Layer III since the difference jumps to about 2000 calendar years as a result of the INTCAL98 curve extension (Jöris and Weninger 1998). This can be addressed more closely in this case.

A final procedure that must be dealt with to complete the development of the working database is the derivation of a single date from a series. This has been addressed in previous section. Here however, the task is dealt with in conjunction with the calibration procedure since "combining" dates (using probability measures) is one advantage to using the OxCal system (Bronk Ramsey 1999). Table 2.22 shows the results when the dates are calibrated at sigma 1 (68.2% confidence), sigma 2 (95.4% confidence and sigma 3 (99.7% confidence) for the series of dates produced for Kraków Spadzista C2, Level 6, Layer 3. Those results corresponding to sigma 3 are highlighted as both programs use the 99.7% confidence ratio. Note the close similarity between the date produced using the R_Combine method of OxCal (where the data are combined prior to calibration), and the median calibrated date (derived after calibration) produced by CALPAL. These two dates will be used as the chronological placement for C2, Level 6, Layer 3. Figure 2.12 compares the calibrated results of the two methods. The only significant discrepancy now is in the result derived for Ly-2545. The date is calibrated inversely between the programs with the OxCal result showing the upper layer as being older than the lower layer and CALPAL showing a more acceptable chronology. This adds more weight to the acceptability of the CALPAL method for the purposes of this research considering its focus on colonisation.

Table 2.22: Kraków Spadzista C2, Level 6, Layer 3 showing the single mean date derived for a given occupation layer, based on the results described in Table 2.21. The sigma 3 dates are highlighted as they were both calculated for a 99.7% confidence.

Sigma	**Level 6, Layer III combined using OxCal**
1	21925
2	21925
3	**21950**
calpal 3	**23243**
	Mean Date Taken
1	21000
2	20883
3	**20790**
calpal 3	**23243**
	Median Date Taken
1	21465
2	20925
3	**20420**
calpal 3	**22280**

Figure 2.12: Comparison of the results for Kraków Spadzista. While most of the dates are comparable, note that the OxCal result for the "lower" level is placed as more recent than the "upper" stratigraphic level, whereas CALPAL is more consistent with stratigraphy.



The analyses presented in the above examples have shown that the CALPAL method of radiocarbon calibration of the Upper Palaeolithic data yields consistently more acceptable results than does the OxCal program. Given the comparative results presented here, the CALPAL method will be used for the calibration of the radiocarbon dates.

2.6 THE FINAL DATABASE

The database to be used as the basis of the remainder of this research is derived through the procedures discussed so far. The final step in the method to produce a working database for spatial and temporal analysis is to obtain a single date to "characterise" each cultural layer. Each date then will represent a point, or location, in time and space.

There is no sound means of achieving this without drawing considerable criticism. However, the examples presented in the previous section support the simpler approach to the problem. In this work, where a series of dates that have met the control criteria for acceptability, exist for a single culture level, the median calibrated date will be deemed appropriate, and used to represent the chronological age of the culture level. Where only one date is available, it is automatically accepted for the same purpose.

The results of this procedure are comparable to those presented by Dolukhanov (1999). Dolukhanov has addressed the need to develop a methodology to achieve this objective for data analyses. The results of his work on the late Pleistocene settlement of modern humans in the East European Plain also culminated in the production of a database consisting of single "characterised" dates. These can be found in Appendix D, and can be compared with the results of my own work, which are presented in Appendix B.

The final database consists of 260 culture levels from 165 sites. This radiocarbon data will be treated as data points, temporally and spatially, through the remainder of this thesis.

2.7 SUMMARY

The goal of this chapter was to meet the objectives of the first part of the research as outline in Chapter One. The problems and perspectives associated with using radiocarbon data as data points for the purpose of modelling colonisation processes were recognized and discussed. Two major issues have arisen out of the discussion. The first is that of quality control of the Upper Palaeolithic archaeological database. This is resolved by establishing a set of quality control criteria that, when applied to the data, allowed for the determination of an acceptability threshold for each radiocarbon date. A second is the problem of how to address unclear groups, or series, of dates for the purposes of deriving a single, yet acceptable, date to characterise a cultural horizon for analytical reasons. This is treated using simple statistical analyses.

To correlate the radiocarbon data with comparative environmental data, two radiocarbon calibration methodologies, OxCal and CALPAL, were tested and assessed to determine the most appropriate method for use in this study. The results suggest that the most acceptable determinations of calibrated dates would be achieved using the CALPAL method (Jöris and Weninger 1998). All radiocarbon dates that met the quality control criteria were calibrated using CALPAL and the extended INTCAL98 calibration curve. While only those radiocarbon dates bounded by 25000 – 11000 uncal bp as set out in Chapter One of this thesis have been used, once calibrated, the range of dates in the final working database extend from approximately 32000 – 10000 BC.

Following this, a methodology has been developed to produce a single characterization date for each stratigraphic cultural layer, and applied on the basis of the acceptability threshold. A working database to be used for the remainder of this research was then produced consisting of one date per archaeological site layer. Only those layers with associated radiocarbon data are used in the study.

The database (Appendix A) initially held 727 uncalibrated radiocarbon dates. A complete list of dating laboratories referenced in the database can be found in Appendix C. After the assessment for both radiocarbon and archaeological acceptability, 41 dates were removed for not meeting control criteria prior to calibration. These did not include any date that is a sole date for a culture level. Of the remaining 686 dates, 63 are considered to be poor dates but will remain in the database for calibration. The resulting database therefore consists of dates 686 dates from 165 sites and 260 cultural levels. The working database is the result of the method presented above to obtain a single acceptable date for each cultural level. This database consists of 260 dates, one for each cultural level. It can be found in Appendix B. These data will be used as chronological and spatial data points for the purposes of meeting the objectives of the second phase of the project and finally, producing a colonisation model for Central Europe. All the analyses presented in the remainder of this research are conducted on the 260 samples from 165 archaeological site locations comprising the working spatial database.

CHAPTER THREE

TEMPORAL ANALYSIS

Before I attempt to conduct spatial analyses on the radiocarbon data, it is prudent to establish the chronological distribution. The major objectives of my research are to establish the timing and rates of colonisation, recolonisation and/or abandonment or continuity, of late Upper Palaeolithic populations. My intention in this chapter is to model the chronological distribution of the radiocarbon data such that the foundation for meeting these objectives is laid.

There are two ways to approach temporal analysis in this type of study. The first is to begin with the more localised chronologies and then build toward the bigger picture. This is usually best suited to smaller scale regional studies where the details of site specific and localized data are more easily managed. The second is to begin with the larger framework, and work through inter-regional comparisons toward finer resolution chronologies. This is more appropriate in large-scale studies where data are more apt to be broadly categorized (after Bailey 1997, 24-25). There are advantages to each.

In the first case, well-documented groupings of sites provide a strong comparative framework from which to radiate out from first a local, then a regional scale. These local groupings, in effect, act as 'hot spots' for more regional studies (Bailey 1997, 24-25). These regional chronologies can be built upon to produce the large-scale model.

In the second case, the data are presented for the whole study area. Available palaeo-climatological and environmental data provide a strong foundation for this approach. Once an overview of the temporal aspect of large-scale colonisation is established the data are segmented to produce more detailed chronology. In Europe, there is support for both options such that either would achieve acceptable results. Bailey (editor, 1997), in *Klithi: Palaeolithic settlement and Quaternary landscapes in northwest Greece*, exemplifies the first approach. The study begins with the detailed analysis of Klithi, expanding on the evidence to place it within a regional context. Svoboda *et al.*, (1996) provide an excellent example of the regional approach in *Hunter's Between East And West*, combining a relatively small spatial scale analysis with an extensive chronological scale. , Djindjian et al. (1999) support the latter of the two approaches to colonisation studies in <u>Le paléolithique supérieur en Europe</u>.

My research is also more suited to the latter approach. There are several reasons for this. In the first instance, as shown in Chapter Two, the application data are prone to variable degrees of quality. The large spatial and chronological framework of this research is such that resolving localised colonisation processes is impossible. Rather, the data can be segmented to determine regional processes and the relationships between those regions. Finally, the geographic area presumed to have the poorest archaeological visibility, the Carpathian Basin, lies at the heart of the study area. For this reason the study will take a 'periphery to the centre' direction, which can only be achieved through the application of the second approach discussed above.

This chapter presents the analysis of the data (characterised radiocarbon dates representing culture layers) designed to resolve the chronological representation of colonisation processes in Central Europe. Having completed the first part of the project in Chapter Two, my aim in this chapter is to meet the first objective of the second part of this research - to establish the timing of colonisation/re-colonisation and/or abandonment of human populations in Central Europe. I will achieve this by producing a general picture of the radiocarbon chronology for the whole of the study area, followed by a closer examination of smaller regions and the relationships between them. Finally, a detailed model representing the colonisation of populations *through time* will be presented such that it may be used in the spatial analysis presented in Chapter Four.

3.1 A CHRONOLOGICAL OVERVIEW

The working database consists of 260 culture layers from 165 archaeological sites. Each layer has been given a representative date, according to the methods developed in Chapter Two, to be used in the analysis. The earliest date in the database, 32830 cal BC comes from Oblazowa Cave, layer VIII in Poland. The youngest, 10200 cal BC, comes from Temnata Cave, Bulgaria, litho-stratigraphic level 3c (Bluszcz et al. 1992, 225). The chronological distribution of the data is shown in Figure 3.1. It is important to note that the reduction (or apparent decline) of data at either end of the chronological spectrum is due in part to radiocarbon calibration. This is because some dates fell outside the temporal boundaries of the analysis only after they were corrected during the calibration process. It is also in part due to those culture layers whose series of radiocarbon dates included dates earlier than 25,000 BP and

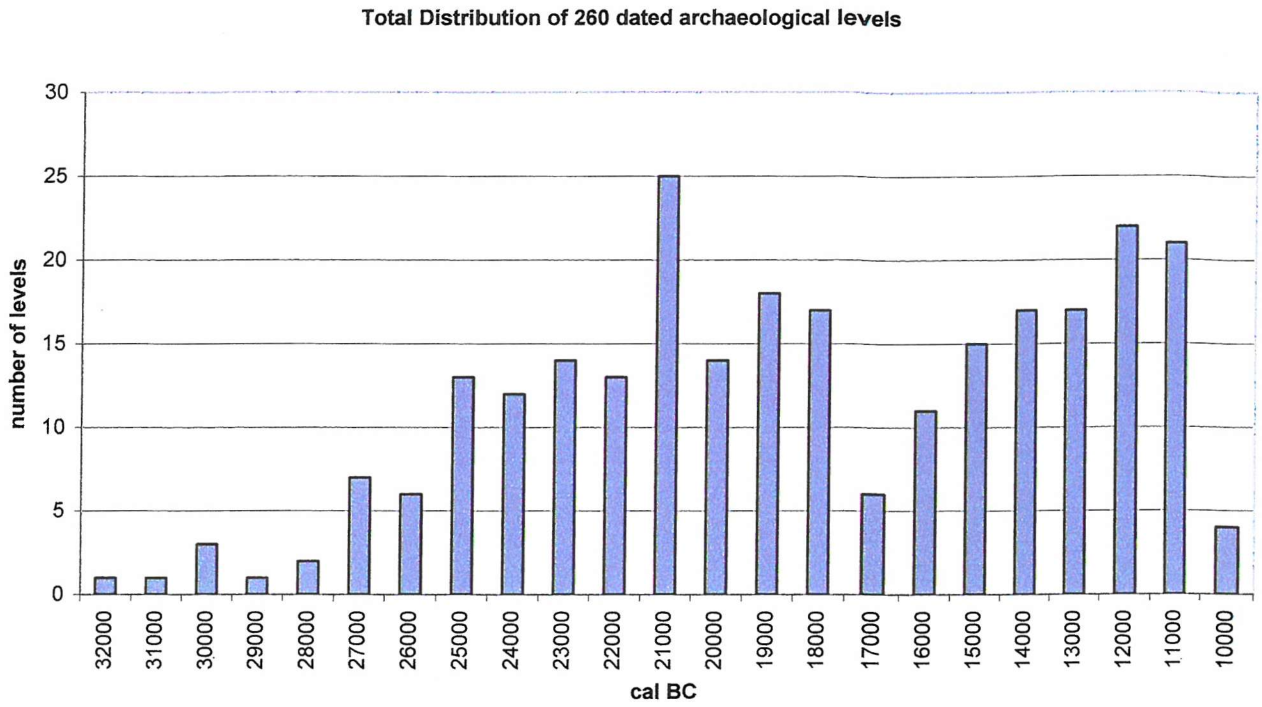


Figure 3.1: The chronological distribution of the 260 archaeological levels at 1000-year intervals cal BC, derived from 650 radiocarbon dates.

younger 11,000 BP. These were included in the database only because they were part of a series and could not be discarded randomly. While all dates are included in all analysis, accuracy of results is best achieved on the range 28000 – 11000 cal BC.

In Figure 3.2, the data are plotted against the GISP2 $\delta^{18}O$ isotope record (after Jöris and Weninger 1999, 3) and stadial / interstadial divisions based on the Summit ice core data (Street and Terberger 1999, figure 1; Djindjian et al. 1999, figure 2.3). Note that the calibrated climate data places the "Cold Maximum" (Jöris and Weninger 1999, 3) at approximately 25000 - 22000 cal BC. The data correlates well with the interstadials in the ice core record. However, when the data are plotted against the North Atlantic surface temperature data (obtained from the CALPAL program - Jöris and Weninger 1999), good correlation can be observed between the data particularly after 18000 cal BC (Figure 3.3).

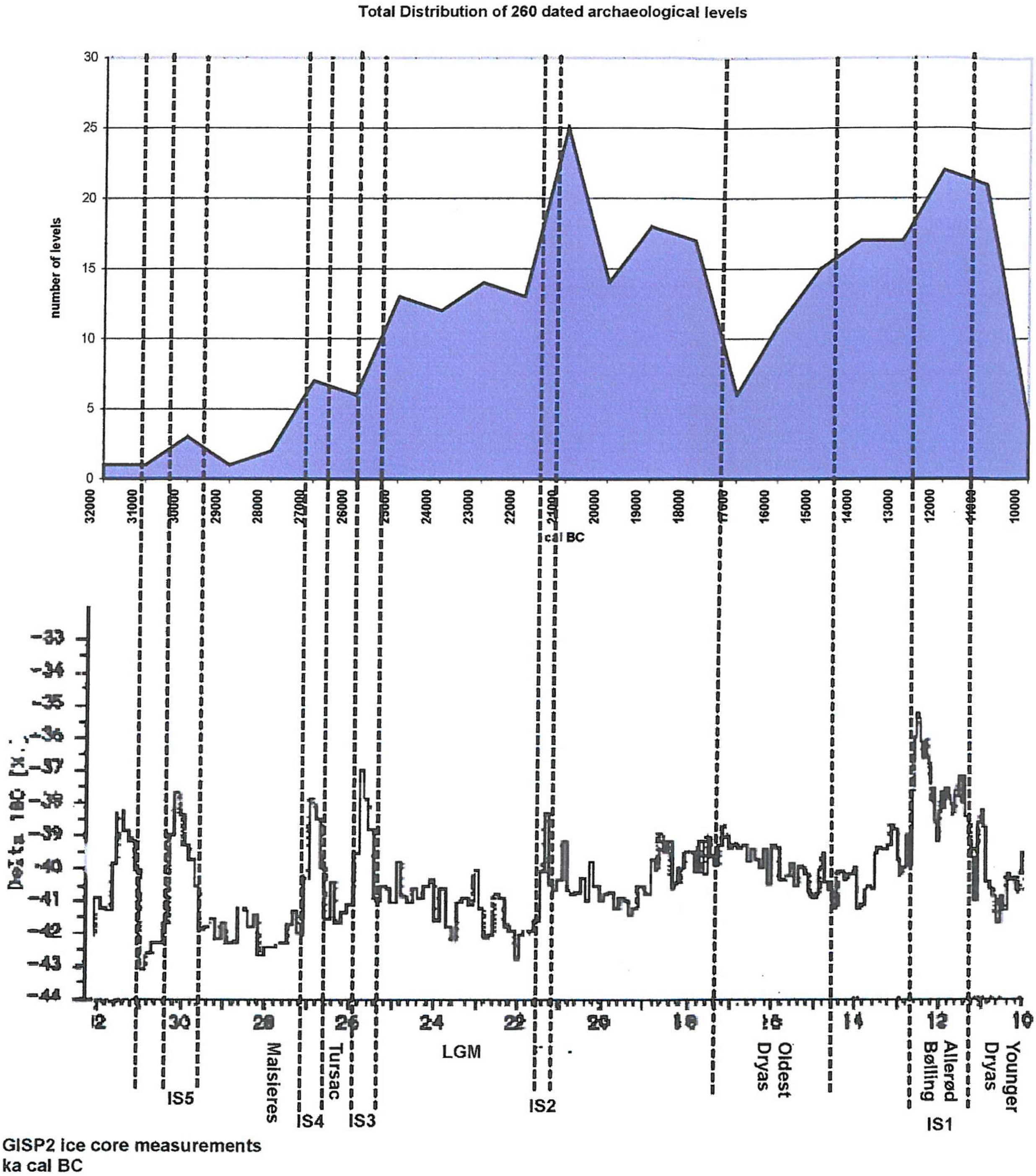


Figure 3.2: Distribution of 260 archaeological levels against $\delta^{18}O$ measured by Greenland ice core, GISP2 (after Jöris and Weninger 1999, 3).

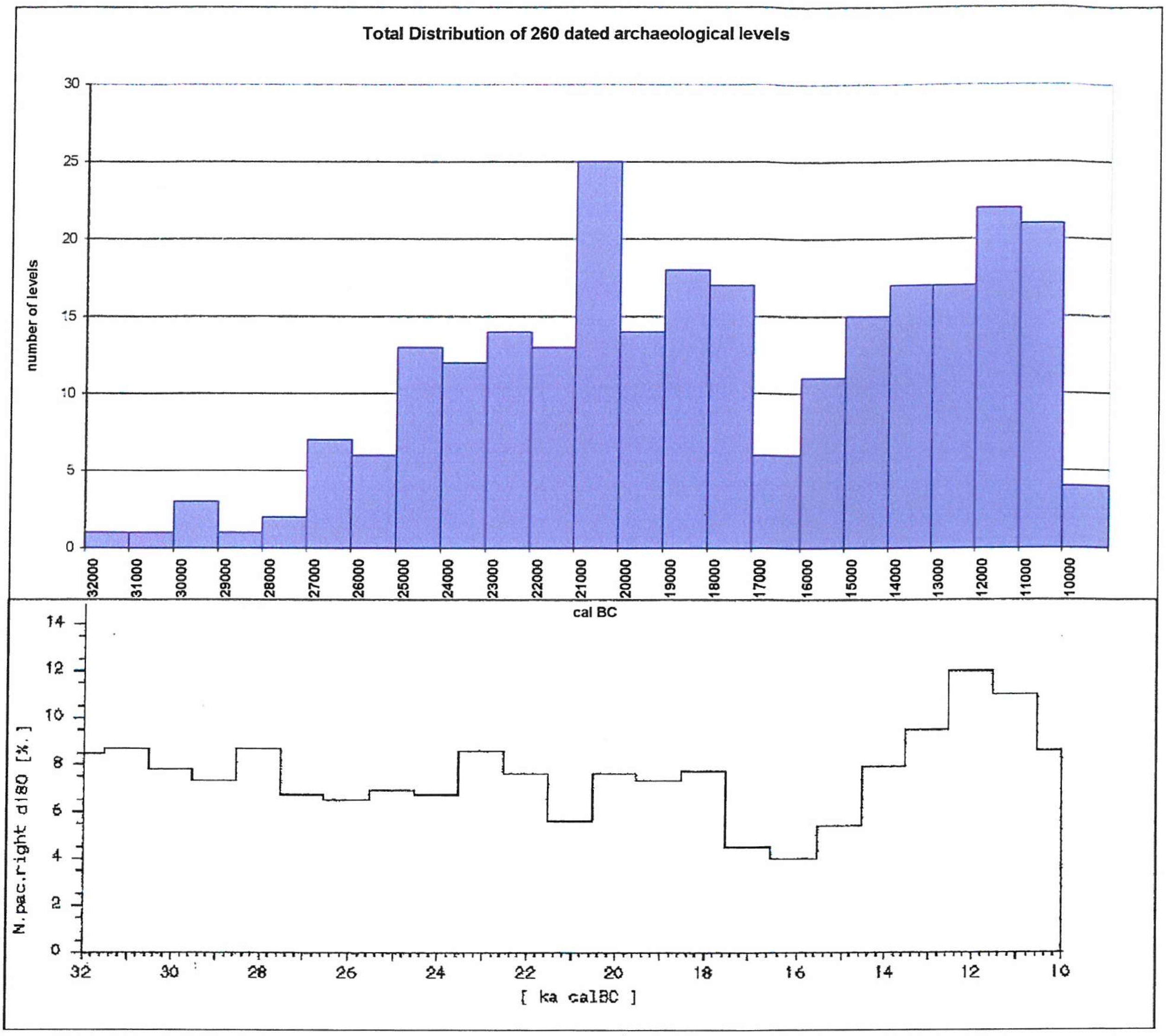


Figure 3.3: Distribution of 260 archaeological levels plotted against North Atlantic surface temperature data, core CH73-139c. Climate plot from CALPAL (Jöris and Weninger 1999).

The distribution of the data suggests that there was not a decline in occupation at this time, but rather a more stable population prior to a rapid increase in the Laugerie interstadial immediately following this cold phase. The rapid decline in population normally associated with the Last Glacial Maximum occurs at approximately 17000 cal BC during a period of comparatively stable climate conditions. This apparent contradiction to previously accepted opinions about colonisation at the LGM raises questions concerning both the climate and control data. In fact, this period corresponds well to the Oldest Dryas stadial (Dryas I) when the climate was cool and dry with no discernible amelioration. It signals the beginning of glacial retreat and the onset of rapid climate warming (Blockley et al. 2000, 117; Djindjian et al. 1999, 46).

It is important to be wary of biases in the data that may occur due to the frequency and variability of sampling from the study area for dating purposes, and the limitations placed on this research in that only those culture layers where radiocarbon dates were available have been used. Likewise, the "fit" of calibration curves, while providing improved timeline accuracy remains contentious (Housley et al. 2000; Jöris and Weninger 1999). Further examination of the distribution of these data should provide an approximation as to the extent that these issues affect the results and/or reveal patterns in the colonisation processes to justify the broad-scale view illustrated in Figure 3.2.

3.2 THE MOVING SUM METHOD AND REGIONAL ANALYSIS

In an article entitled Cyclical patterns in the Pleistocene human occupation of Southwest Tasmania (1995), Holdaway and Porch implemented a methodology originally developed by Rick (1987) for applying radiocarbon determinations as measures of occupation at a regional scale. The purpose of the method was to amplify the data such that patterns of occupation based on radiocarbon indicators would be more boldly defined. The procedure involves "the calculation of a moving sum of the total number of determinations that fall into a 1000 year span centred on a multiple of 500 years" (1995, 75). This means that dates, as data points, can be counted more than once. For example the date of 14800 can be counted twice - once in the range 14000 - 15000 and once in the range 14500 - 15500. The method uses the mean of the radiocarbon determination and ignore as the associated standard deviation. This was applied to 203 radiocarbon dates from twelve sites. The results revealed a cyclic pattern of punctuated peaks and troughs having a mean of approximately 3000 years. These observations led to the authors' suggestion that the radiocarbon determinations fluctuate according to a global scale environmental change and lithic abundance (Holdaway and Porch 1995, 75-76).

Housley et al. (1997) followed this example and applied the moving sum method to examine the AMS radiocarbon evidence for the late glacial Human recolonisation of Northern Europe. These authors modelled the distribution of dates using a 400 year moving sum with the 200 year span. The application of the shorter chronological range enabled an assessment of the size of standard deviations on the radiocarbon dates. The data were divided according to geographic regions and the moving sum

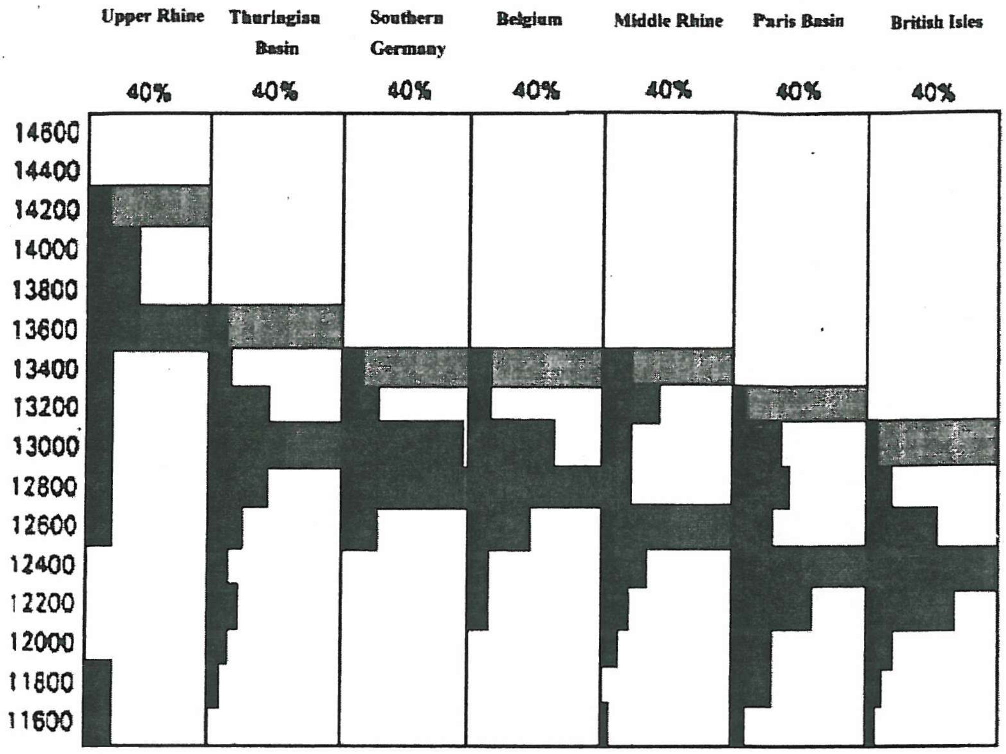


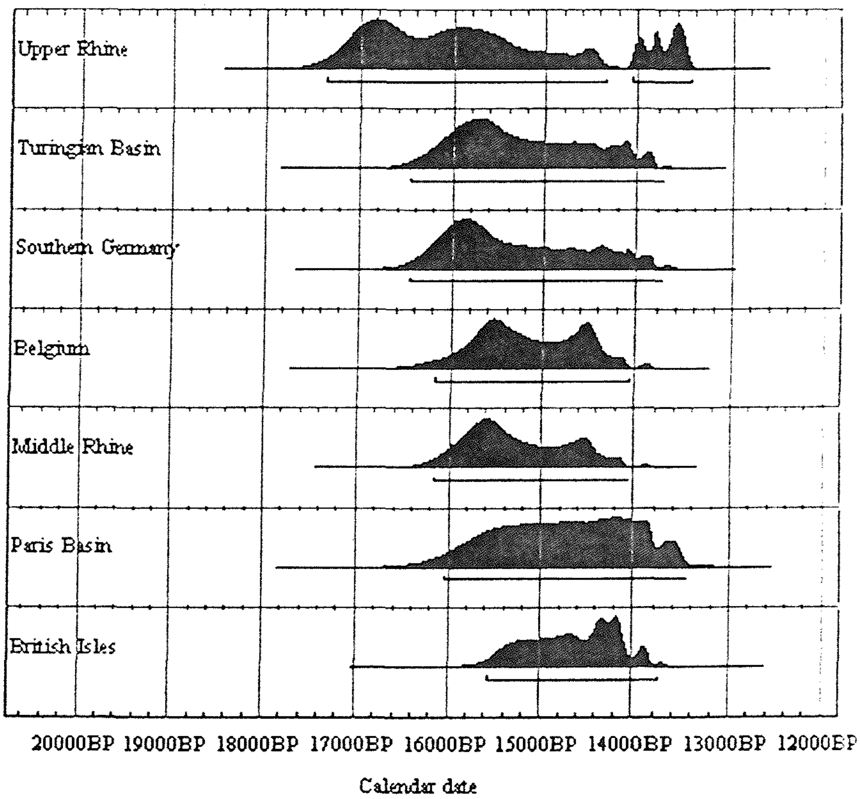
Figure 3.4: Moving sum distribution of radiocarbon dates in Northern Europe as determined by Housley et al. (1997, 45).

procedure applied. Accepting the first radiocarbon date as the earliest phase of recolonisation in each region (termed the pioneer phase), the authors suggest that the process took place in 200 year intervals, with the largest number of determinations occurring more 400 - 600 years after the initial recolonisation (Housley et al. 1997, 44). This is interpreted as the residential phase. A series of histograms were produced to illustrate this movement of populations (Figure 3.4).

Blockley et al. recently argued that the approach taken by Housley et al. (1997) resulted in an over-simplification that statistically "is not an accurate representation of the chronology of the proposed re-colonisation phases" (Blockley et al. 2000, 114). These authors outline difficulties in the approach as applied by Housley et al. (1997). The first is that the moving sum method may allow for 1σ (68% confidence) error on uncalibrated dates, it is not account for errors at 2σ (95% confidence). Secondly, the study had been totally based on uncalibrated radiocarbon dates, a non-linear time-scale where "true chronological relationships" could not be known. The authors argue that once calibrated, "dates must be expressed as a range" and can no longer be considered as data points. Third they suggested the regions used were not totally relevant to Late Glacial geography. Finally, Blockley et al. reiterate that the bone samples used as data (as used in the original study) can be difficult to date (Blockley et al. 2000, 113).

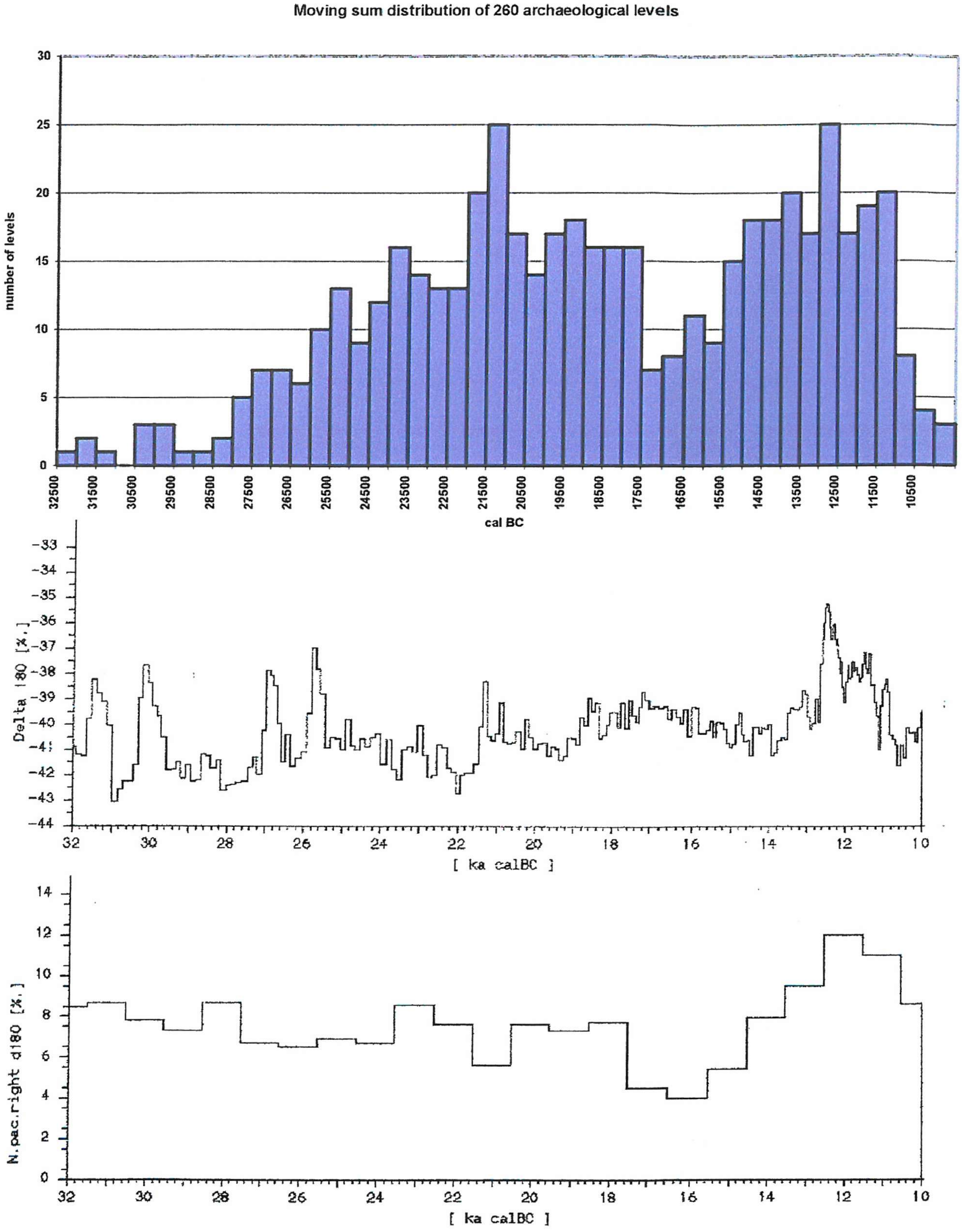
Blockley et al. (2000) re-applied the data first using the moving sum method to 2σ radiocarbon errors, then, using the OxCal program (Bronk Ramsey 1999) calibrated the dates according to first the InterCal 93 curve (Stuiver et al. 1993) and then the INTCAL98 curve (Stuiver et al. 1998). The authors argue that since "the probability distribution of a calibrated date is partly a function of the shape of the calibration curve", the summed probability distributions of calibrated dates is a more accurate assessment of chronology than does the original method. Blockley et al. (2000, 116) suggest that this re-application indicates that there is no clear distribution between regions, nor is it appropriate "to infer separate 'pioneer' and 'residential' phases" (Figure 3.5). According to these authors interpretation the pioneer phase as suggested by Housley et al. (1997) would fall during a relatively stable climatic period, prior 14700 years BP when rapid climate warming began, when in fact, their own research would place the pioneer phase correctly at the peak of the interstadial.

Figure 3.5: The summed probability distributions of dates after calibration with INTCAL98 using the OxCal program (after Blockley et al. 2000, figure 4).



In this section the moving sum approach is again examined as a method for discerning chronological patterns. While the criticisms regarding the need for calibration by Blockley et al. (2000) are supported, my research also agrees with the view that radiocarbon dates can be used as data points (Housley et al. 1997; Holdaway and Porch 1995) in both chronological and spatial analysis. One difficulty observed in previous applications of the method however, is that the databases to which it was applied consisted of the total of the available dates. For this reason, despite whether or not the moving sum is weighted according to the calibration curve or not as in the case of uncalibrated dates, the results are influenced according to the number of dates provided per cultural layer. The research presented here accounts for the potential error that may arise from this. The moving sum is applied here to the single characterised dates (obtained after calibration) produced in Chapter Two. The assumption is that these dates are representative of the chronological placement of each cultural layer in time. As in the case of Holdaway and Porch (1995), standard deviations can therefore be ignored. Given that Housley et al. (1997) show a 400 – 600 year range between their two phases of colonisation (pioneer and residential), and due to the large scale of this research, the total number of characterised dates that fall into a 1000 year span and centred on a multiple of 500 years (as illustrated by Holdaway and Porch 1995) can be counted (with confidence) so that satisfactory results can be achieved. Figure 3.6 illustrates the moving sum distribution of the total of characterised dates in the study area. Rather than the actual 260 dates there are now 520 data points plotted.

Figure 3.6: the moving sum distribution of 260 archaeological levels plotted against the GISP2 $\delta^{18}O$ measurements and the North Atlantic surface temperature data (core CH73-139c) obtained via CALPAL (Jöris and Weninger 1999).



The results correlate well with the with interstadial peaks in the GISP2 data, but the characterised dates corresponding to the troughs (cold phases) in the GISP2 measurements are better correlated to the North Atlantic surface temperature data. In fact, the observations made here are consistent with the opinions of Holdaway and Porch (1995, 77) who argue that the moving sum method applied to the Tasmanian data is consistent with palaeo-environmental data for that particular region. The authors suggest that troughs in the moving sum data correspond to colder, drier climate conditions and coincide with the interstadial – stadial transitions. While this is certainly worthy of consideration, further examination of the data suggests that climate and environmental conditions may not have been the driving force determining the processes of Palaeolithic colonisation.

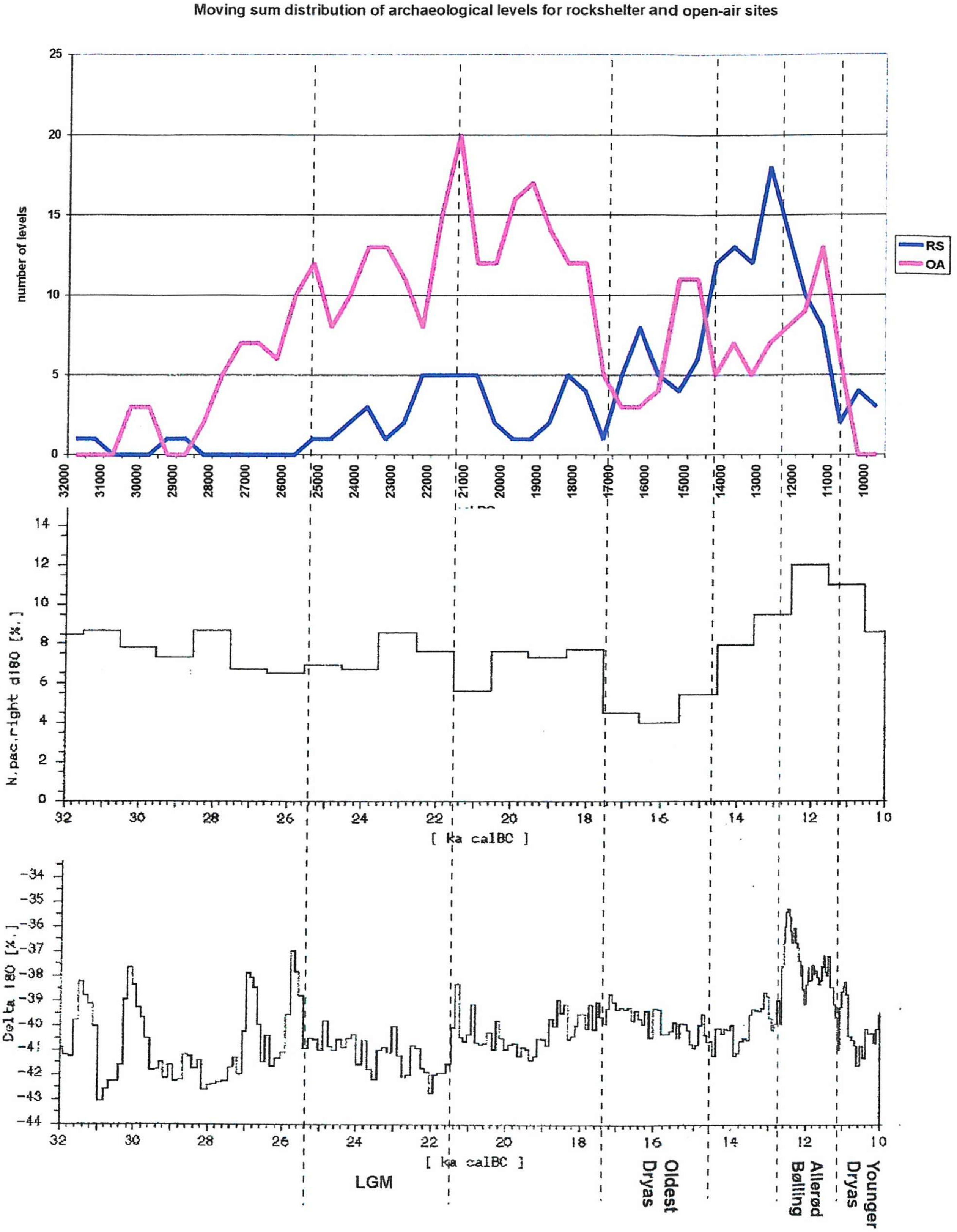
3.3 OPEN-AIR SITES AND ROCKSHELTERS

The first division that must be made between the data is that of open-air sites and rockshelters. There are 124 open-air sites and 40 rockshelters in the study area. Differences between these two types of archaeological sites can leave the data subject to bias. Often, because rockshelters tend to be more confined spatially and better preserved stratigraphically, they are subject to more vigorous dating programmes. Examples of such studies include Klithi: Paleolithic settlement and Quaternary landscapes in northwest Greece, (2 vols., Bailey 1997) and Temnata Cave (Kozlowski, Laville and Ginter, eds., 1992). On the other hand, open-air sites are more widely and variably distributed across a landscape. They are often single occupation sites, or small surface finds, and more prone to geomorphological erosion processes. The dating of the sites is therefore considered less reliable. Examples of open-air sites where multiple occupation and good stratigraphy exist and where sufficient quantity and quality of radiocarbon data support detailed excavations can be seen at the Kostenki complex (Sinitsyn and Praslov 1997) and at Grubgraben (Williams 1998). It is therefore recognised that the representation of rockshelters and open-air sites according to the number of available dates in the working database may be weighted to a certain degree by more concentrated excavations of rockshelters producing more dates for analyses. The number of site representations in the database is dependent on available radiocarbon dates. There is likelihood that those sites where radiocarbon dates are not available and thus not represented in the database are more apt to be open-air sites. Even so, there is sufficient representation to assume that the number of dates is representative of the total population, accepting that the accuracy of representation is probably stronger for rockshelters.

It can be shown however that the influence such considerations may have on the analytical process does not necessarily skew the results to such a degree that distinct patterning cannot be observed. In Figure 3.6 the moving sum method is applied to rockshelter and open-air site culture layers and plotted against the GISP2 and the North Atlantic surface temperature data.

The plotted data in Figure 3.7 show clear trends in the choices that Upper Palaeolithic hunter-gatherers made about occupation sites. While both types of sites exist throughout the late Upper Palaeolithic, open-air sites dominate the landscape prior to the Oldest Dryas. At this time a transition between rockshelters and open-air sites occurs. The preference for occupation of open-air sites begins to diminish while there is a marked increase in the use of rockshelters. Following the Oldest Dryas, and despite continued occupation of open-air sites, rockshelters become the dominant choice for habitation. On either side of this transition period, the peaks and troughs present in the data correspond well to the GISP2 $\delta^{18}O$ data, and show similar rates of increase during the interstadial warming episodes.

Figure 3.7: the moving sum distribution of archaeological levels for rockshelter (RS) and open-air site (OA). Middle - North Atlantic temperature data, core CH73-139c; Lower – GISP2 $\delta^{18}O$ data. Data plots are from CALPAL (Jöris and Weninger 1999).



The 3000-year span (17000 – 14000 cal BC) covering the transition between open-air sites and rockshelters consists of 35 actual dates, 18 of which belong to open-air sites and 17 belonging to rockshelters. Half of the dates belonging to open-air sites can be placed into two groups, Eliseevitchian and Kostenkian in Russia, as defined by Kozlowski (1986, figure 3.4). There are five rockshelters sites occupied at this time. Eleven of the seventeen dates are from 2 rockshelter sites in the Klithi environs in Greece, Klithi and Megalakkos (Gowlett et al. 1997, 27-40). The concentration of characterised dates attributed to these sites is due largely to the history of discovery, and the quality of preservation. Bias in the data is not only a result of continuity and quality of excavation, but of sampling. Spatially, these concentrated groupings are at opposing latitudes and longitudes of the study area. Conclusions about the transition from one type of archaeological site to another can therefore not be drawn solely on the basis of the number of sites, or characterised dates, present for each type. It is also unlikely that satisfactory interpretations about this transitional phase can be based on groupings that are not regionally comparable, either due to the vast distance between them or to environmental and geographical differences (the Eliseevitchian and Kostenkian groups are located in the valleys of the Don and Dnepr Rivers of the East European Plain, while the Klithi environs of Greece are in a mountainous region).

Even though the number of site locations is comparatively small to the number of available dates for this time, the spatial distribution of the remaining sites is spread, albeit thinly, across the entire study area. It is highly possible therefore that this bias in the data is not significant enough to exclude plausible explanations.

A more appropriate comparison of sites that fall within this transition period comes from the region of Moravia. Brno-Vídeňská Koněvova and Velké Pavlovice are Epigravettian open-air sites "located in the uppermost parts of the last loess, after the Upper Pleniglacial maximum", dated to 14500 BP with characterised dates of 15250 and 15245 cal BC respectively (Svoboda et al. 1996, 135). These dates are midrange in the whole of the Eastern Epigravettian technocomplex represented in the working database. The classification of these sites as Eastern Epigravettian in the database is according to Kozlowski (1986, figure 3.1) and discussed in the following section (3.4) of this chapter. They are compared to Maszycka Cave in southern Poland, which has been dated to 15490 BP (level III) and 14520 BP (levels I-II) and given characterised dates of 16135 and 15310 cal BC respectively, and has been given credit as representing the earliest Magdalenian dates in Eastern Central Europe (Svoboda et al. 1996, 174). These are also the earliest Magdalenian dates present in the working database.

The distinctly colder climate conditions of the Oldest Dryas indicated in the North Atlantic surface temperature data may be linked to the occupation transition from open-air sites to rockshelters. The location and availability of suitable resources may have necessitated the transition from open-air sites to rockshelters for the majority of the population. The open-air sites are located in a lowland sheltered valley with abundant lithic resources. Maszycka Cave is located in a highland karst region with limited outcrops of lithic resources (Svoboda et al. 1996, 196-204). Svoboda et al. (1996, 145) note that the microblade and backed bladelet technologies that dominate the open-air site assemblages of the Epigravettian give way to end scrapers and burins, and a bone and antler toolkit in the Magdalenian. This differentiation in toolkits suggests that new choices were being made with regard to subsistence strategies.

The transition from open-air sites to rockshelters is further visible in social expression between the Epigravettian (primarily associated with open-air sites) and the Magdalenian (primarily associated with rockshelters). Svoboda et al. (1996, 161,188-189) comment that the Epigravettian evidence for art (contrary to that of the earlier Gravettian) in Eastern Central Europe is rare, consisting of ornamental objects including pierced animal teeth, a whistle and a few pierced ivory fragments from the site of Grubgraben, Lower Austria. The Magdalenian on the other hand demonstrates multiple forms of decorative patterns on bone and antler tools and weapons, particularly at the cave sites.

Svoboda et al. (1996, 196-204) suggest that " the correlation of the spatial distributions of paleontological finds is complicated by the various states of preservation... whereas the available information has been biased by uneven intensity of regional paleontological surveys" (Svoboda et al. 1996, 197). Despite this and the obvious influence that geomorphological and resource conditions had on hunter-gatherer adaptations, "models of hunter-gatherer communities... may have been structured by various exploitive, social, and ritual activities... " (Svoboda et al. 1996, 197). While rockshelters provided dry shelters during glaciations and cold phases, open-air sites allowed for control over larger landscapes. Transition between these two types of sites would have meant a change in hunter-gatherer social behaviour.

Svoboda et al. (1996, 203) suggest that hunting strategies and mobility patterns in particular would have differed. Open-air site inhabitants would have moved over longer distances travelling in a " more circulating pattern", whereas rockshelter inhabitants would have travelled relatively short distances in a radiating pattern centred on the cave.

While it should now be clear why a transition to rockshelters occurred during the Oldest Dryas, the discussion so far would hint that the dominant form of occupation *after* the Oldest Dryas should be the habitation of open-air sites. This is not immediately the case. The continued preference for rockshelters until the onset of the Holocene can likely be attributed to social adaptations such as that evidenced in Magdalenian art. Svoboda et al. (1996, 200) suggest that the territorial type of highland karst occupation would have meant minimal contact with the adjacent lowland areas. This would lead to the assumption that increased specialisation took place on a local level. This is evidenced further in the discussion regarding the distribution of technocomplexes in section 3.4 of this chapter. The rapid warming of the Bölling / Alleröd can be characterised by an increased abundance of resources in the highlands such that the need for populations to be highly mobilised would have been diminished. As a result, though the hunter-gatherer behaviour associated with lowland open-air sites and warm climate scenarios would have been preferential to some, it is clear that certain hunter-gatherer cultures chose to remain using rockshelters. This can only mean that social behaviour would have weighed more heavily than environmental determinism on the choices that hunter-gatherer populations made about occupation sites during the Upper Palaeolithic.

3.4 TECHNOCOMPLEXES

The primary means of categorising and interpreting the archaeological record of the Upper Palaeolithic culturally and chronologically has traditionally been dependant on the typological association of archaeological assemblages to their stratigraphic context. In particular, lithic topologies form the basis of these groupings. Often, subtle differences in the hunter-gatherer toolkit, either through style or lithic source, can make the difference in the group classification of one culture layer. Svoboda et al. (1996, 143) note that typologically variable assemblages that defined technocomplexes have a meaning that is more chronological than cultural. Bailey cautions that "even typologically distinctive flints can only be dated by means of a 'type fossil' approach, and the use of type-fossils as a guide to chronology is notoriously unreliable in the Palaeolithic context without a well-dated and provenanced sequence of assemblages... " (Bailey 1997, 17). Improvements in radiocarbon dating techniques, calibration curves etc, have greatly improved chronological resolution. Even so, the detailed analysis and categorisation of each site's stratigraphy and archaeological assemblage is, of course, necessary for understanding and interpreting the Upper Palaeolithic record. Yet, the larger the scale of the study, the more variability there is in the data set, and the more prone to variability the archaeological interpretation is. For this reason large-scale colonisation studies often use coarse categories of analysis.

Kozlowski (1986, figure 3.1) broadly defined and grouped technocomplexes whose classification most appropriately covers the whole of the study area. Since Kozlowski uses uncalibrated radiocarbon boundaries, the data were assigned to these categories prior to calibration. As a result, the characterised dates in the working database retain these assignments. Five terms of classification are used in this research. The earliest defined technocomplex is the *Aurignacian.* The Aurignacian dates prior to 29000 cal BC in the database and is characterised by endscrapers and burins, a bone and antler toolkit and some leaf points (Svoboda et al. 1996, 115). It correlates to the Maisières soils of the interpleniglacial. The earliest representation of this technocomplex in the database comes from the lowest levels of Oblazowa Cave, Poland.

The term *Gravettian* is given to a technocomplex characterised by a broadly similar method of lithic production. It refers to an industry of retouched backed points, blades, and bladelets (Kozlowski 1986, 131). The technocomplex is found in Western Europe and north Central Europe. Culturally, Kozlowski notes the development of distinct regional centres and single site industries. Svoboda et al. (1996, 145) agree that the 'Gravettian' represents a complex set of industries where attitudes toward landscape, resources and ritual are inherent within an efficient cultural adaptation. It is suggested further that competing cultural systems operated within the same territory. The Gravettian "is usually found in extended sites under loess deposits near river valleys, at 200-300 m above sea level" (Svoboda et al. 1996, 146). Chronologically, the Gravettian is placed immediately prior to the LGM, extending back to the Aurignacian (Kozlowski 1986, 131).

The *Eastern Gravettian* represents a derivation, primarily in terms of settlement patterns, of the Gravettian technocomplex, which occurs in Central and Eastern Europe. It is suggested by Kozlowski (1986, 149), that cultural systems in Eastern Europe were less regionally defined and more mobile. The Gravettian begins later in Eastern Europe (approximately 16000 cal BC) than in Western Europe (Kozlowski 1986, figure 3.1). The diversity in the lithic assemblages of the Eastern Gravettian is visible in the sites of the Russian Plain. Kozlowski (1986, 149) comments in particular about Pushkari I where "an unusual set of backed blades (both straight and arched) occurs accompanied by truncated elements".

The *Epigravettian* is marked by an increase in retouched blades, microblades, backed bladelets, and the wedge-shaped microblade core (Svoboda et al. 1996, 145). Kozlowski (1986, 132) notes that the Gravettian-Epigravettian transition "was the period of the maximum advance of the ice sheet and their maximum southward shift of ecological zones". The Epigravettian in the Mediterranean extends to the Holocene. In north Central Europe, it borders the Magdalenian both temporally and spatially. The *Eastern Epigravettian* is closely correlated to the *Epigravettian* and begins with the recession of the ice sheet during the Late Glacial (Kozlowski 1986, 132) and extends to the Holocene.

The *Magdalenian* industry consists primarily of end scrapers and burins, and a bone and antler toolkit (Svoboda et al. 1996, 145), with only a few of the backed elements present in the Epigravettian assemblages. It begins after the Older Dryas and extends to the Holocene and geographically is found in Western and north Central European sites. In the latter region however, the Magdalenian coincides with some Epigravettian settlements. Svoboda et al. (1996, 187) have shown that the Moravian data indicate that the Magdalenian settlement patterns suggest "a more efficient type of hunting using both the large home bases and smaller hunting posts at strategic places", adding that "the unfavourable location of home basis for hunting may have been reduced by more efficient group organisation and planning... ". This is evidenced in both the rockshelter – open-air site comparison for the Oldest Dryas discussed in the previous section, and in the moving sum distributions shown in Figure 3.9.

Figure 3.8 shows the six technocomplexes discussed above in relationship to palaeo-geographical events according to Kozlowski (1986, figure 3.1).

Figure 3.8: The six technocomplexes and their regional relationships plotted against Late Pleistocene events as defined by Kozlowski (1986, figure 3.1). Note that his chronological divisions are represented by uncalibrated radiocarbon dates.

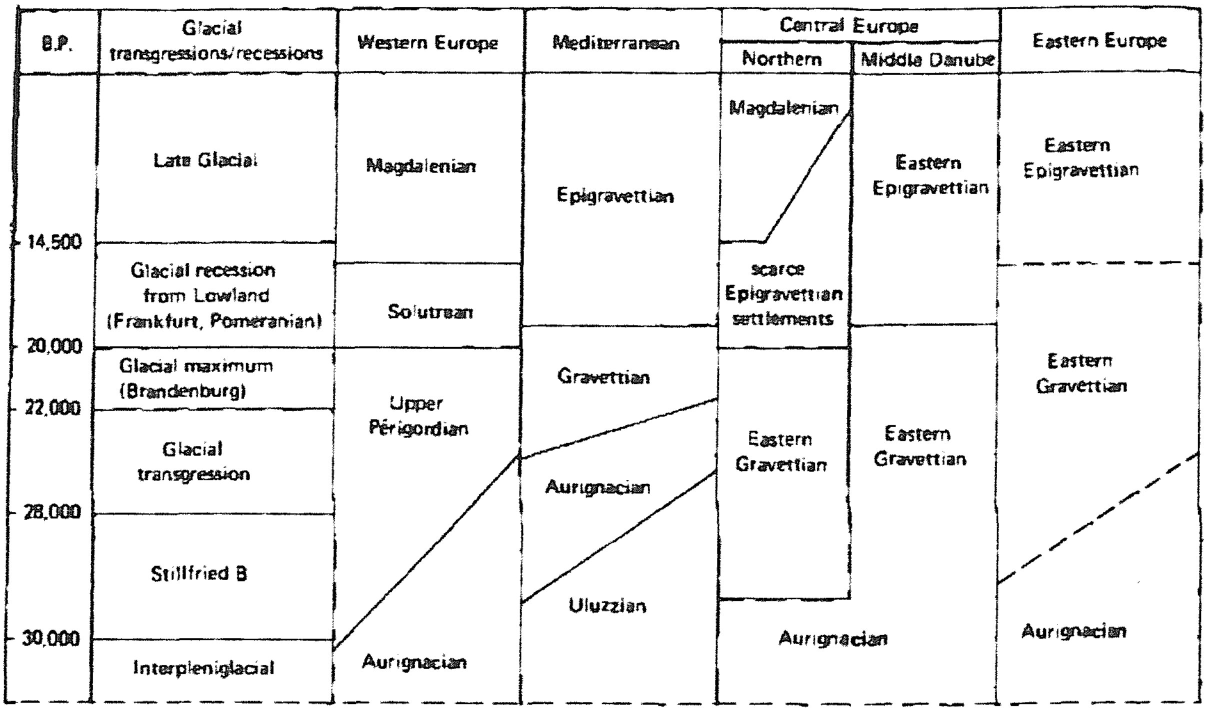
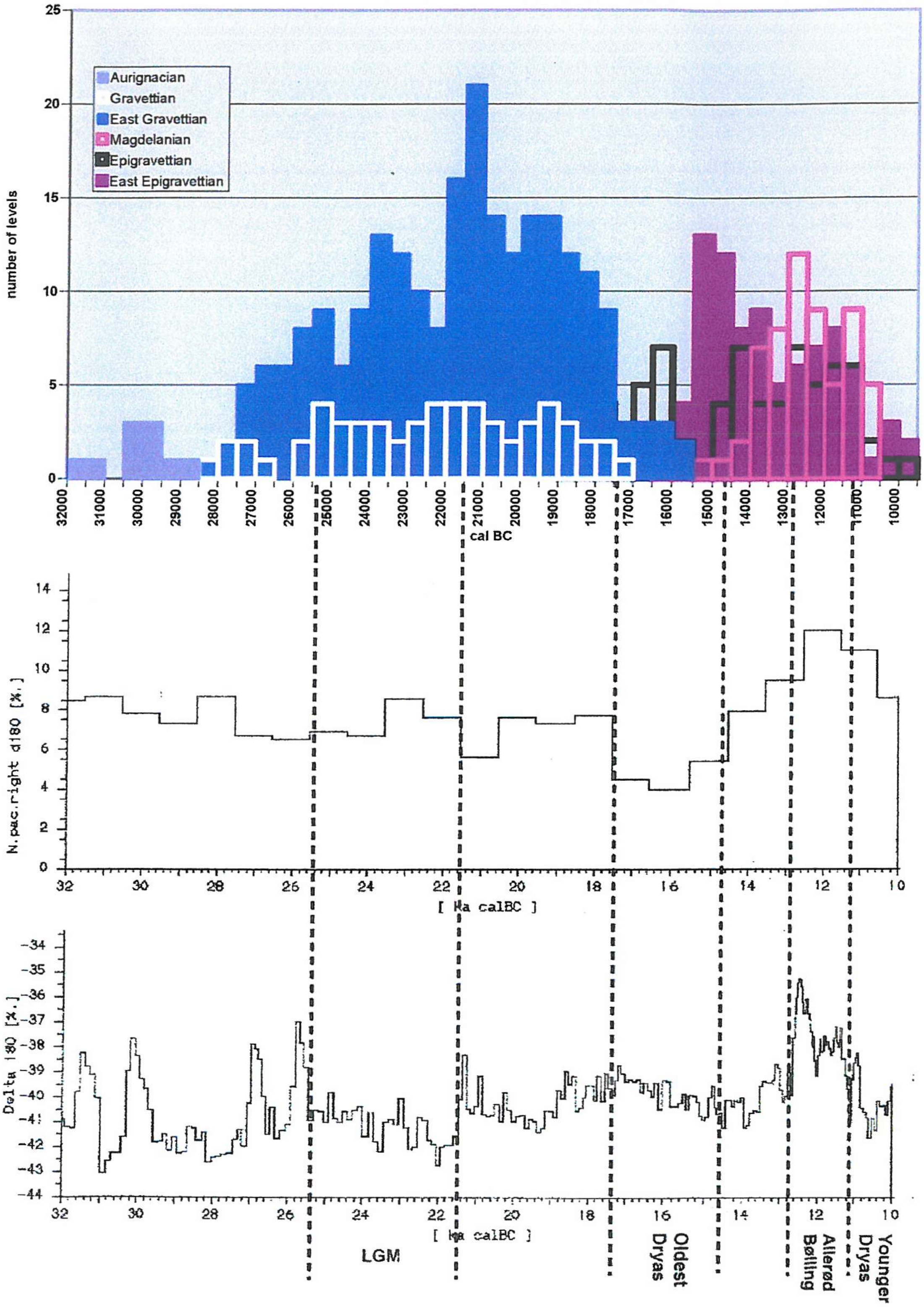


Figure 3.9 shows the moving sum distribution of the total number of characterised dates according to the chronological distribution of technocomplexes for Central and Eastern Europe (Kozlowski 1986, 3.1). The data are not shown according to the regional distributions as presented in Figure 3.8 but rather for the entire study area. The results illustrated in Figure 3.9 begin to show a pattern in the chronological processes of late Upper Palaeolithic repopulation.

Figure 3.9: The moving sum distribution of 260 archaeological levels according to the technocomplex divisions defined by Kozlowski (1986, figure 3.1; this thesis, figure 3.8) plotted against the GISP2 $\delta^{18}O$ measurements and the North Atlantic surface temperature data (core CH73-139c) obtained from CALPAL (Jöris and Weninger, 1999).



As discussed earlier, the Aurignacian dates present in the database consist only of those that border the lower end of the chronological boundaries of the research framework and thus do not constitute proper sampling of the Aurignacian. We can see that the final Aurignacian dates coincide with the initial onset of the East Gravettian technocomplex. This next group of dates show a steep increase in the East Gravettian populations corresponding well with the interstadial peaks recorded in the GISP2 core at 25500, 23500 and 21000 cal BC. The population remains relatively stable until a sudden decrease in the number of archaeological levels at 17500 cal BC, coinciding with the onset of the Oldest Dryas. Two options for interpretations about the temporal direction of colonisation are open for debate at this point.

First, one can ignore the fluctuations in the palaeo-climate data and solely observe the dates. This interpretation would suggest a three-phase process to the colonisation/recolonisation of the East Gravettian populations over a longer time period. For example, Bang-Andersen (1996, 219-234) interprets the earliest colonisation of Southwest Norway as a three-phase process consisting of a "pioneer and discovery" initial phase followed by an "immigration" phase and resulting in a settlement phase that can be defined as "complete annual exploitation" of the newly occupied territory. There are two major differences between the Norwegian study and Central Europe. First, the Norwegian study is of coastal colonisation while the Central European study is of inland colonisation. Second the Norwegian study is chronologically placed in the Holocene while the Central European East Gravettian/Gravettian corresponds to the LGM. Open-air sites are the primary type of occupation sites featured in both studies. Further examination of the significance of this similarity in section 3.5 of this chapter will support the potential for a three-phase approach to the colonisation of East Gravettian populations in Central Europe.

The second interpretation would recognise the decreases in population during colder climate conditions. If we choose to treat the coldest periods between interstadials (the Maisières, the LGM and the Oldest Dryas providing the most obvious troughs in the climate record) as initial settlement, assuming that populations existing during these cold periods are the minimum number present, the data would suggest that initial colonisation comprised of continuous increase in population until the first climate cooling at 25500 cal BC. Following this a two-phase process of recolonisation took place where the pioneer phase occurred within 500 years after initial settlement (i.e. the earliest known date) and the residential phase (as defined by Housley et al. 1997, 44-45) occurred within 500 to 1000 years of the pioneer phase.

The distribution of Gravettian dates appears to illustrate continuity of occupation despite a comparatively small data set compared to that of the East Gravettian. Yet, where a chronological process of colonisation is visible, it occurs minimally and within the 500-year interval pattern as shown in the second interpretation of data discussed above.

The Epigravettian/East Epigravettian and Magdalenian groups of dates favour a pattern well suited to the second scenario of interpretation, but with the colonisation phases occurring closer to 1000 year intervals. The major difference in these later population groups is a rapid increase in the number of characterised dates following the Oldest Dryas. This, in turn, can be interpreted as an increase in the number of sites and thus a rapid increase in population. This would be consistent with the accepted view that the rapid population increase and expansion began towards the end of the Late Glacial and the onset of the Holocene.

Another consideration that can be seen in the chronological processes of Upper Palaeolithic recolonisation is also illustrated in Figure 3.9. Magdalenian and Epigravettian/East Epigravettian populations appear to coexist. It has been shown that the latter technocomplexes differ significantly from Magdalenian in both technological (toolkits) productivity and social manifestations (e.g. art). The fact that they coexist lends further credence to the conclusion that climate and environment could not have been the driving influence in colonisation processes. Rather, social and ideological constructs governing such behavioural strategies as subsistence, mobility and social relationships, and resulting specialisation resulted in the successful repopulation of distinct groups.

Finally, rockshelters feature more prominently during this period and it may be suggested that there is a potentially significant difference between observable patterns of colonisation between rockshelters and open-air sites.

3.5 TECHNOCOMPLEXES DIVIDED: OPEN-AIR SITES AND ROCKSHELTERS

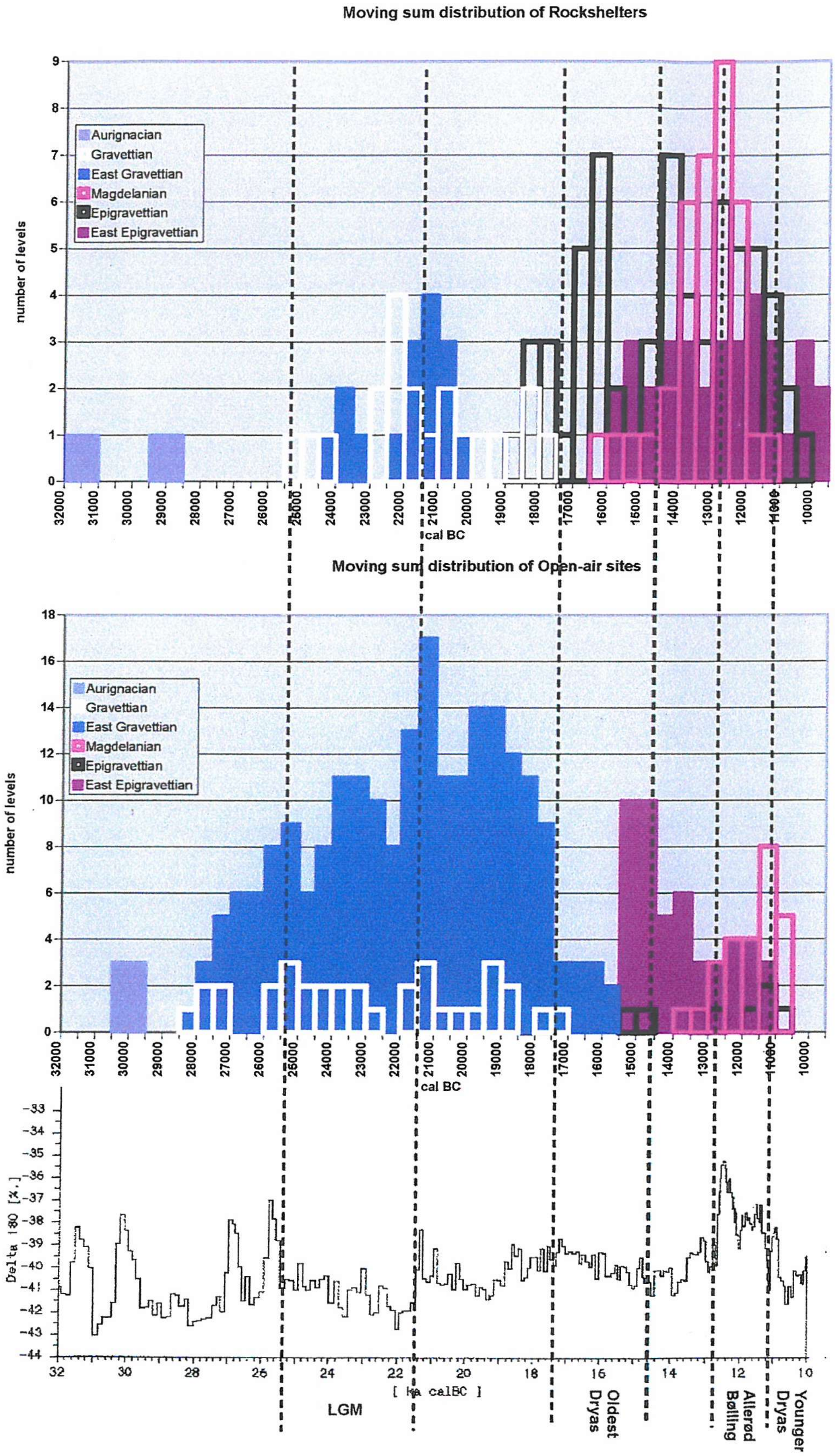
The next appropriate step is to incorporate the discussion so far by examining the six technocomplexes in terms of rockshelters and open-air sites. In this section, the moving sum method is used to elucidate a more defined chronological resolution to the data and reveal distinctive temporal colonisation processes for late Upper Palaeolithic populations. The results of this analysis will form the basis for the development of a chronological model of colonisation/recolonisation so that questions about the timing and rates of colonisation may be answered with confidence.

In the previous discussion the suggestion was made that the data showed potential for a three-phased approach to colonisation with an initial discovery phase, an immigration phase and a settlement phase and/or a two-phased approach where the immigration phase is eliminated. The application of the moving sum method to the division of the six technocomplexes into rockshelters and open-air sites allows these processes to colonisation to be explored further. Figure 3.10 shows the moving sum distribution of rockshelters and open-air sites at 1000-year intervals and a 500-year span.

A comparison of the moving sum distribution of open-air sites and rockshelters in Figure 3.10 supports conclusions made earlier. First, contrary to the observation made earlier that distinct differences in the number of phases of colonisation occurs between rockshelters and open-air sites, differentiation is less visible when the data are divided between not only these two, but the six technocomplexes. One consideration for this may be attributed to the fact that the classification of a site to a technocomplex is at the discretion of the researcher. Due to the time constraints of my project, such classifications are assumed to be correct.

It is clear however that the processes of colonisation between the initial (first) phase and the phase of maximum population occur much more rapidly over a shorter time span for the rockshelter occupation type as opposed to open-air site types. There is a slower, more continuous process of colonisation for open-air sites. Second, it appears that increased adaptation of rockshelter occupation is associated significantly with

Figure 3.10: A comparison of the moving sum distribution of archaeological levels for rockshelters and open-air sites by the 6 major technocomplexes.



the cold and dry conditions occurring prior to periods of rapid warming. Finally, prior to the Oldest Dryas the preferred habitation choice is open-air sites. With the onset of the cold Oldest Dryas, a shift begins to emerge resulting in a change of this preference. It can be suggested that while the decision to occupy rockshelters may have been influenced by climatic conditions, the sustained dominance of this form of occupation throughout the Bölling / Alleröd and into the Younger Dryas must be socially driven (Svoboda et al. 1997, 187). In other words, colonisation or recolonisation occurred not as a response to climate change, but rather in line with social and behavioural strategies based on individual and group dynamics.

This breakdown of the data as shown in Figure 3.10 results in the visibility of distinct changes that suggest conscious choices are being made with regard to social and behavioural adaptations. This is especially exemplified by examining the differences between the East Gravettian / East Epigravettian, and Gravettian / Epigravettian technocomplexes.

For example, a noticeable difference exists between the East Gravettian and Gravettian technocomplexes particularly at the height of the LGM. The open-air occupation sites of the Gravettian are few throughout the LGM and give way briefly to a rapid increase in the presence of rockshelters at the coldest period (approximately 22500 cal BC). By 21000 cal BC, until the introduction of Epigravettian / East Epigravettian technocomplexes, the number of archaeological levels for rockshelters and open-air sites is comparable. In contrast, East Gravettian data reveals that while rockshelter sites are introduced as a habitation option at the LGM, open-air sites remain the dominant choice. The appearance of East Gravettian rockshelters does not appear to be related to climate nor do they appear to have an affect on the preference to occupy open-air sites. Likewise, the data show that Upper Palaeolithic hunter-gatherer population levels were not drastically affected by the LGM.

A similar observation can be made about the Epigravettian during and following the Oldest Dryas. A minimal number of Epigravettian open-air sites gives way to rapid and continuous occupation of rockshelters. In the East Epigravettian, an initial and rapid accumulation of open-air sites at the end of the Oldest Dryas into the onset of rapid warming is quickly balanced by continuity in rockshelter occupation and indeed a return to this form of habitation as the climate deteriorates to the Younger Dryas.

The differences between the East Gravettian and Gravettian, and the East Epigravettian and Epigravettian are defined by the variations in the lithic toolkit that ultimately can be geographically separated (with limited overlap) between Central and Eastern Europe (Kozlowski 1986). With this in mind, Figure 3.10 would indicate that established Eastern populations may have moved back to the west during the coldest climatic stages before heading east again when warmer conditions allowed. Protection from the cold might be a driving force (i.e. seeking refugia). This would likely require adopting the appropriate technology toolkit to adapt to the resource landscape. This is an environmentally deterministic explanation for the observable patterns. However, particularly during the cold maximum, it is clear that some technologically different groups coexisted temporally, occupying both rockshelter and open-air sites. Climate conditions could not have played such an important role. At the height of the LGM around 22000 cal BC, habitation of Gravettian rockshelters parallels occupation of Eastern Gravettian open-air sites.

Finally, in the previous section it was noted that Magdalenian groups existed contemporaneously with the Epigravettian and East Epigravettian populations. Magdalenian sites are primarily located in the higher latitudes of Western Europe. In this case, differentiating between open-air sites and rockshelters in Figure 3.10 may alter the notion that the rockshelters of the Magdalenian are contemporary with the open-air sites of the Epigravettian / East Epigravettian. Rather, it is the rockshelter occupations of these two cultural complexes that coexist. Though there is a limited extent of coexistence before, it is not until the period prior to the onset of the Holocene that we see multiple technocomplexes occupying both open-air sites and rockshelter contemporaneously.

The period following the Oldest Dryas consists of much more variability in the data than prior to it. This would suggest that people were choosing subsistence and social behaviours, not based on climate conditions, but from within a framework of socialization. This will be examined further in the spatial analysis to follow in Chapter Four.

3.6 SUMMARY

In this chapter a broad temporal analysis of the data has revealed that the colonisation / recolonisation of Central Europe could not have been a straightforward process dependent primarily on climate and environmental conditions. Several points are in need of further discussion.

The only observation that can be made initially is that there is a period equating to the Oldest Dryas when the number of occupied sites drops significantly. The first clear discernment that can be made is the result (visible in the data) of choices Upper Palaeolithic hunter-gatherers made about the types of occupation sites they would inhabit. Throughout the LGM, until the onset of the Oldest Dryas, open-air sites dominate the archaeological record. During this very cold period, a transition from open-air sites to rockshelters takes place that subsequently leads to this form of occupation site dominating the post-Oldest Dryas period. As the climate continues to warm prior to the onset of the Holocene, both types of site are favoured despite climate conditions. This supports the suggestion that colonisation processes cannot be environmentally determined.

The results presented here also appear to parallel the results achieved by Holdaway and Porch (1995, 77) in their examination of the moving sum method applied to radiocarbon dates as they can reveal patterns in the Pleistocene occupation of Southwest Tasmania. Arguing that the peaks and troughs in the data correlate with major climatic events over a long time period, the authors remain cautious about such interpretations when they note "humans do not respond to long term climate changes directly" (1995, 77). Instead they suggest that humans adapt to "short term micro-environmental differences" that may prove to be only "incidentally related" to long-term climate changes. This research is in agreement. By examining the Central European data using the same methodology, and beginning with the broader picture and working toward more detailed observations, it has been shown that at first glance the data appears to correlate well with major climate fluctuations. Upon closer examination however, it was revealed that significant variability occurs in the data regardless of climate influence.

Housley et al. (1997) modelled the distribution of uncalibrated radiocarbon dates at 1σ (68% confidence) using a 400-year moving sum with the 200-year span. Blockley et al. argued that these authors' method resulted in an over-simplification that could not be considered accurate (Blockley et al. 2000, 114). These authors argued for better accuracy, suggesting that data needed to be calibrated before the moving sum method could be applied. They argued that the method applied by Housley et al. (1997) did not account for errors at 2σ (95% confidence). Blockley et al. (2000, 113) suggested that once the method is applied to the calibrated data, the data could no longer be considered data points. A re-application of the method left the authors with the conclusion that the chronology is more accurate but spatial distribution no longer showed the clear patterns suggested by Housley et al. (1997), whose conclusions were not only based on the moving sum application, but on the nature of the observed archaeological evidence. The latter (spatial) part of this conclusion will be re-examined in Chapter Four. The points made here with respect to chronology can be addressed, and compared to the data from Central Europe.

The large scale of this analysis required that the moving sum method be applied using a 1000-year interval and a 500-year span in the same manner as Holdaway and Porch (1995). The radiocarbon data however are calibrated and reduced to a single date per occupation site layer. If Blockley et al. (2000) are correct then these data cannot be appropriately applied using the moving sum method. It is argued here that, using this method, these data can indeed be applied successfully in a temporal analysis. Accepting the first radiocarbon date as the earliest phase of recolonisation in each region (termed the pioneer phase), Housley et al. (1997, 44) suggested that the process took place in 200-year intervals, with the largest number of determinations occurring more 400 - 600 years after the initial recolonisation. In this research a standard deviation of 2σ was used for the calibration. The problem of working with these deviations during the application of the moving sum methodology was eliminated by applying statistical calculations to the calibrated dates to produce a single date that could be used as a data point for each site layer.

Though the results are not as clearly defined as Housley et al. (1997) suggest, it is possible to propose plausible interpretations of temporal colonisation patterns. For example, there appears to be a distinct difference in the chronological phases of colonisation between open-air site and rockshelter habitation particularly during the LGM prior to the Oldest Dryas – the Gravettian / East Gravettian technocomplexes. The colonisation of rockshelters can clearly be seen to consist of a rapid, two-phase process consistent with the results of Housley et al. (1997). Open-air sites however, show a more continuous, slightly slower (temporally longer) three-phase process consistent with suggestions made by Bang-Andersen (1996, 219-234) who interprets the earliest colonisation of Southwest Norway as consisting of a "pioneer and discovery" initial phase followed by an "immigration" phase and resulting in a settlement phase that can be defined as "complete annual exploitation". Holdaway and Porch (1995, 77) suggest that a range of interpretation can be proposed that include not only differences in site occupation types, but, the frequency or continuity that a site was used as compared to other sites during cold and warm climate periods. Certainly, the determination of colonisation processes is dependent to some degree on this point. This consideration is in need of further exploration.

The period following the Oldest Dryas requires some explanation. Initial observation conducted without regard to differences between rockshelters and open-air sites boldly illustrated coexistence between two very different technocomplexes: East Epigravettian / Epigravettian and the Magdalenian. It was first thought that these two groups differed primarily not just in social structure and toolkits, but, in site occupation types where the former consisted mainly of open-air sites and the latter of rockshelters. Further examination of the data revealed much more variability. While the evidence is clear that these two groups are indeed contemporaneous, they cannot be neatly categorized.

No further conclusions can be drawn from this broad temporal analysis without incorporating spatial analyses. Chapter Four will attempt to further explore the radiocarbon data points from within a spatial context. The results of this analysis should enable the processes of colonisation / recolonisation to be determined more accurately, and interpretations to be made about the visible patterns.

CHAPTER 4

SPATIAL ANALYSIS AND SETTLEMENT PATTERNS

In the previous chapter the radiocarbon data points were examined using statistical methods. In particular, the moving sum method was used to elucidate temporal observations about the colonisation processes of Upper Palaeolithic populations. Several important arguments are proposed as a result of the analyses. The most significant of these is the suggestion that climate could not have been a driving factor in the decisions Palaeolithic hunter-gatherers made about colonisation. Another notable consideration is that there is a distinct difference between the colonisation processes involving rockshelters as opposed to those of open-air sites. This is reflected in both the timing of occupation of these sites and the rates of expansion as seen in the temporal patterning. A third observation is that the Oldest Dryas episode very clearly represents, albeit possibly inadvertently, a period of significant settlement change. Temporal patterns through the LGM prior to this period are more visible and apparently straightforward. Open-air sites dominate and a three-phase approach to colonisation of these sites is clear. Rockshelters are marked by a rapid two-phase colonisation during the coldest periods. After the Oldest Dryas however, there is a clear switch from open-air sites to more favoured rockshelters, and very different groups, whose choices about settlement are clearly diverse, coexist.

While it is clear that patterns in the data are beginning to emerge, few conclusions can be drawn without attempting to understand the spatial dispersion of the chronological data. In this chapter the characterised dates are examined from the spatial perspective. The results of these analyses will add further evidence to the results and hypotheses derived from the temporal analysis of Chapter Three. The aim of Chapter Four is to determine the regional processes of colonisation, to better establish the rates and directions of movement, and to thus achieve a clearer picture of the colonisation of Central Europe. The results will be compared to evidence obtained from the literature, and evaluated against empirical data.

4.1 A SPATIAL OVERVIEW OF THE DATA

A spatial overview of the data is obtained by developing a chronological-spatial contour map representing the whole of the data points (representing archaeological levels) across the entire study area. This was done using a geo-statistical analysis and mapping package called *GS+*, developed by Gamma Design Software (1998-2000) for the purposes of measuring and illustrating spatial relationships. GS+ is particularly suited to building accurate statistically rigorous spatial representations for landscapes that cannot be exhaustively sampled. Point data randomly distributed over large temporal and spatial areas, as in the case of the study, can be analysed with some degree of confidence.

The GS+ package can produce interpolation maps using the kriging method. Kriging is a means of interpolating values for points where knowledge about underlying spatial relationships between those points is unknown. It is used in spatial prediction under the assumption that "variables at one location are not independent of those at another" (Shennan 1997, 385). Kriging is based on "regionalized variable theory" (Burrough and McDonnell, 2000, 133-135), which assumes that the spatial variation of any variable can be expressed as the sum of three parts. These are a) structure – having a constant mean or trend, b) a random or spatial correlation and c) a residual error. The procedure for quantifying the data is the fitting of variogram models. A model can be fitted using a variety of means such a linear, exponential and gaussian. The best fit model is one where, within the range from the constant, points and predicted sites are closer together as the further apart they are the less significance the data point is to the outcome. Once the variogram is produced and accepted it can be used in spatial analysis.

Burrough and McDonnell (2000, 142) describe kriging and the computation of the "moments of the distribution of residuals" where each point is removed and then predicted from the remaining data. The process is designed to test variograms for self-consistency and lack of bias. Variograms, derived from semivariance analysis that measure lag distance intervals between pairs of points, provide the spatial knowledge used in the kriging method. An optimal interpolation estimate is given for each coordinate location, as well as the variance estimate for the interpolated value.

Where normal point kriging can produce maps with large spikes at data points due to the number of data within a given space, block kriging can be used to smooth the results. This method involves "modifying the kriging equations to estimate an average value *z(B)* of the variable *z* over a block of land *B*" (Burrough and McDonnell 2000, 143).

Contour maps illustrating the results of interpolation are then produced. Distance between the contours is automatically determined in GS+ using a distance matrix based on the variogram. As a result, intervals between contours are dependent on the number of samples in the data and their distances from each interpolation point. This method was compared to the Inverse Distance Weighting and Normal Distance Weighting, both of which are based only on the assumption that points near to each other should be more closely related than the distance to those points. Interpolation is based on values at nearby locations and weighted only by distance from the interpolation location. Based on these comparative experiments with the data, kriging using the block method is considered to be superior over other forms of interpolation, showing higher degrees of confidence and accuracy.

Figure 4.1 shows the locations of all radiocarbon data points in the working database. Figure 4.2 shows the interpolated contours of the radiocarbon data points across the whole of the temporal and spatial scales. What the results shown in Figure 4.2 cannot reveal are the rates of population dispersal nor absolute dispersal patterns. This is because interpolation is based on a flat continuous surface. Unknown data points are assumed to exist anywhere in space and are interpolated as such. Where the distance between known points is greater, the results are less accurate, but unknown points are still generated and interpolated. This yields a contour map that does not recognise empty spaces, either temporally or spatially, and where accuracy is reduced, linearity of the contours is often visible. However, there is still valuable information that can be gained using this analysis.

Figure 4.1: Distribution map of data locations. 260 archaeological levels at 165 sites.
Red = rockshelters; Blue = open-air sites.

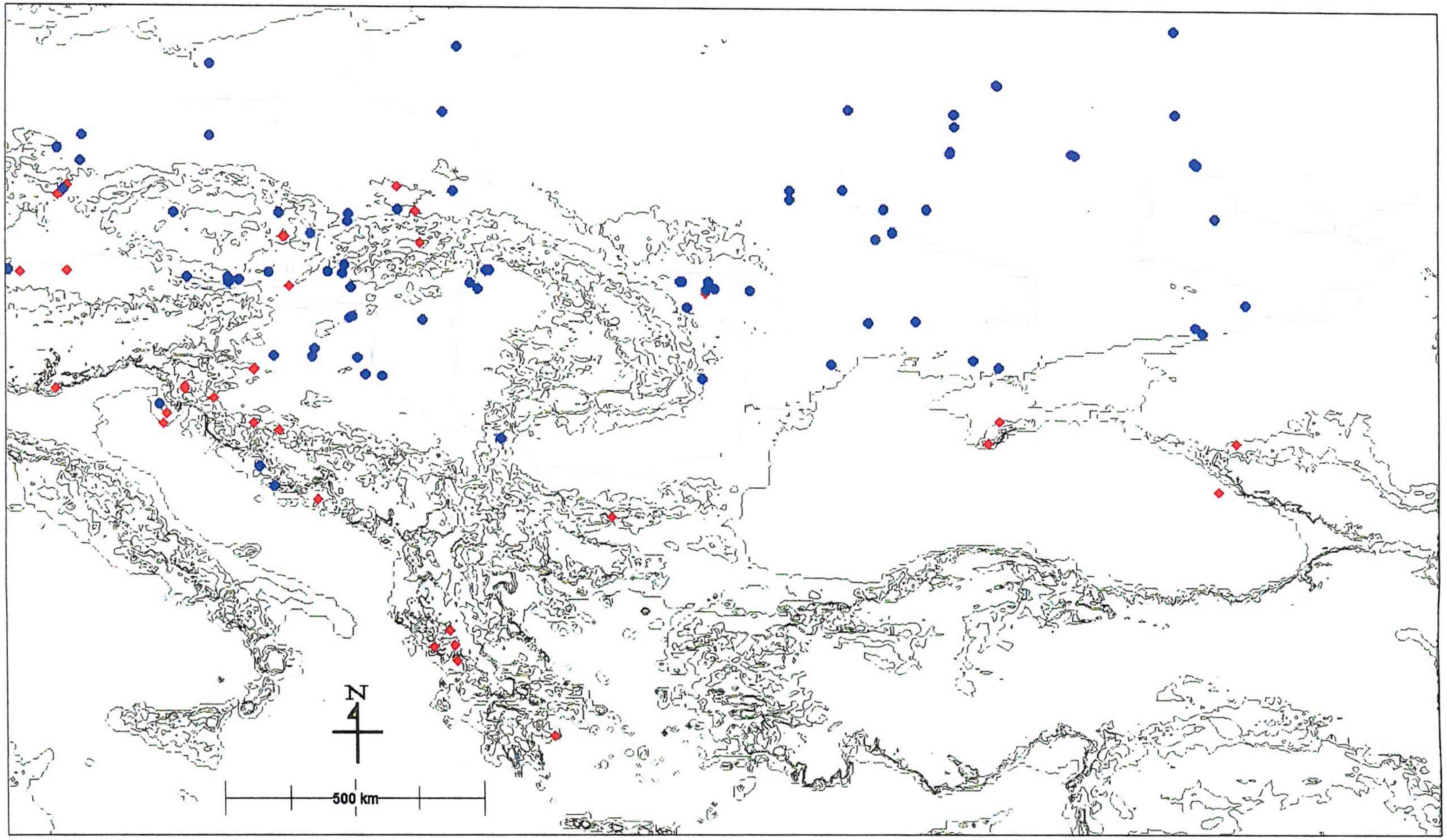
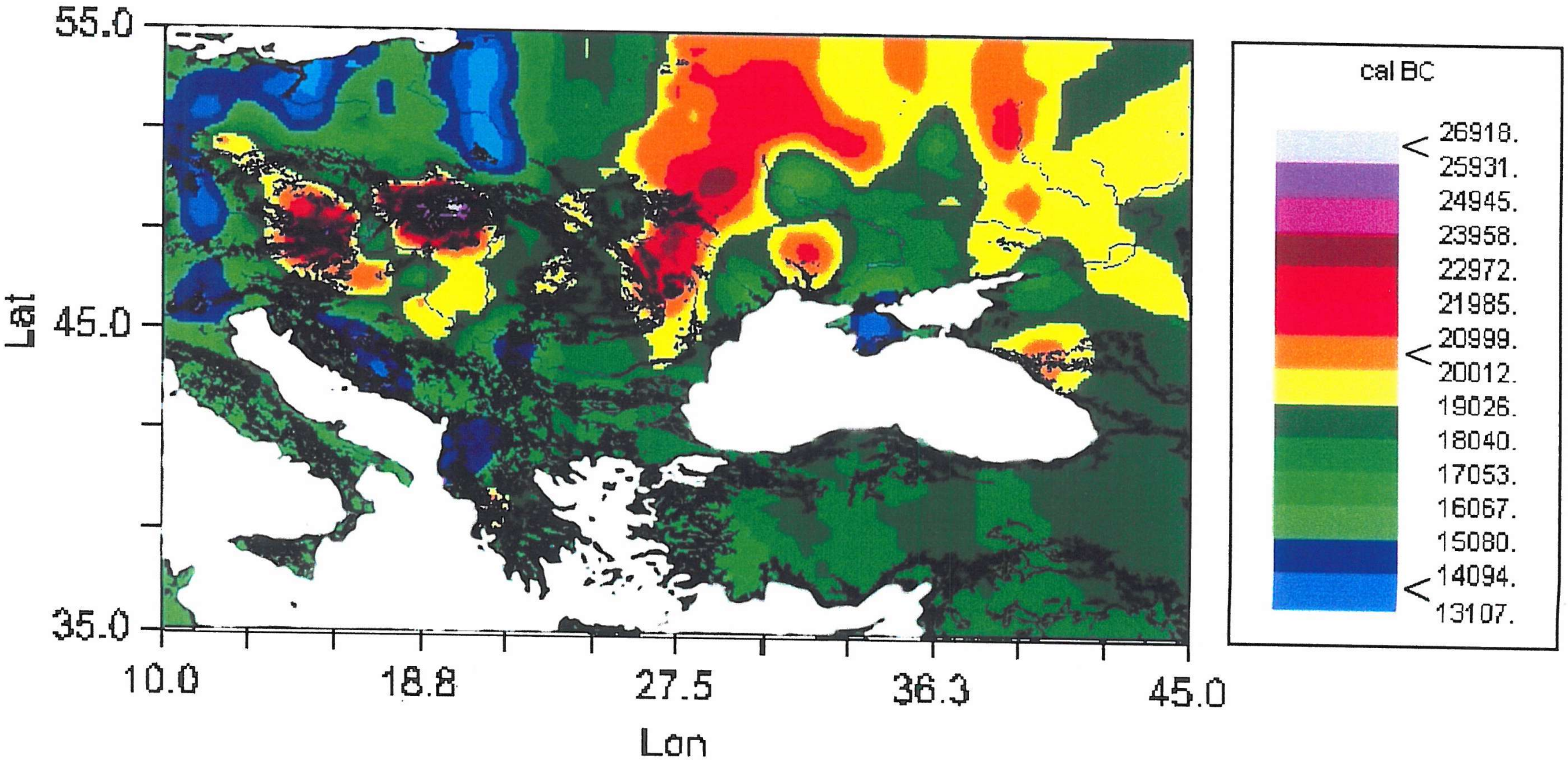


Figure 4.2: Contour map showing kriging interpolation results for all dated archaeological levels



The results do enable comparative interpretations to be made about the spatial-temporal relationships of the archaeological levels to be put forth and tested against empirical data and further analyses. Because the output is produced on the basis of spatial relationships dependent on distance between points and variability, it is possible to draw inferences from the contours on the basis of certain assumptions. First, where the distance between contours is less, the distribution of the data points is more substantial. Second, the assumption is made that because the data points represent human occupation of sites, interpolated unknown values predict the most likely distribution of sites in areas of known and unknown site density. This is solely dependent on the distribution of radiocarbon data assumed to act as archaeological indicators of colonisation patterns. While this is not to suggest that firm conclusions about colonisation processes can be drawn from such analyses, the results do show patterns that must be addressed in further examination.

Four main concentrations of points can be identified where the strongest relationships between data are visible. These occur for sites in the Moravian Karst region, the north Carpathian Mountains in the south of Poland (predominantly dates from Oblazowa Cave), the Dnieper Valley and the Kostenki locale along the river Don in Eastern Europe. Way to the south, the rockshelters of Northwest Greece form a fifth distinct cluster, which will be addressed in later sections. The interpolation of the data allows the following interpretations to be suggested regarding the relationships within and between these main concentrations. These interpretations are supported in the current literature about colonisation in Central and Eastern Europe.

1) The flow of the data suggests that movement, beginning with the earliest dates in the north of the Carpathians, proceeded into the Carpathian Basin. Potentially, populations then moved east through the Tisza Valley to the eastern slopes of the Carpathian Mountains, and/or southwest from the Dnieper region to the eastern slopes of the Carpathians. In the Dnieper River region there is a corridor of data points along a north easterly transect where movement occurs from the centre (around Korolevo) in both a southwest (to Moldova) and northeast (to Mezin) direction. These arguments are directly relevant to considerations about refugia and colonisation processes.

2) Distribution of the data to the east suggests that movement east across the northernmost latitudes led to colonisation along the Don River, where Kostenki-related sites are concentrated. The distribution of the contours suggests that expansion into this region occurred more quickly over greater distances. However, because the contour map is based on a flat surface (i.e. variables such as topography are not taken into account), it represents a predictive spatial model on the assumption that unknown data points exist in the whole of the landscape. The concept that some spaces may have been empty (i.e. were not occupied such that no data points could be present, known or unknown) is not addressed.

3) With the climate warming and the retreat of glacial ice, populations began to move into previously colder or glaciated regions in the northwest of the study area and into areas of higher altitude (e.g. Buran-Kaya in the Ukraine and sites in the Alps and Dinaric Alps).

4.2 OPEN-AIR SITES AND ROCKSHELTERS

The work in Chapter Three clearly identified distinct differences in the colonisation processes of populations who chose to occupy open-air sites versus those occupying rockshelters, whether due to responses to environmental stress or to social and economic frameworks. It is important to analyse these differences spatially, to begin to understand the extent to which these contrasting habitation strategies might reflect the social implications of colonisation processes. In this section the data for open-air sites (subsection 4.2.1) and rockshelters (subsection 4.2.2) are examined separately.

To this end, the distribution of open-air sites and rockshelters will be reviewed using the moving sum method applied to regional divisions relative to latitude, longitude and relief such as those defined by Gamble (1999, 66, figure 3.1).

Gamble (1986; 1999, 66) produced a spatial model (Figure 4.3) identifying nine subdivisions whose regional boundaries would allow for the researcher to observe variations in three "behavioural domains". He suggested that spatial, demographic and social behaviours "could be predicted from the ecological structure of resources" (1999, 66). This being the case, Gamble proposed that, at the continental scale, settlement behaviours could be observed as they relate to latitude, longitude and relief, since these factors "controlled continentality, growing season and hence the productivity of resources... irrespective of the prevailing climatic conditions, glacial or interglacial" (1999, 66). He suggested that variation in behaviours across the nine regional divisions could be shown via density and frequency of occupation, and that social relations could be shown to be the dominant influence over settlement patterns.

In this section, the moving sum method is applied to the dated archaeological levels for open-air sites and rockshelters as they are distributed through the regionally bounded areas of Central and Eastern Europe as defined by Gamble (1986, figure 3) and shown in Figure 4.3.

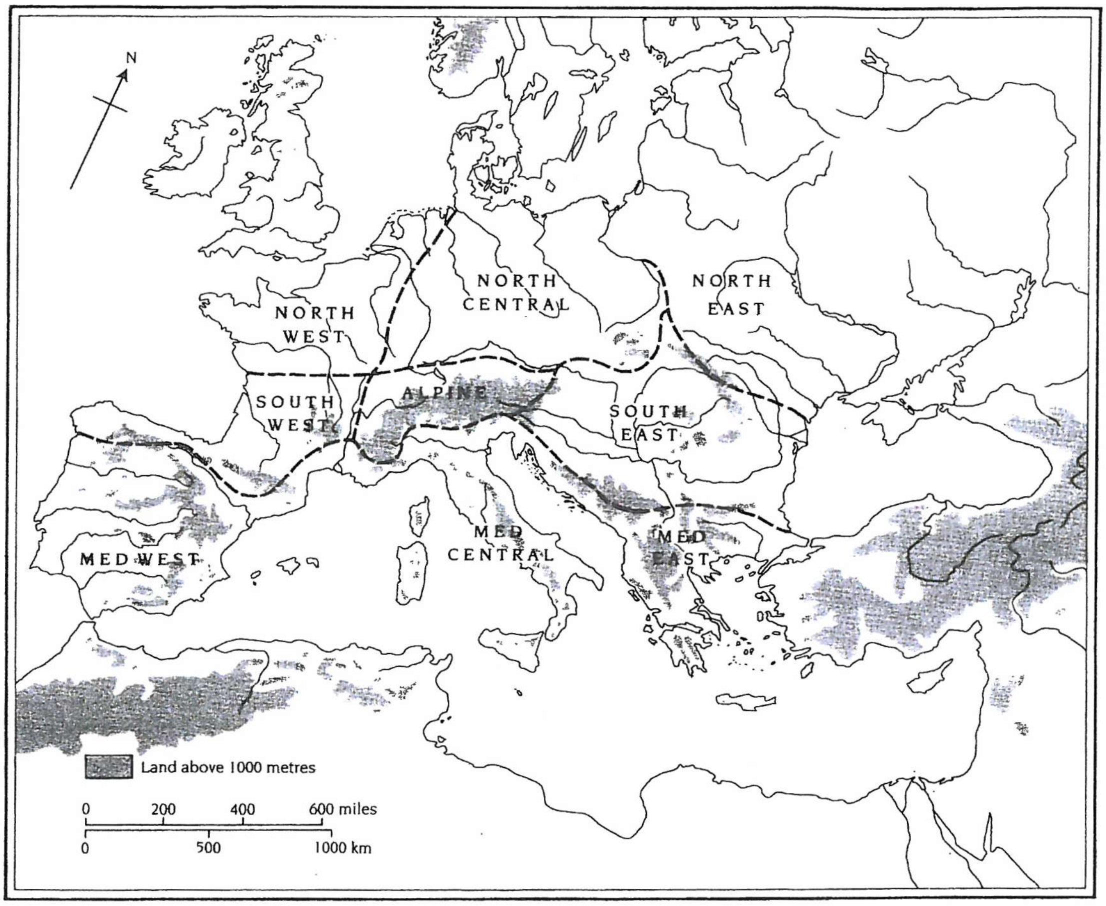


Figure 4.3: Regional model of Europe as defined by Gamble for "the investigation of long-term survival strategies by mobile populations" (after Gamble 1999, 66; 1986, figure 3.1)

4.2.1 Open-Air Sites

Soffer (1987, 333-348) argued that the distribution of Kostenki knives might be used as a diagnostic reference to suggest human dispersal patterns (Figure 4.4). Kostenki assemblages are found “almost exclusively at open-air sites” (Soffer 1987, 340). Soffer argues that these assemblages first appear at Moravian sites such as Dolni Vestonice around 26000 BP (and are also found on some sites along the Danube west of Moravia), disappear from this region, and then reappear around 22000 BP at the Kostenki-Avdeevo sites some 2200km to the east. She suggests that this west to east trajectory parallels the west to east extinction of Würmian megafauna (1987, 346). But, because all of Europe was occupied prior to the LGM, recolonisation of the region is difficult to assess both in terms of group relationships and potential refugia.

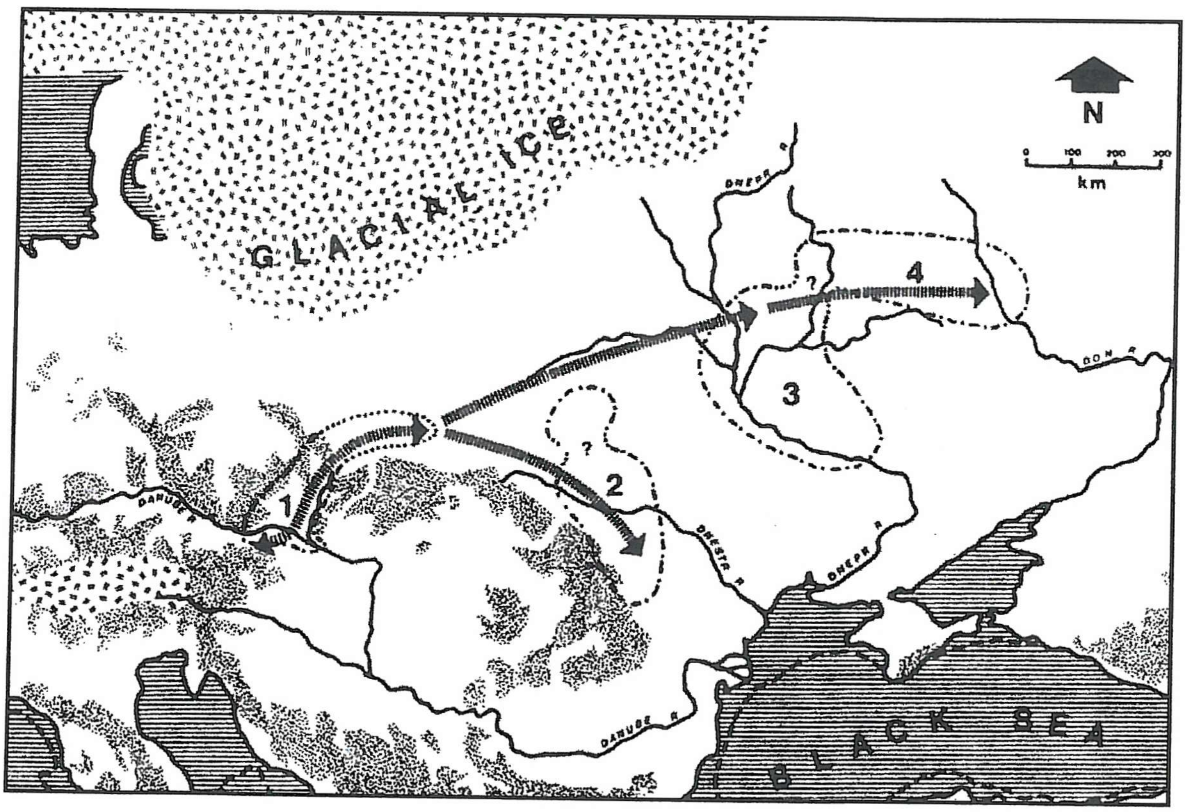
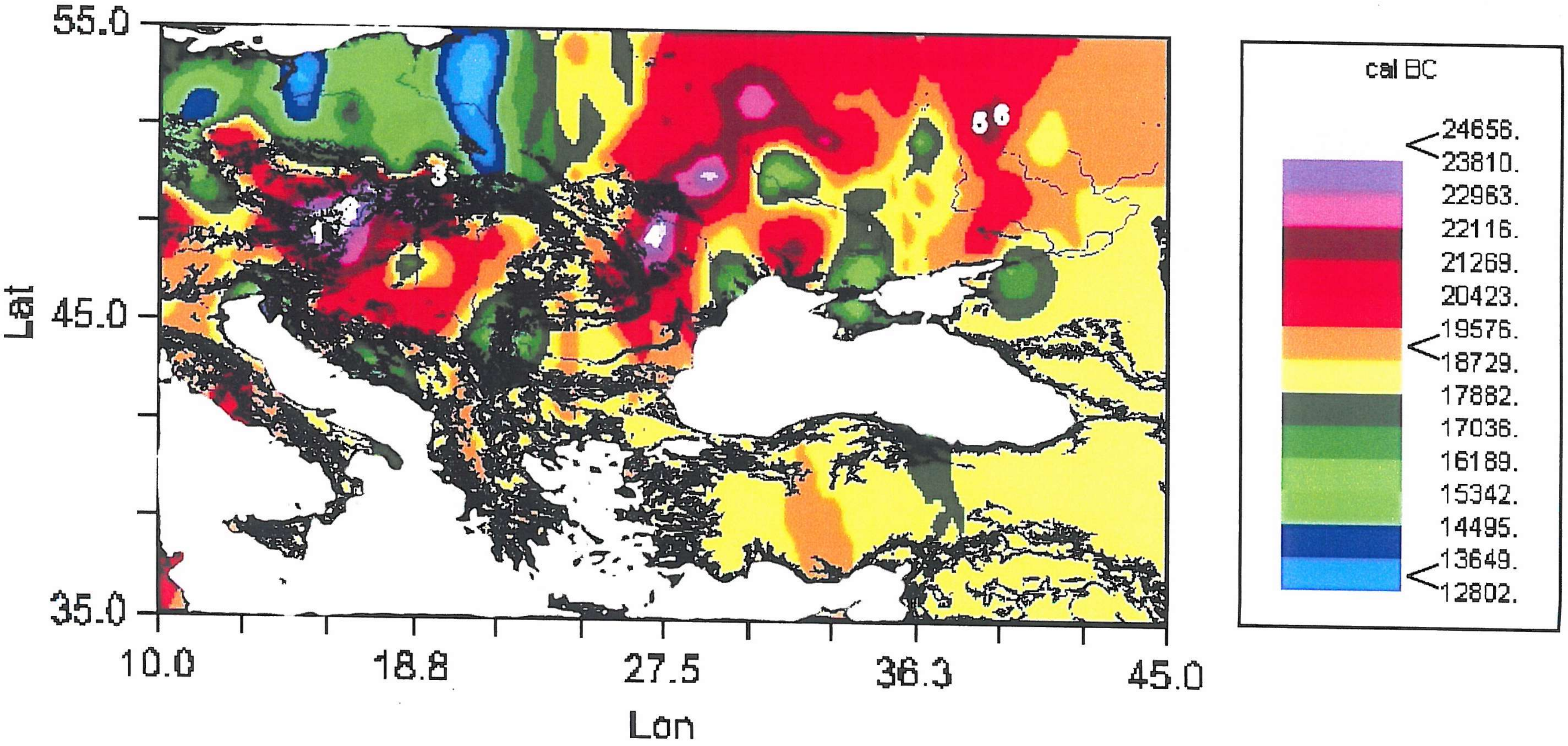


Figure 4.4: Possible distribution route of Kostenki knives as suggested by Soffer (1987, figure 5).
1) Moravian Pavlov culture sites and Spadzista; 2) Molodova culture; 3) sites on the Central Russian Plain including Khotylevo; and 4) sites of the Kostenki-Avdeevo culture.

Figure 4.5: Interpolation results for dated archaeological levels of open-air sites. 1) Willendorf II, 2) Dolni Vestonice, 3) Spadzista, 4) Moldova V, 5) gargarino 6) Kostenki



An examination of the kriging interpolation of the radiocarbon data for open-air sites shows a slightly different west to east movement (Figure 4.5). It can be suggested that the distribution of radiocarbon point data argues that the Carpathian Basin must be included in hypotheses about west to east movement of populations to a greater extent than previously considered. Soffer points out that Kostenki knives and points are concentrated at sites along major rivers including the Danube, Dnestr, Dnieper and Don, and at the sites of Willendorf II, Dolni Vestonice, Spadzista, Moldova V, Gargarino and Kostenki sites (1987, 341). Support for the Carpathian Basin – Tiza Valley route is evident when these sites are plotted on the interpolated contour map. Kozlowski (1986) has argued that only in the middle Danube Basin could there have been a suitable environment for Palaeolithic hunters. Rybonίčková and Rybníček (1996) would agree that since most of the region had never been glaciated, there would be sufficient continuity and soil development during the LGM in this region.

Figure 4.6 shows the moving sum distribution of the archaeological levels of open-air sites at 1000-year intervals and a 500-year span, across the three regions where open-air sites are represented. These results support the hypothesis that a three-phase process of colonisation – an initial discovery phase, an immigration phase and a settlement phase (Bang-Andersen, 1996, 219-234) – would best describe Upper Palaeolithic colonisation by populations whose survival strategies are reflective of open-air settlement. The Alpine and Mediterranean regions each hold only one open-air site and are thus excluded from discussion for the moment. The remaining three regions can be evaluated further.

Prior to the onset of the LGM, all of Europe was occupied to some extent (Soffer 1987, 346). It can be assumed then that movement during the time frame of this research can be attributed to *re*-colonisation processes rather than to the colonisation of uncharted territories. Within the limits of the database temporal framework, the Upper Palaeolithic begins at about 28000 cal BC in the North Central and North Eastern regions. This coincides with the decline of the Maisiéres-Tursac interstadial identified in the Summit ice core (Djindjian et al. 1999, 44; Chapter One, 16). The maximum number of dated archaeological levels in the North Central region is reached at about 24000 cal BC. With the onset of the Glacial Maximum

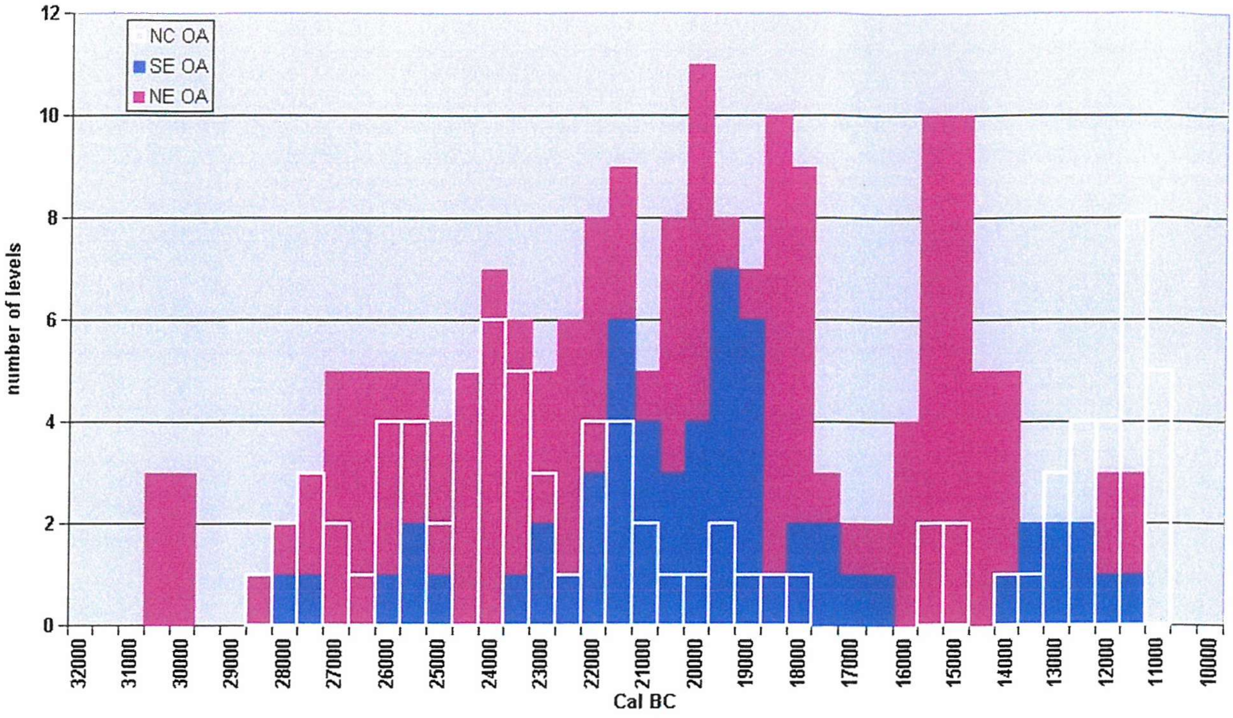


Figure 4.6: The moving sum distribution of open-air site archaeological levels by region at 1000-year intervals with a 500-year span.

this region is then depopulated until after the Oldest Dryas. Occupation of the South East region levels appears at the LGM. The maximum number of dated archaeological levels is reached at about 19500 cal BC. During the short period of rapid warming immediately following the Oldest Dryas, there is a period of abandonment in the South East as a rapid increase in the number of archaeological levels takes place in the North East. In the North East, the distribution of data points is not as clear. To address this, Gamble's North East region is further divided to separate the Ukrainian/ Moldavian Uplands from the Central Russian Uplands, along the watershed of the Dnieper River (Figure 4.7).

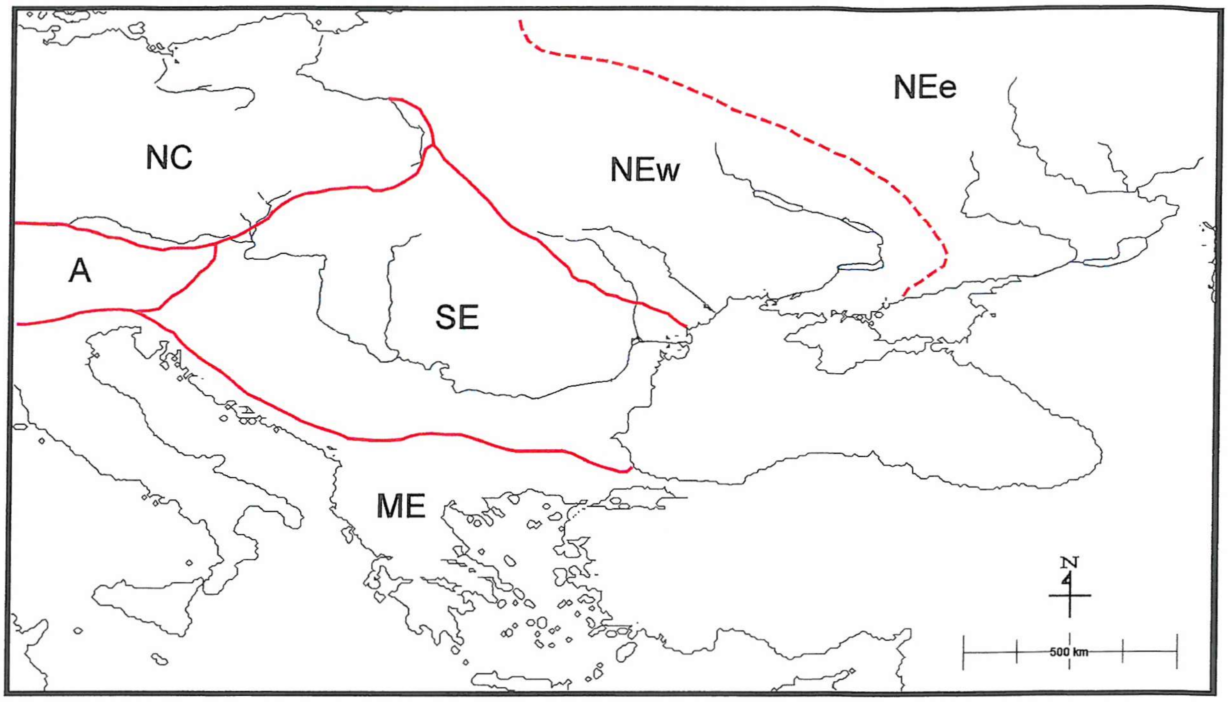


Figure 4.7: Adaptation of Gamble's (1986, figure 3.1) regional model subdividing the North East region into NE West and NE East.

The subdivision of the North East region into two parts is not arbitrary. The line runs along the valley of the Dnieper watershed, between the Uplands of the Ukraine and Russia. The division can be correlated to agree with Gamble's model in terms of latitude, longitude and relief. Coincidently, the line separates the sites of the Central Russian Plain and the Kostenki-Avdeevo culture as defined by Soffer (1987, figure 5). I have termed these divisions North East west (NEw) and North East east (NEe). Re-analysis of the moving sum distribution of the open-air site archaeological levels into the new subdivisions of the North East Region is shown in Figure 4.8. It is evident that the three-phase approach is applicable to the open-air site data for this area.

Figure 4.9 shows the moving sum data distribution for the South East and North Central divisions, and the subdivisions of the North East region.

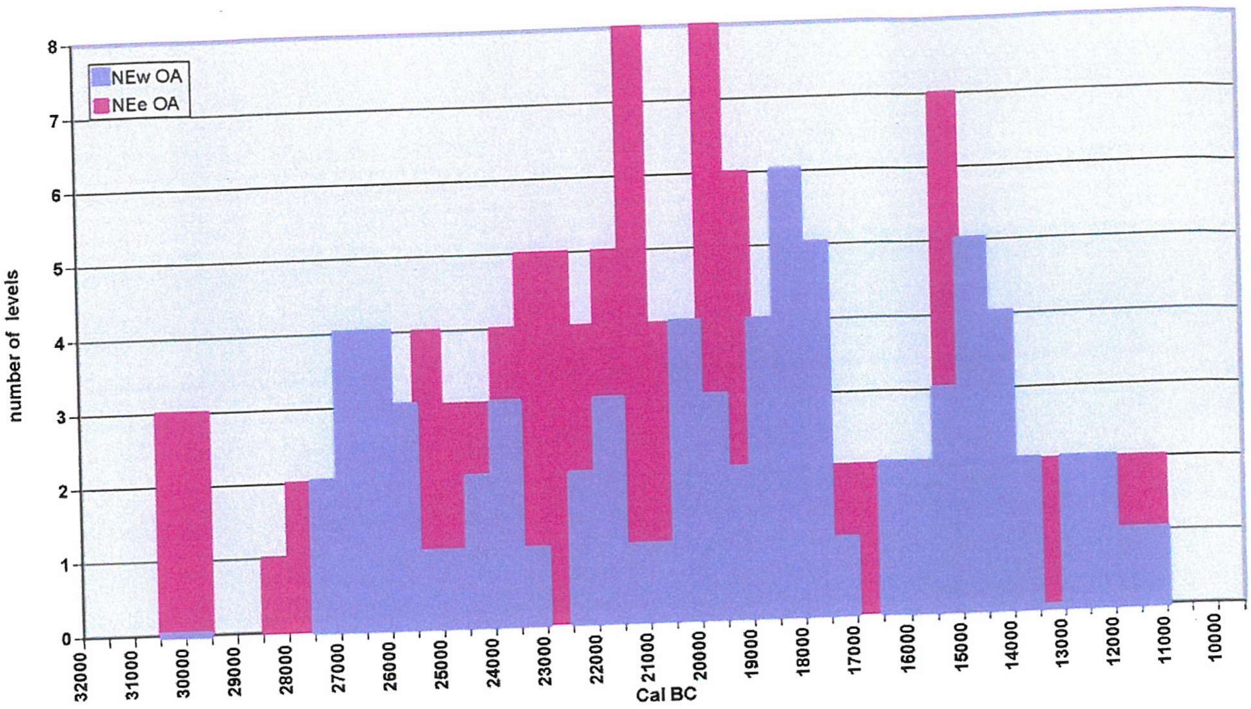


Figure 4.8: Moving sum distribution of open-air archaeological levels in the NE West and NE East Subdivisions.

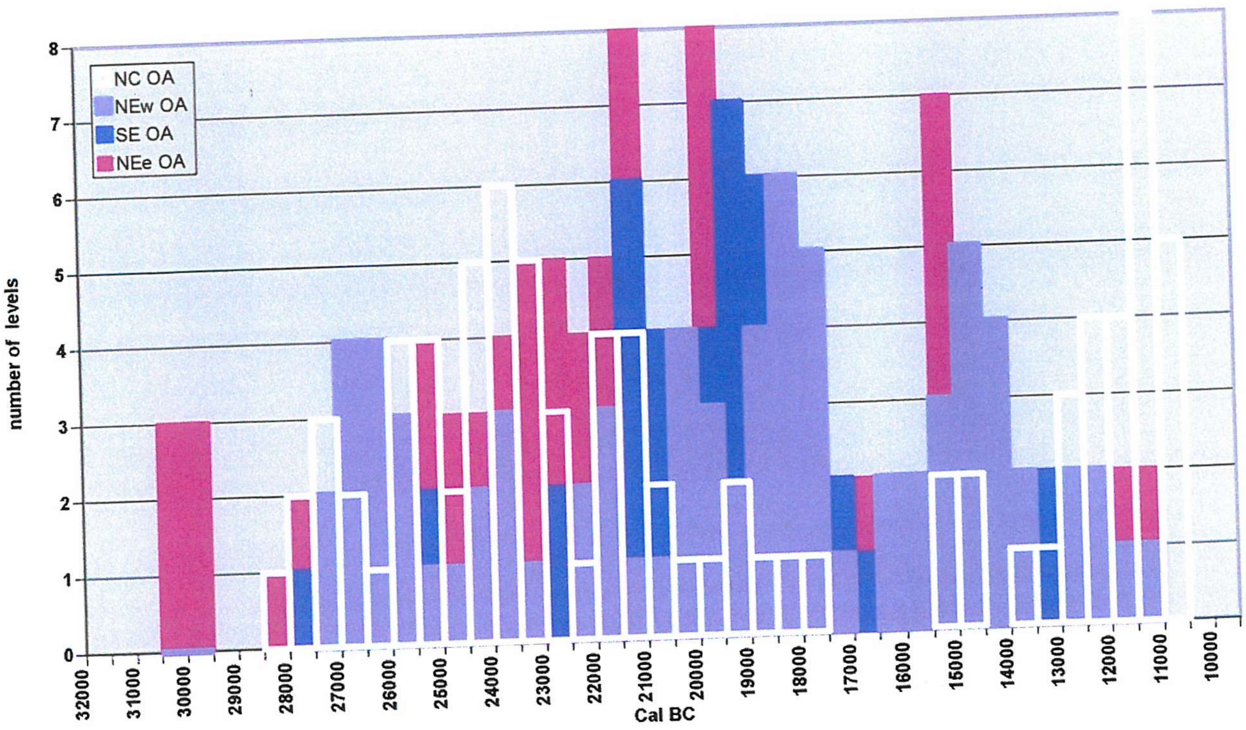


Figure 4.9: Moving sum distribution of all open-air site archaeological levels after NE regional subdivision.

The distribution of the data in Figure 4.9 supports evidence suggesting that all of the northern parts of Europe were occupied prior to the LGM (Kozlowski 1986; Svoboda et al. 1996; Soffer 1987; Djindjian et al. 1999). With the onset of the cold maximum, depopulation occurs in these northern regions (Kozlowski 1986). The data however, clearly brings into question any issue of abandonment in the North East, South East or even North Central at the LGM. Rather, there are more grounds to argue for the abandonment of open-air sites during the coldest part of the Oldest Dryas.

As the number of archaeological sites in the North Central region decreased following the glacial maximum, recolonisation took place throughout the NE West region and in the South East. The cold temperatures of the Oldest Dryas brought a rapid depopulation of open-air sites until warmer climate conditions allowed recolonisation of the northern regions for a second time.

4.2.2 Rockshelters

I have argued previously that the temporal patterning of rockshelters differs considerably from that of open-air sites. I suggest that the same is true for spatial patterning. In this section the moving sum distribution of rockshelters (Figure 4.10) and kriging interpolation (Figure 4.11) are used to explore the spatial dynamics of rockshelter occupation (as indicated by the number and location of archaeological levels).

The moving sum distribution of rockshelter radiocarbon data does not show as clear a pattern of distribution over the whole of the study area, as did the chronological analysis presented in Chapter Three. In two of the regions however, Mediterranean East and North Central, the data do support the two-phase rapid colonisation process as previously suggested. Evidence to suggest that climate played a significant role in the decision to occupy rockshelters is lacking. Only in the Mediterranean East region does there appear to be a considerable increase in the number of archaeological levels that correlate with the LGM and the Oldest Dryas. Likewise, the distribution of the data from the North Central region indicates that this region was recolonised coincidentally with the deglaciation of the Scandinavian ice sheet.

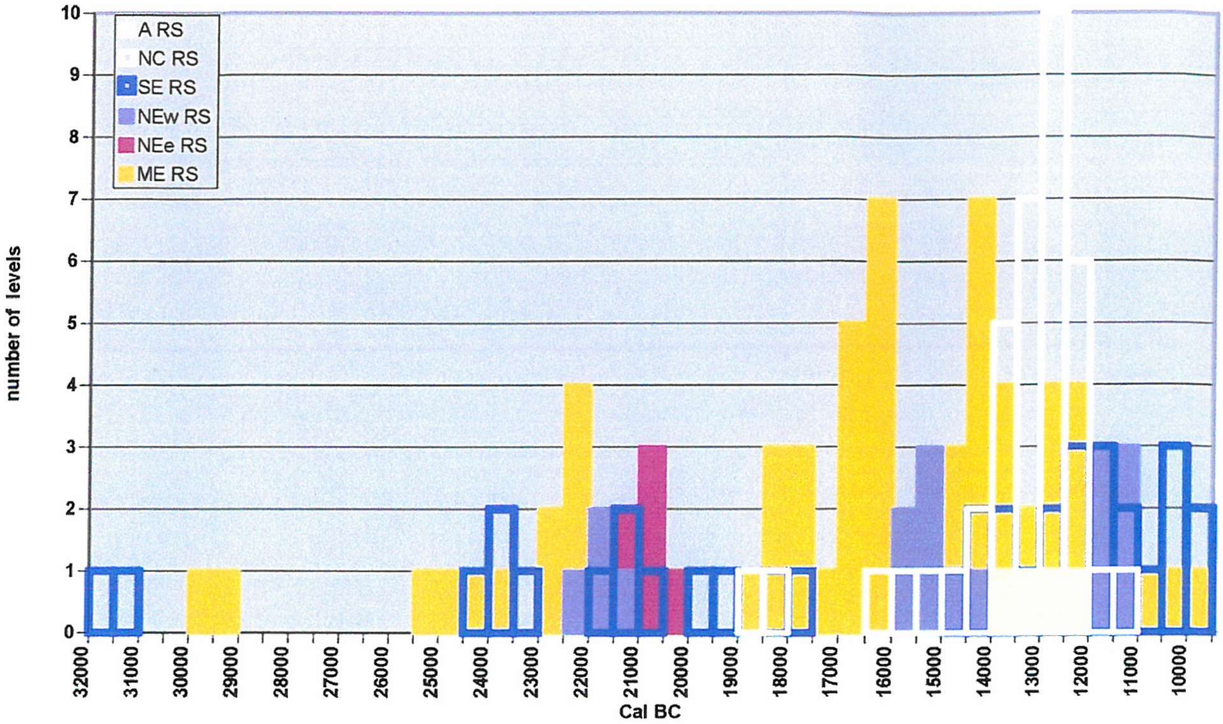
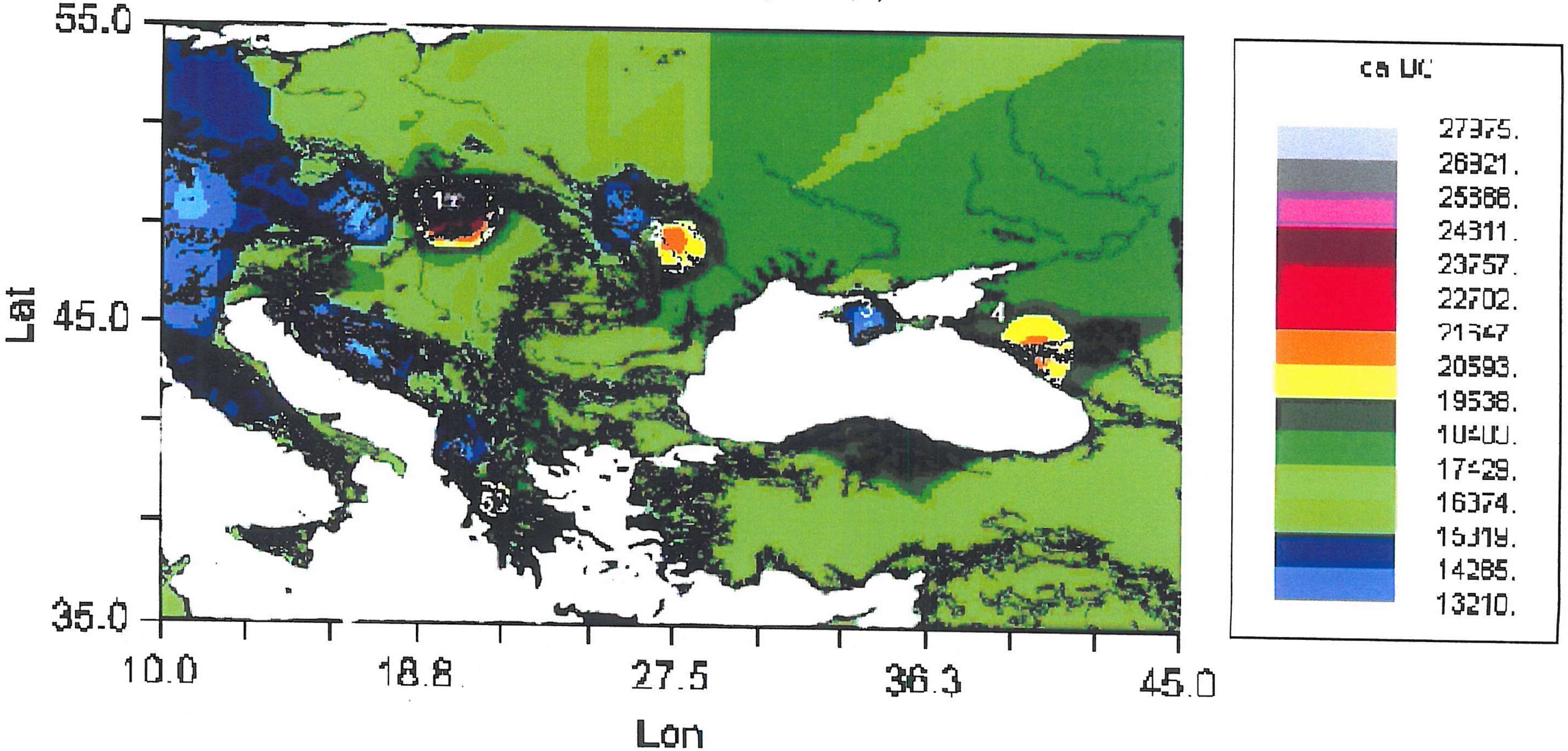


Figure 4.10: Moving sum distribution of rockshelter archaeological levels for the six regional divisions.

In the North East, with the exception of Novgorod-Severskii and Kaszonskaya Cave in the Central Russian Uplands, rockshelter locations are concentrated in Moldova (e.g. Brînzeni I) and the southeast coast of the Black Sea and the Sea of Avov (e.g. Akhshtyr Cave, Skalisty, Buran-Kaya III). These small groups of sites are separated by great distance spatially and temporally. In the South East, sites appear to be randomly occupied until the onset of the Younger Dryas. The location of sites in the North Central and Mediterranean regions however can be compared to the distribution of chronologically earlier sites and interpreted using the kriging analysis.

Figure 4.11: Interpolation results for dated archaeological levels of rockshelters.
1) Oblazowa Cave, 2) Brinzeni I, 3) Skalistiy, 4) Akhshtyr Cave, 5) Klithi



The oldest Aurignacian dates are obtained from Oblazowa Cave, Poland, in the north Carpathian Mountains and spatially placed on the northern edge of the South East region (Figure 4.11). Interpolation suggests that throughout the glacial maximum, spatial movement in this area was limited. Occupation of rockshelter sites in this confined space increased relative to the rate of depopulation of open-air sites in the North Central region.

Interpretation of potential rockshelter settlement processes is difficult until the onset of the Oldest Dryas. As I discussed in Chapter Three (see Figure 3.7), this is the period when the preferred choice of open-air site occupation gives way to rockshelter occupation. At this time, the Mediterranean rockshelters appear to be the preferred settlement location for the duration of this period when almost all open-air adaptations are abandoned. Indeed, the densest concentration of sites at this time is located along the length of the Dinaric Alps. With the exception of Skalistiy, even rockshelters in the North East seem to be abandoned for the duration of the Oldest Dryas.

The trend in the data changes with the rapid warming of the Bölling and Alleröd interstadials. Despite the reintroduction of open-air settlement and a rapid increase the numbers of these sites, rockshelter adaptations, frequently attributed to harsh climatic conditions, remained a dominant settlement strategy for the hunter-gatherers of northern Europe. Not only does the number of rockshelter occupations increase rapidly, but also spatially they are distributed over much greater distances, spreading rapidly into previously glaciated areas. This may suggest that behavioural strategies (social or survival) of rockshelter inhabitants changed as a result of increased resource availability and/or reduced climate stress, or that mobility of these groups increased due to population growth and the development of either social or economic relationships with groups from neighbouring locales.

4.2.3 Summary

This broad scale examination of open-air and rockshelter settlement strategies suggests very different processes. A comparison of the moving sum analysis presented in Figures 4.9 and 4.10 provide the following summation.

Open-air sites dominate the landscape of the North Central and North East regions prior to the LGM. While the number of sites in the North East remained relatively stable through the LGM, there was a reduction in the number of sites in the North Central region. At the same time, occupation of open-air sites in the South East increased. Rockshelter sites appeared in the North East, South East and

Mediterranean. Following the LGM the number of rockshelter sites diminishes while the number of open-air sites increases in the North East and South East. The scenario is reversed with the onset of the Oldest Dryas. The number of open-air sites is minimal and the rockshelters of the Mediterranean dominate. For a brief period, during the Bölling / Alleröd interstadials, there is a newfound preference for open-air sites, and for a short time, the evidence suggests that rockshelter occupation decreased. The numbers of both open-air sites and rockshelters increased rapidly in the North Central region during the Bølling / Allerød.

In broader terms, the whole of the study area, particularly northern latitudes were occupied prior to the LGM. There is some movement south during the LGM but some North Eastern regions remained occupied. Further movement southwest occurred during the Oldest Dryas. Following this, there was a repopulation of northern latitudes, particularly noticeable to the northwest, in the North Central region.

4.3 TECHNOCOMPLEXES

The moving sum analysis conducted in Chapter Three allowed several hypotheses to be put forward regarding the distribution of the radiocarbon data by technocomplex. First, there was a noticeable difference in the patterns of distribution between the Gravettian / East Gravettian data and the subsequent Epigravettian / East Epigravettian and Magdalenian data. Prior to the Oldest Dryas, the data suggest continuity of East Gravettian occupation throughout the LGM and a difference in the settlement patterns of open-air sites and rockshelters. There was also a transition period coinciding with the Oldest Dryas that saw a shift in habitation preference from open-air sites to rockshelters. It was noted that colonisation of rockshelters became more intense during cold and dry climatic conditions, particularly at the LGM and the Oldest Dryas. Though rockshelters remained the dominant habitation strategy following depopulation during the Oldest Dryas, the intensity and variability, in terms of both rates of settlement and numbers, with which sites (open-air and rockshelters) were occupied increased. Finally, it was observed that Magdalenian and Epigravettian / East Epigravettian populations coexisted.

In this section, the spatial distribution of technocomplexes by region is examined using the moving sum method.

Aurignacian

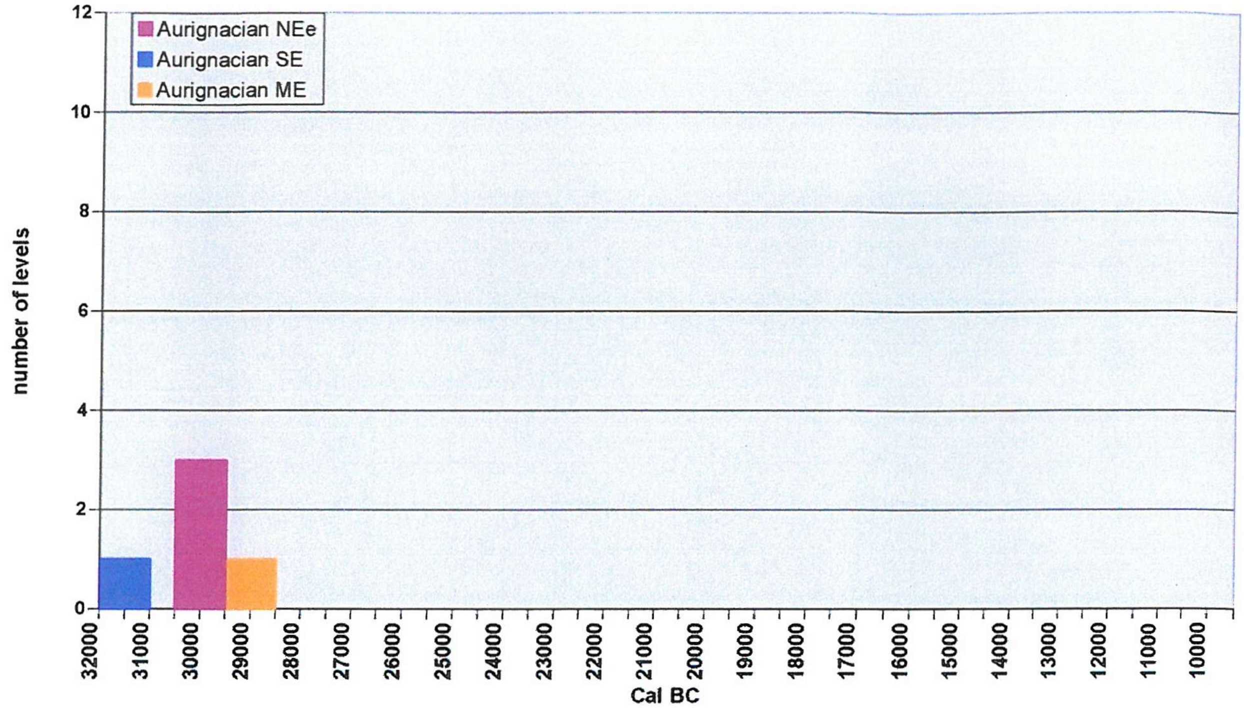


Figure 4.12: Moving sum distribution of Aurignacian archaeological levels by region.

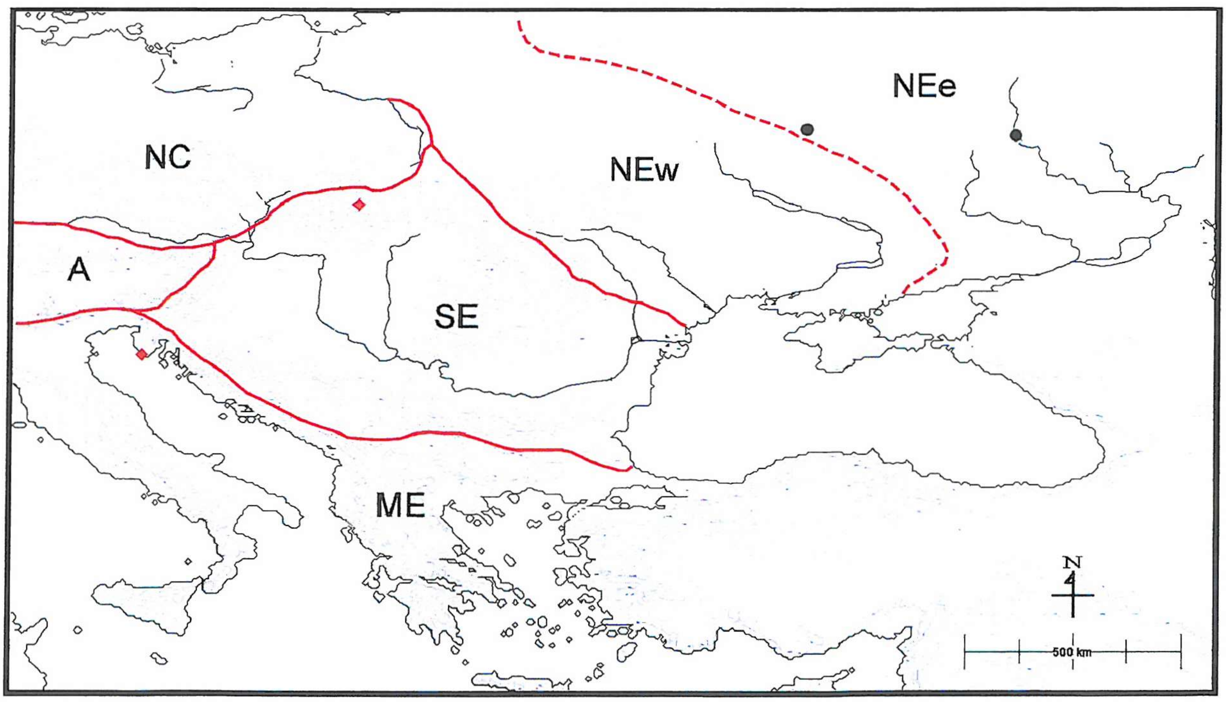


Figure 4.13: Aurignacian site locations in relation to regional model adapted from Gamble (1986, figure 3.1). Black = open-air Red = rockshelter

The Aurignacian data are the earliest in the working database. The lower chronological boundary of this research is set at 25000 uncal bp. Because, the Aurignacian begins much earlier than this, the data for this technocomplex are incomplete, leaving little room for interpretation. Figure 4.12 is illustrative of this.

As the Aurignacian data is incomplete due to the temporal boundaries of this research, these data are plotted (Figure 4.13) primarily to show that sites exist from the Mediterranean to the North East, which suggests that the whole of the study area was occupied by this time, confirming that my thesis is about the *recolonisation* of Central Europe rather than initial colonisation.

Gravettian

The Gravettian technocomplex is spatially oriented in the west and central parts of the study area (Figure 4.14).

Prior to the LGM, open-air sites in the North Central region are dominant, although Franchthi Cave in the south of Greece is also occupied at this time. At the height of the LGM the rockshelters of the Mediterranean prevail. Figure 4.15 suggests that Gravettian populations abandoned the North Central region during the Cold Maximum. However, as the following section will show, there is evidence of occupation by East Gravettian populations. This distinction would indicate that there was some change in regional behaviours and adaptations. Alternatively, the distinction may be due to error resulting from interpretations drawn on such broadly categorised sites.

Both open-air sites and rockshelters are contemporaneously occupied following the LGM. Figure 4.15 shows the Gravettian technocomplex has moved from the Northern latitudes into the south, and remains there until the onset of the Oldest Dryas.

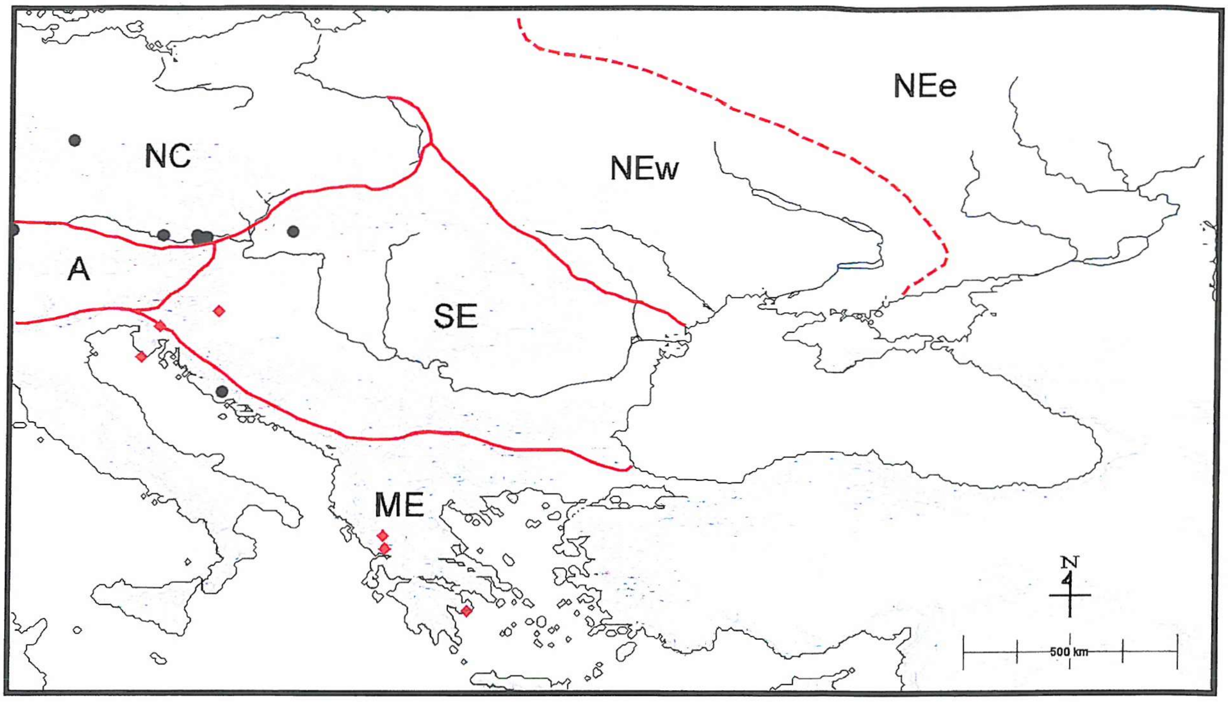


Figure 4.14: Gravettian site locations in relation to regional model adapted from Gamble (1986, figure 3.1). Black = open-air Red = rockshelter

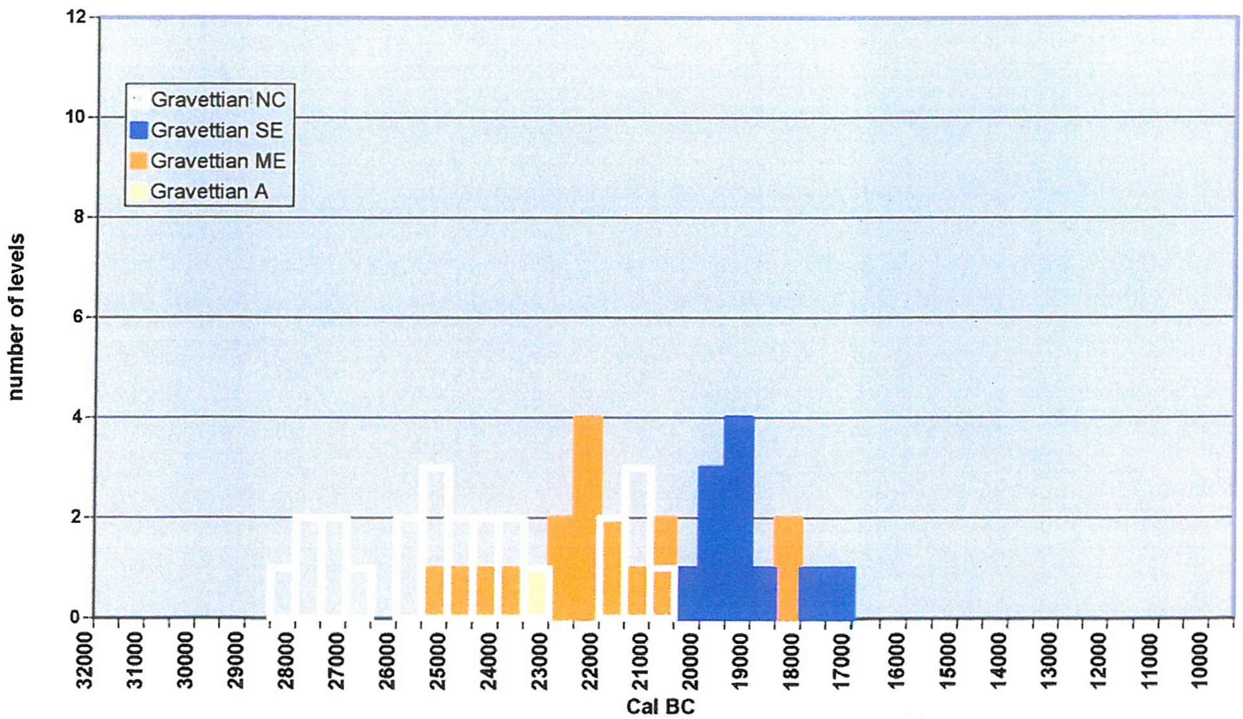


Figure 4.15: Moving sum distribution of Gravettian archaeological levels by region.

East Gravettian

The East Gravettian data shows continuity of occupation throughout the LGM (Figure 4.16). This technocomplex is dominated by open-air site occupation. Distribution of the data shows that both mid and upper latitudes of the study area are populated throughout. While prior to the height of the LGM (approximately 22000 cal BC) the main settlement is spread across the northern latitudes, at the LGM Cold Maximum, it appears that populations settled primarily in the North East region. The number of archaeological levels rapidly increases, and climaxes immediately following the LGM in both the North East Eastern and South East regions. The data shows that the East Gravettian technocomplex was strongly visible until the onset of the Oldest Dryas.

Rockshelter occupation by Eastern Gravettian populations is minimal and sparsely distributed (Figure 4.17).

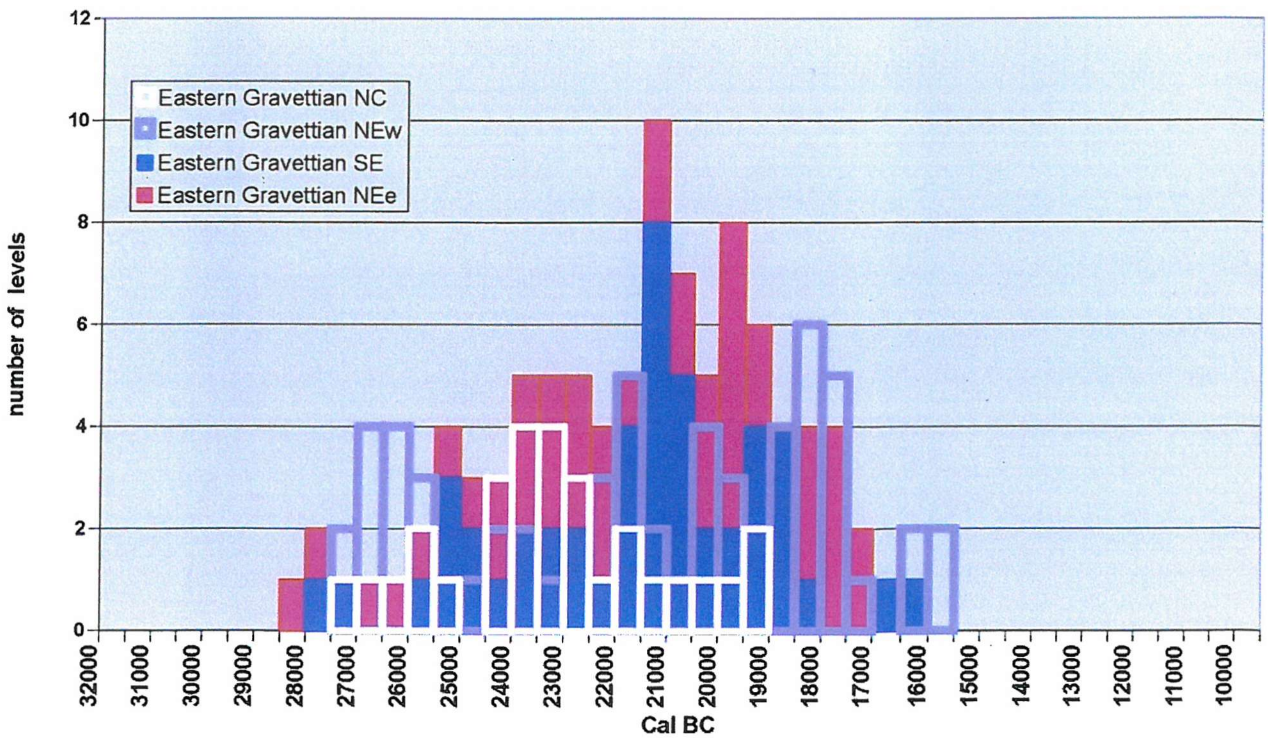


Figure 4.16: Moving sum distribution of East Gravettian archaeological levels by region.

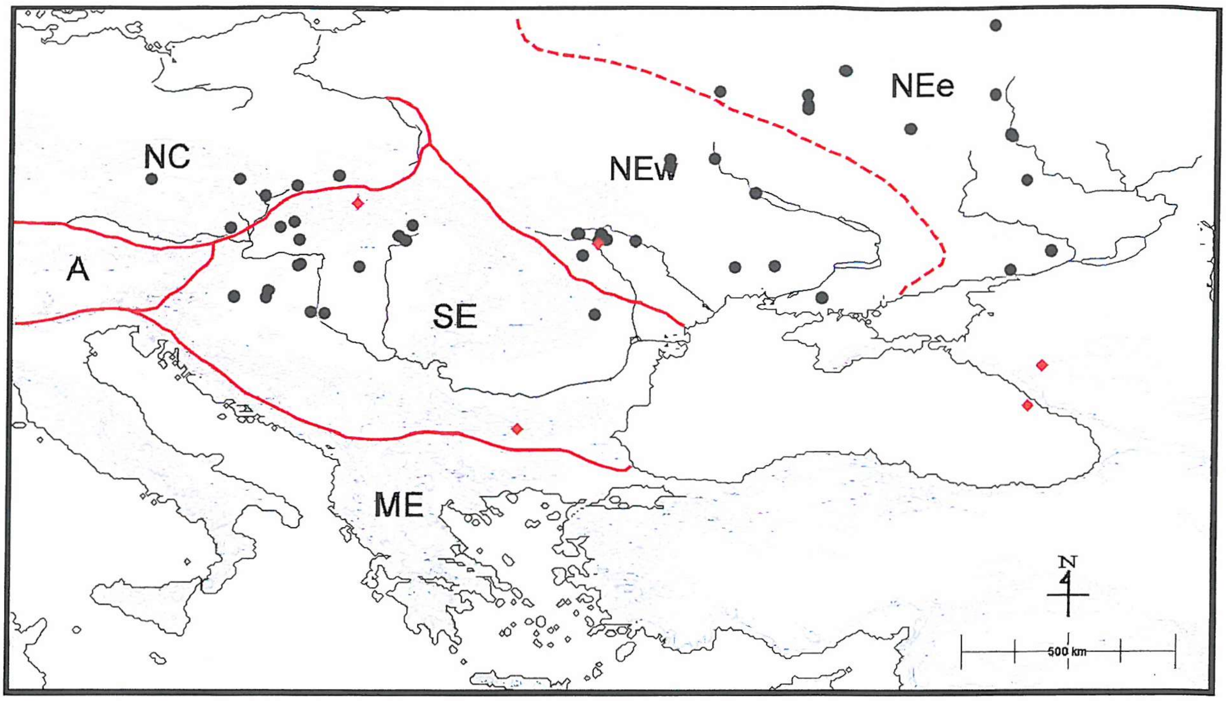


Figure 4.17: East Gravettian site locations in relation to regional model adapted from Gamble (1986, figure 3.1). Black = open-air Red = rockshelter

Epigravettian

The end of the Gravettian occurs in the South East and Mediterranean regions by 17000 cal BC when the emergence of the Epigravettian technocomplex takes place in the South East, Mediterranean and North Central regions (Figure 4.18). The Epigravettian is dominated by rockshelters.

During the Oldest Dryas settlement appears to exist only in the Mediterranean region (Figure 4.19). It should be noted that Epigravettian data for this region comes primarily from Klithi Rockshelter in Northwest Greece and this may have weighted the moving sum, although I would suggest that despite this, the result is the same. There is a brief hiatus in the data between 16000 cal BC and 15000 cal BC with the exception of a single site, Brno-Vídenská, Czech Republic, in the North Central region. During the Bölling / Alleröd interstadials, Epigravettian occupation in the Mediterranean region moves north along the Adriatic Coast to sites such as Županov Spodmol, Slovenia, Nová Drátenická and Kulna, Czech Republic, and Abri Tagliente in Italy.

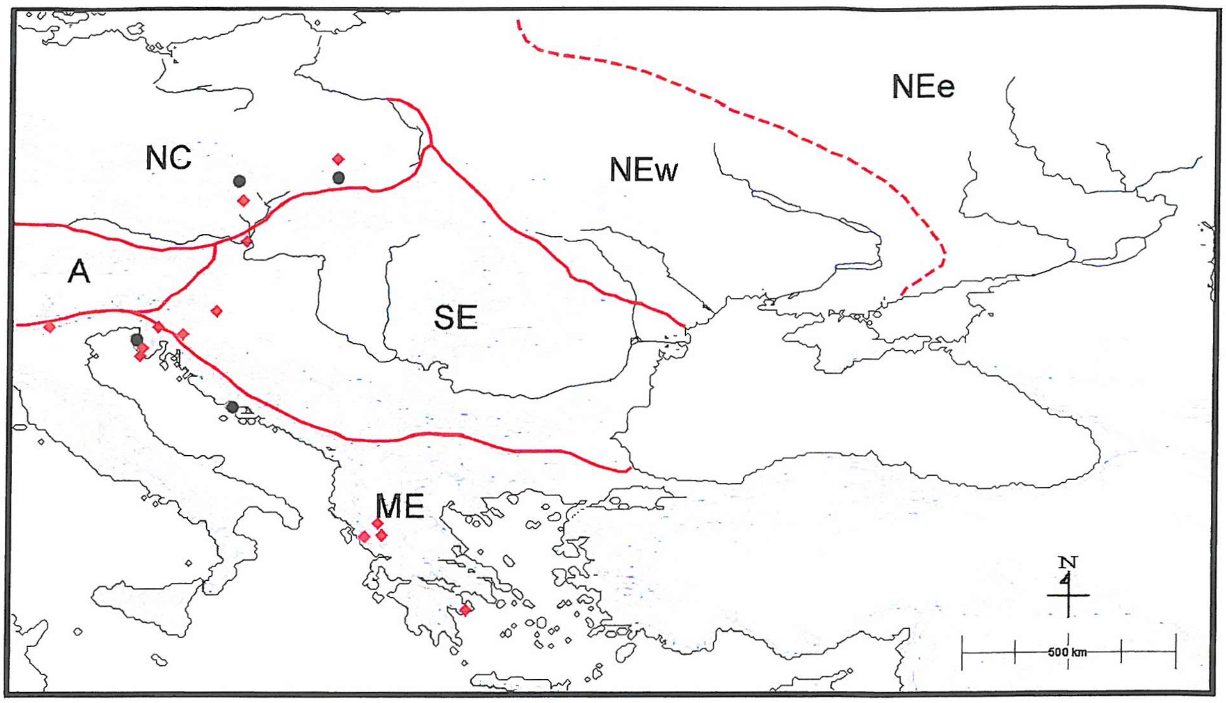


Figure 4.18: Epigravettian site locations in relation to regional model adapted from Gamble (1986, figure 3.1). Black = open-air Red = rockshelter
Figure 4.19: Moving sum distribution of Epigravettian archaeological levels by region.

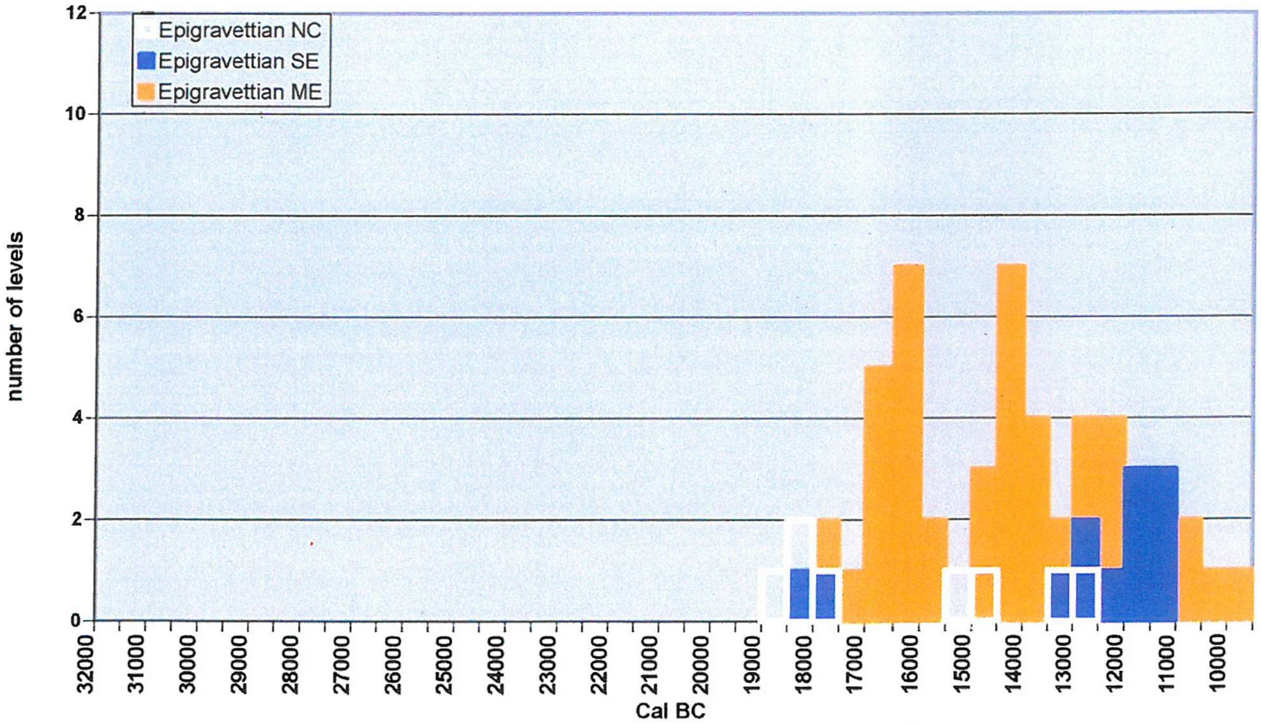


Figure 4.19: Moving sum distribution of Epigravettian archaeological levels by region.

East Epigravettian

The only dated Eastern Epigravettian sites prior to the Oldest Dryas are located very near each other in the South East region at Pilismarót-Palrét and Esztergom-Gyurgyalag in Hungary. During the Oldest Dryas however a transition from East Gravettian to East Epigravettian is visible. The end of the Oldest Dryas shows rapid settlement back into the North East of the study area (Figure 4.20). Interestingly, this sudden increase coincides with the hiatus period shown in Figure 4.19 for the Mediterranean Epigravettian. Following this, Eastern Epigravettian occupation stabilizes in the eastern and south-eastern parts of Central Europe to similar numbers as can be seen for the Epigravettian in the northwest. Figure 4.21 clearly shows that both rockshelters and open-air sites are in use.

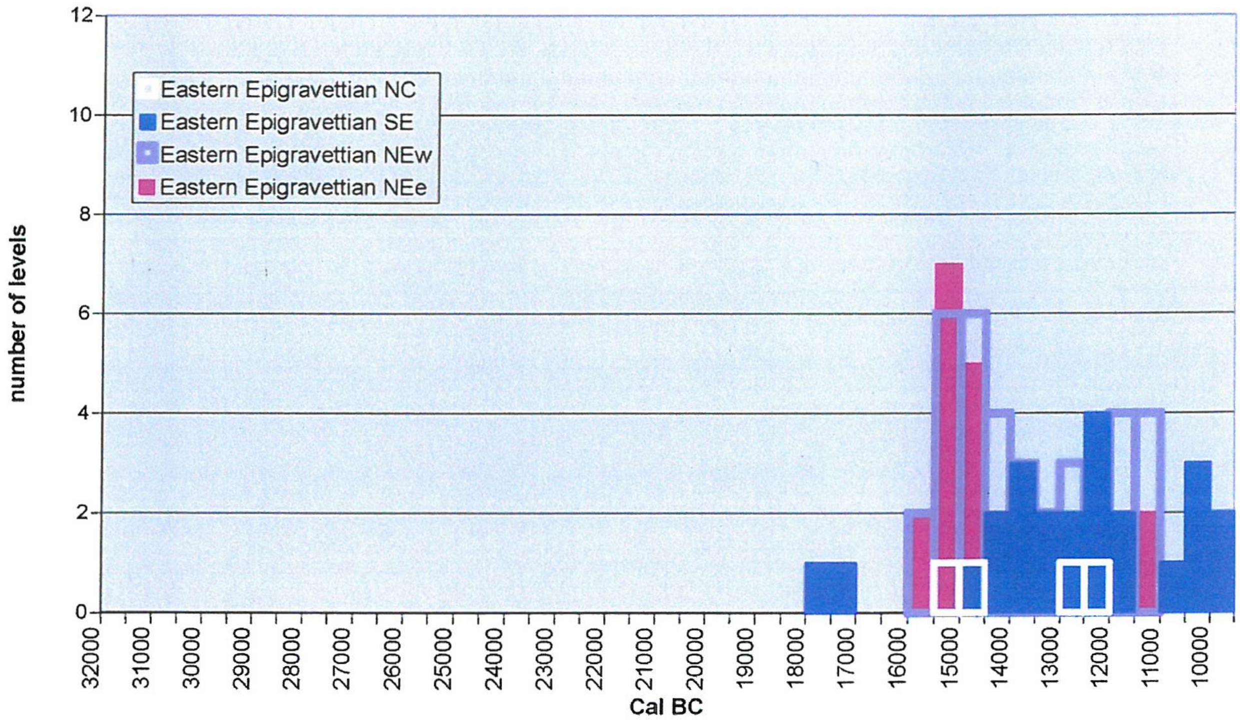


Figure 4.20: Moving sum distribution of East Epigravettian archaeological levels by region.

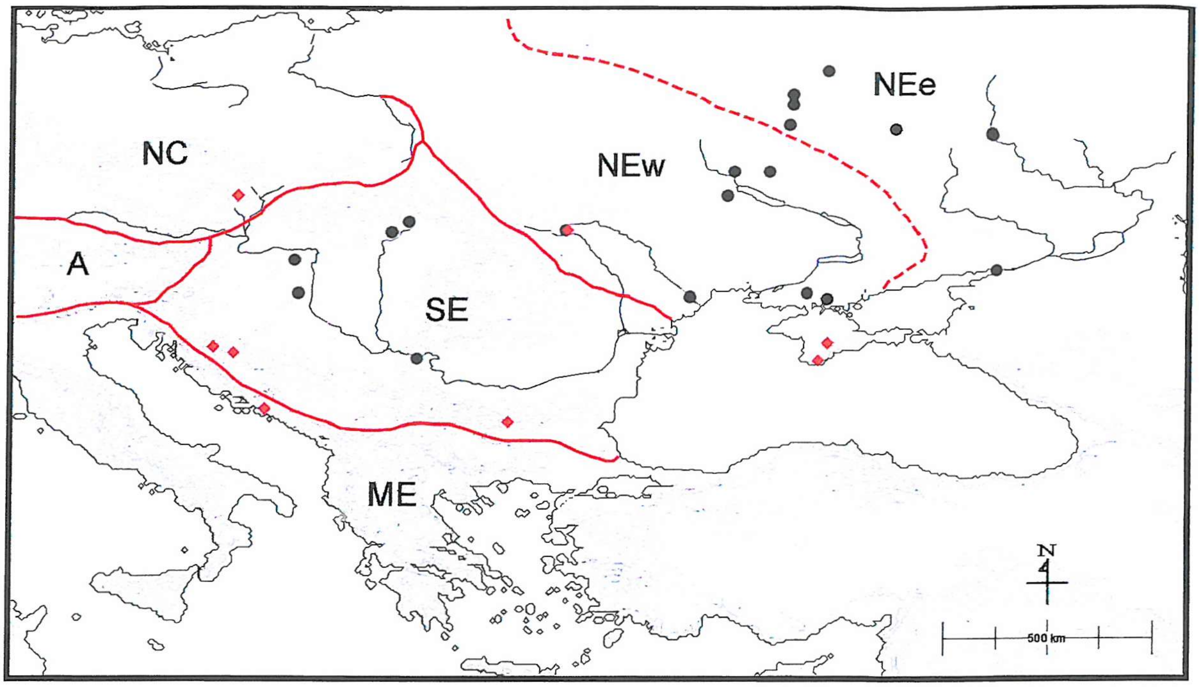


Figure 4.21: East Epigravettian site locations in relation to regional model adapted from Gamble (1986, figure 3.1). Black = open-air Red = rockshelter

Magdalenian

The first occurrence of the Magdalenian takes place in the Oldest Dryas at Maszycka Cave, in Poland, but it is not until the Bölling / Alleröd interstadials that a rapid and sustained increase in the number of Magdalenian sites takes place - primarily in the North Central region and in Austria (Figure 4.22, Figure 4.23). Again, when viewed with the evidence presented in Chapter Three (p. 88), there appears to be coexistence between the occupants of open-air sites and rockshelters, Epigravettian / East Epigravettian and Magdalenian technocomplexes.

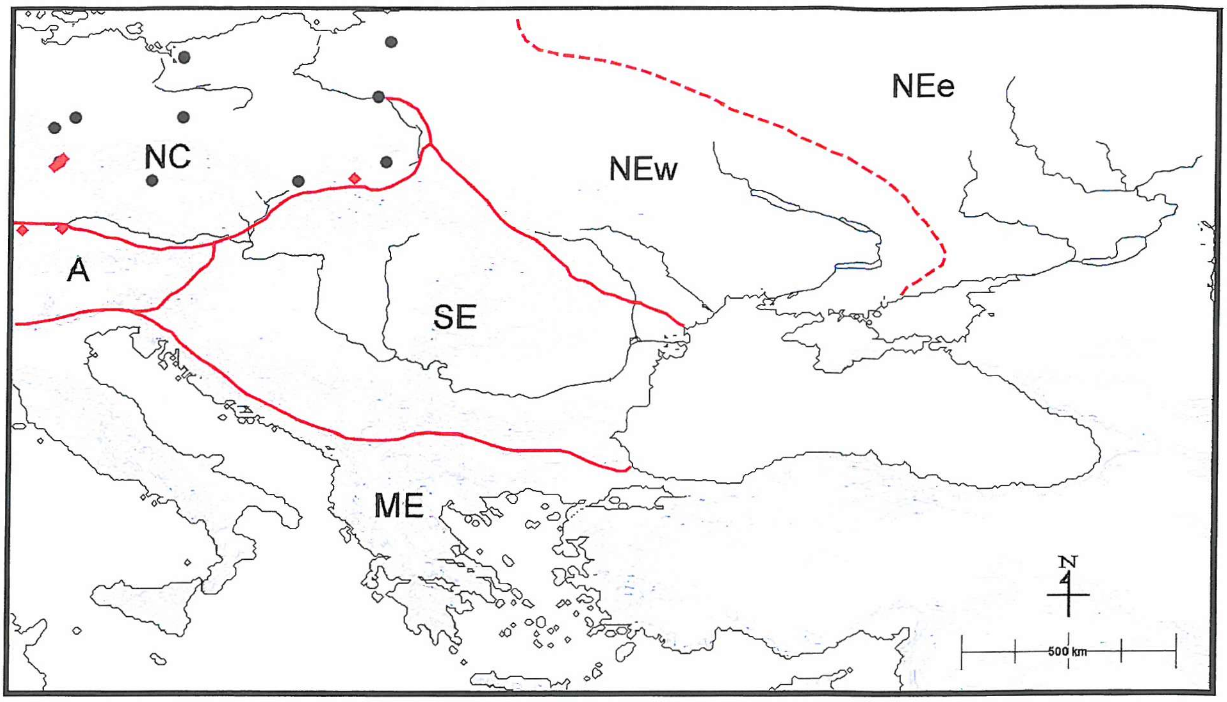


Figure 4.22: Magdalenian site locations in relation to regional model adapted from Gamble (1986, figure 3.1). Black = open-air Red = rockshelter

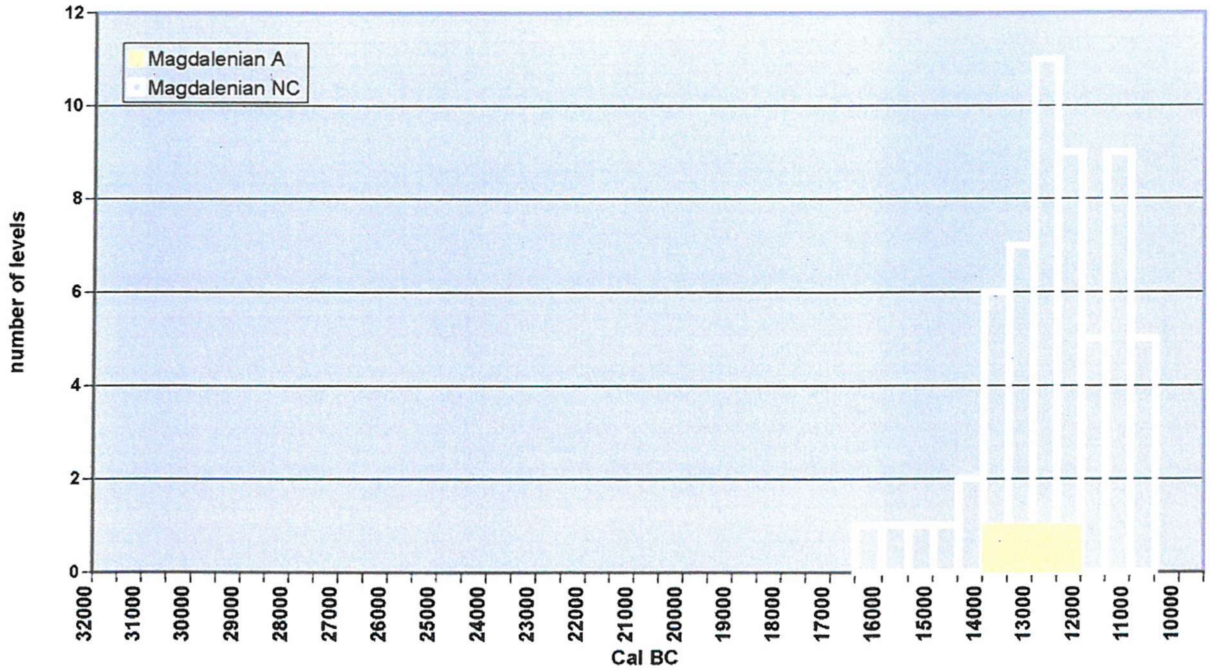


Figure 4.23: Moving sum distribution of Magdalenian archaeological levels by region.

Summary

Again, most regions of Central and Eastern Europe were occupied prior to the Last Glacial Maximum. The onset of the Cold Maximum marks the first point at which a shift in population movement is noticeable. While Gravettian and East Gravettian populations continue to settle most of the study area, the Gravettian disappears from the North Central region at the height of the LGM. At this time population increases take place in the in the Mediterranean, while the North East region the number of sites remains stable.

Immediately following the Cold Maximum, there is a rapid increase in the intensity of occupation in the North East Eastern and South East regions, and Gravettian sites reappear in the North Central region.

The onset of the Oldest Dryas initiates a major shift in late Upper Palaeolithic settlement. At the height of this cold phase, about 16500-16000 cal BC, northern regions are seemingly abandoned with the exception of a single Magdalenian site, (Maszycka Cave, Poland) in the North Central region, a single East Gravettian site (Esztergom-Gyurgyalag, Hungary) in the South East region and a few sites in the North East western region. There is however, a significant increase in the intensity of occupation in the Mediterranean region by Epigravettian populations.

As the climate began to warm, another short period of adjustment took place between 16000 cal BC and 15000 cal BC. There is a brief hiatus in the Mediterranean that coincided with a rapid increase in the number of sites in whole of the North East. From about 15000 cal BC to 14000 cal BC the Mediterranean was again intensely populated with sites. A rapid, sustained increase in the settlement of the North Central region occurred, that saw important changes in regional behaviours.

4.4 REGIONAL SETTLEMENT

In this section the radiocarbon data are examined more directly by exploring intra-regional settlement patterns. An examination of these data provides an indication of the timing of abandonment and/or continuity of settlement within each region. The moving sum of each of the six technocomplexes is analysed, and larger-scale settlement patterns are proposed.

4.4.1 North Central Region

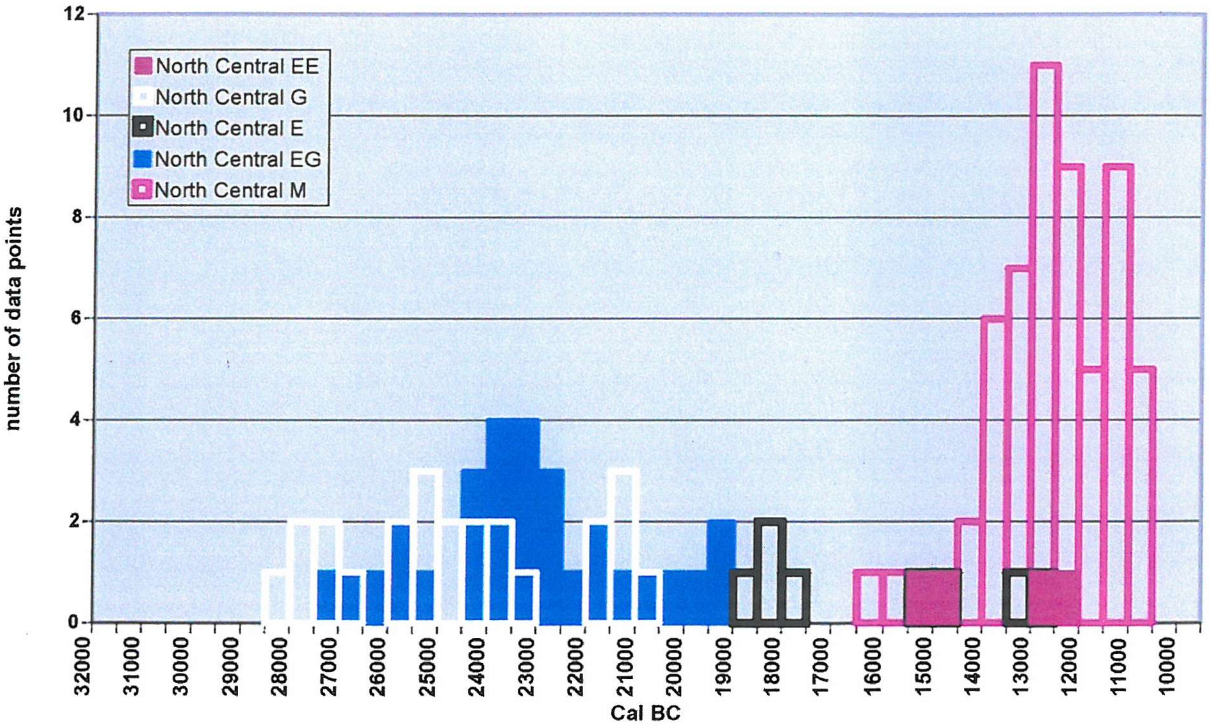
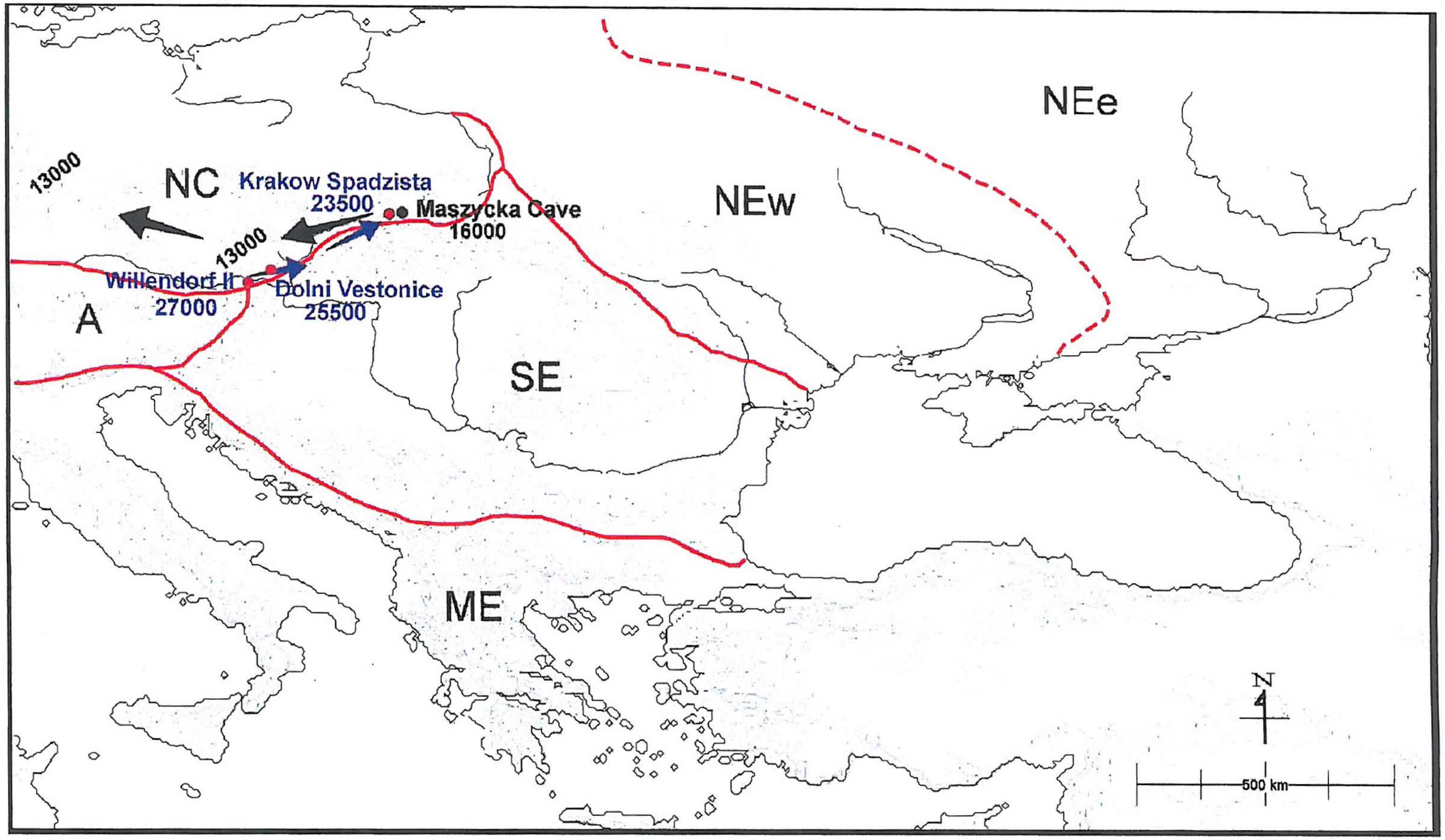


Figure 4.24: Moving sum distribution of dated archaeological levels for the North Central Region (after Gamble 1986, figure 3.1) by technocomplex. A=Aurignacian G=Gravettian EG=East Gravettian E=Epigravettian EE=East Epigravettian M=Magdalenian

Figure 4.25: Settlement in the North Central Region. Black = settlement following the Oldest Dryas; also representing possible rockshelter settlement processes.
Blue = settlement leading into the LGM; also representing possible open-air settlement processes.



In the North Central region prior to the LGM, there are three prominent peaks in the data at 27000 cal BC, 25500 cal BC and 23500 cal BC representing Gravettian and East Gravettian technocomplexes (Figure 4.24). The earliest date, obtained from Aggsbach in Austria is 28250 cal BC. The first peak in the data at about 27000 cal BC is attributed mainly to the nearby sites of Pavlov and Willendorf II. By 25500 cal BC the data show settlement at the sites of Dolní Věstonice and Predmosti in the Czech Republic, as well as continued occupation at Willendorf II in Austria. The maximum number of sites during the LGM occurs at about 23500 cal BC, when two sites, Nitra-Čermáň, Slovakia, and Kraków Spadzista, Poland, are occupied. Aggsbach, Willendorf II and Dolní Věstonice are also occupied at this time (Figure 4.25). All of the occupied sites in the North Central region during the LGM are open-air sites.

There is a decrease in the number of sites in the region leading into the Oldest Dryas when only a single site, Maszycka Cave, Poland, is represented. Following this, a rapid and intense recolonisation of the region took place by Magdalenian populations occupying primarily rockshelters. The number of dated archaeological levels peaks at about 13000 cal BC in the Czech Republic and at numerous sites in Germany.

This corresponds well to the conclusion that open-air sites reflect the three-phase hypothesis and rockshelters reflected the two-phase model since open-air sites dominate the Gravettian / East Gravettian technocomplexes while rockshelters dominate the Magdalenian technocomplex. Figure 4.25 is illustrative of the potential movement of both within the regional boundaries.

4.4.2 North East Western Region

The North East Western region is not so straightforward. Rather than a clear view of population movement into and through the region, the data corresponds more appropriately to the peaks and troughs of the GISP2 ice core (Figure 4.26). Moreover, all the peaks in the data correspond to troughs in the GISP2 measurements, where troughs in the data correlate with periods of more amenable climate. This is the only region where the data is climatically responsive. This lends credence to the concept of refugia put forth by Jochim (1987) and others (Soffer

1987; Housley et al. 1997). Housley et al. (1997, 50) in fact identified potential refugium north of the Black Sea in the Ukraine and the Russian Plain.

The sites of the Moldavian culture complex (Soffer 1987) show continuity of occupation throughout the study period, particularly during the coldest stages. Moldova V shows continuous Eastern Gravettian settlement from about 26000 cal BC to the onset of the Cold Maximum (c. 22000 cal BC). Post LGM climate warming sees sites occupied on the Desna and Dnieper Rivers (e.g. Kirillovskaya, Anetovka). Cosaoutsi, Ukraine appears to be continuously occupied immediately following the Cold Maximum until the onset of the Oldest Dryas. During the LGM and the Oldest Dryas, the sites of Sagaidak and Eliseevitichii are occupied respectively in the southeast. During the Bölling / Alleröd interstadials, the region again sees settlement along the Dnieper (e.g. Gonsty). There appears to be no correlation between climate change and occupation of the Moldova region. However, settlement in the southeast by the Eliseevitichian complex occurs briefly during the LGM and is identified at the site of Sagaidak. The data suggests that this settlement is abandoned and is only reoccupied here at the Oldest Dryas.

This analysis would suggest that initial settlement in the North East Western region began (within the research temporal and spatial boundaries) in the Moldavian locale. During the LGM, exploration of warmer frontiers took place briefly. Following this expansion into northern regions along the Dienper drainage system took place. The Oldest Dryas triggered a second movement to the southeast and continued exploitation of this region. Figure 4.27 shows the locations of the culture complexes and sites discussed in this section.

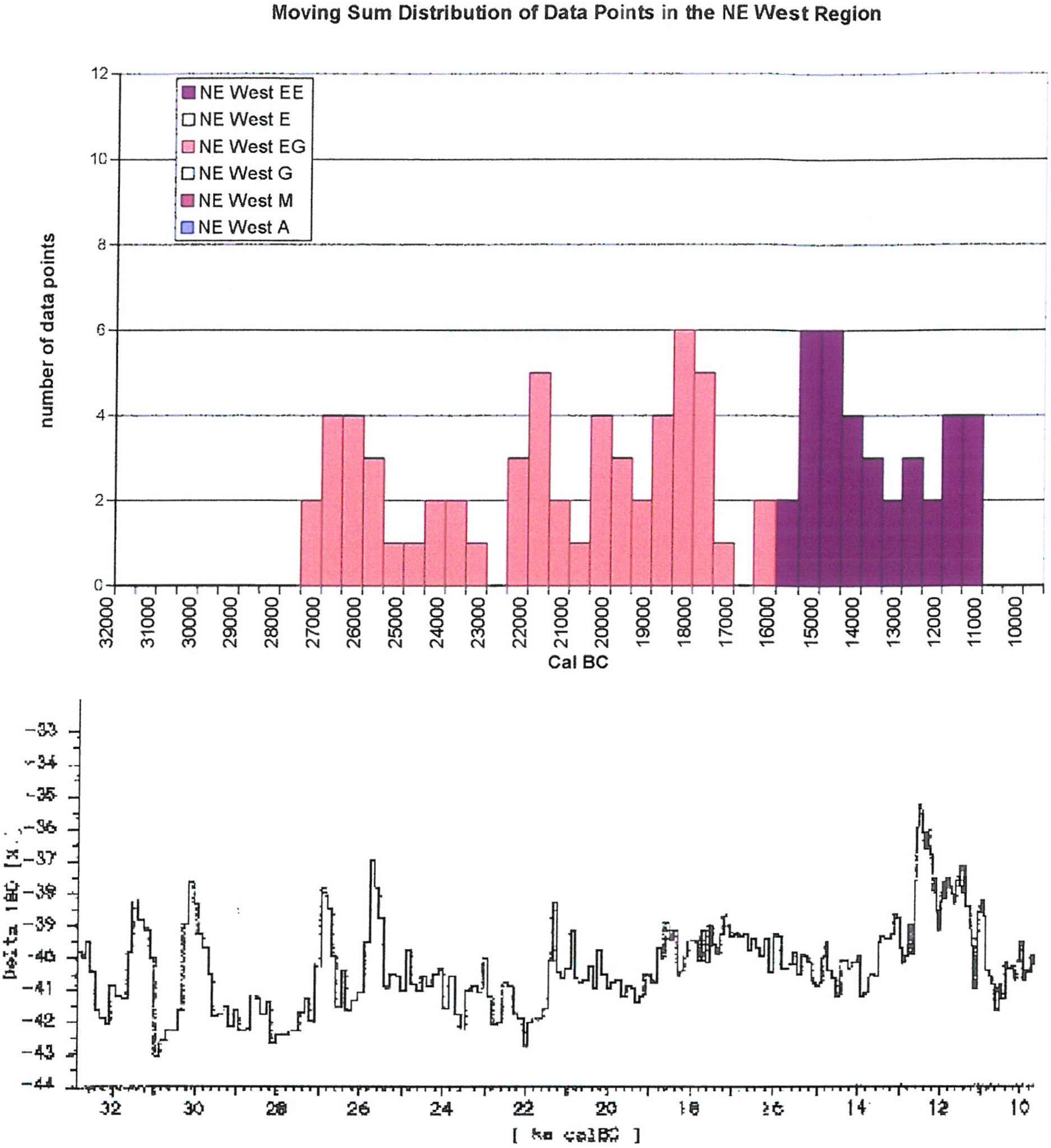
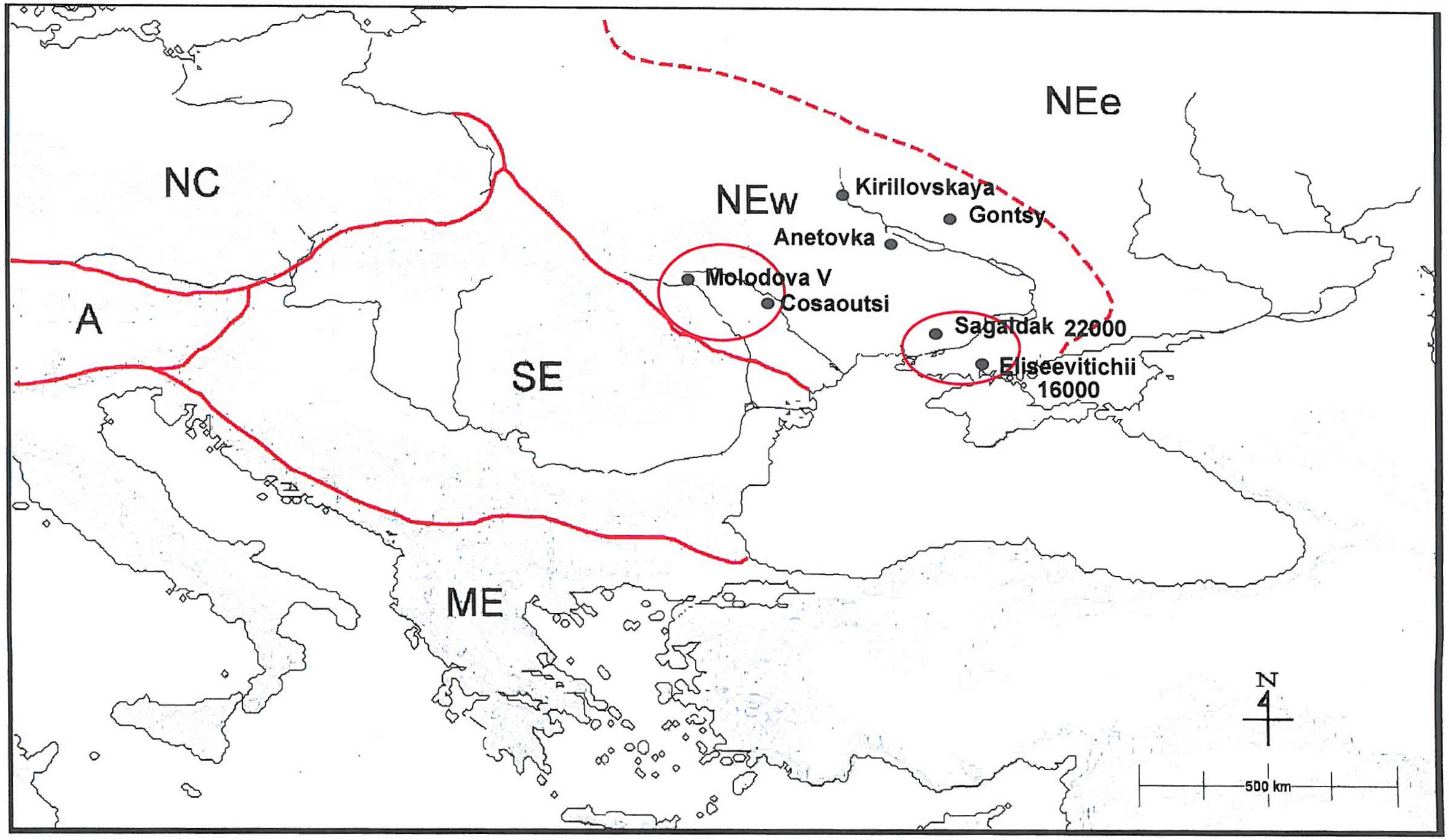


Figure 4.26: Moving sum distribution of dated archaeological levels in the North East Western region (adapted after Gamble 1986, figure 3.1), by technocomplex, as it corresponds to the GISP2 ice core measurements (Vöris and Weninger, 1999). A=Aurignacian G=Gravettian EG=East Gravettian E=Epigravettian EE=East Epigravettian M=Magdalenian

Figure 4.27: Settlement in the North East west Region. Red outlines the two main groupings of sites.



4.4.3 North East Eastern Region

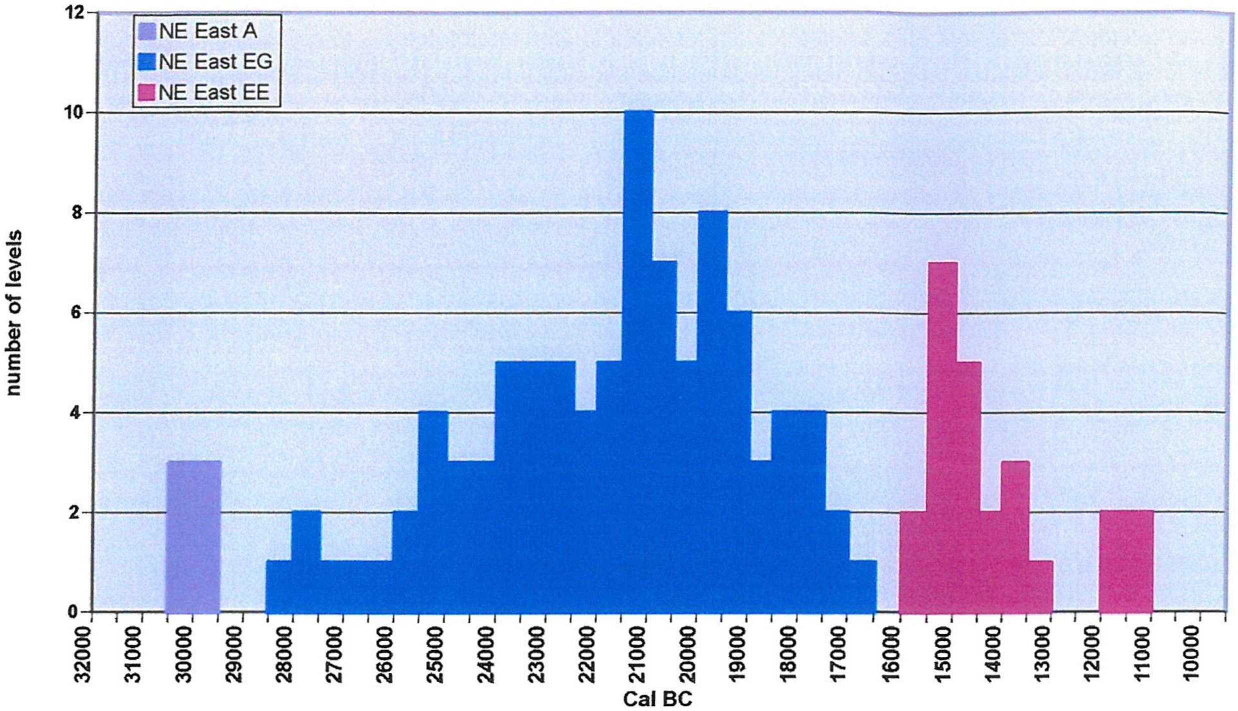


Figure 4.28: Moving sum distribution of dated archaeological levels for the North East Eastern Region (adapted after Gamble 1986, figure 3.1) by technocomplex. A=Aurignacian EG=East Gravettian EE=East Epigravettian

The data in the North East Eastern region supports the two suggested models for colonisation. While there is a brief hiatus between the Eastern Gravettian and Eastern Epigravettian populations at the Oldest Dryas, the number of dated archaeological levels in the region during the LGM sustained increased levels (Figure 4.28).

The data for the Kostenki culture complex (Sinitsyn and Praslov 1997) shows its prominence in this region from 28000 cal BC through the LGM. It represents the first two peaks in the moving sum data (Figure 4.28). Because the number of dated archaeological levels for the Kostenki sites is high compared to the rest of the regional data, it is important to note that the moving sum distribution is biased. The data in Figure 4.28 visually suggests increased spatial settlement where, it is more appropriate to suggest that there was increased settlement in a single locale (Figure 4.29).

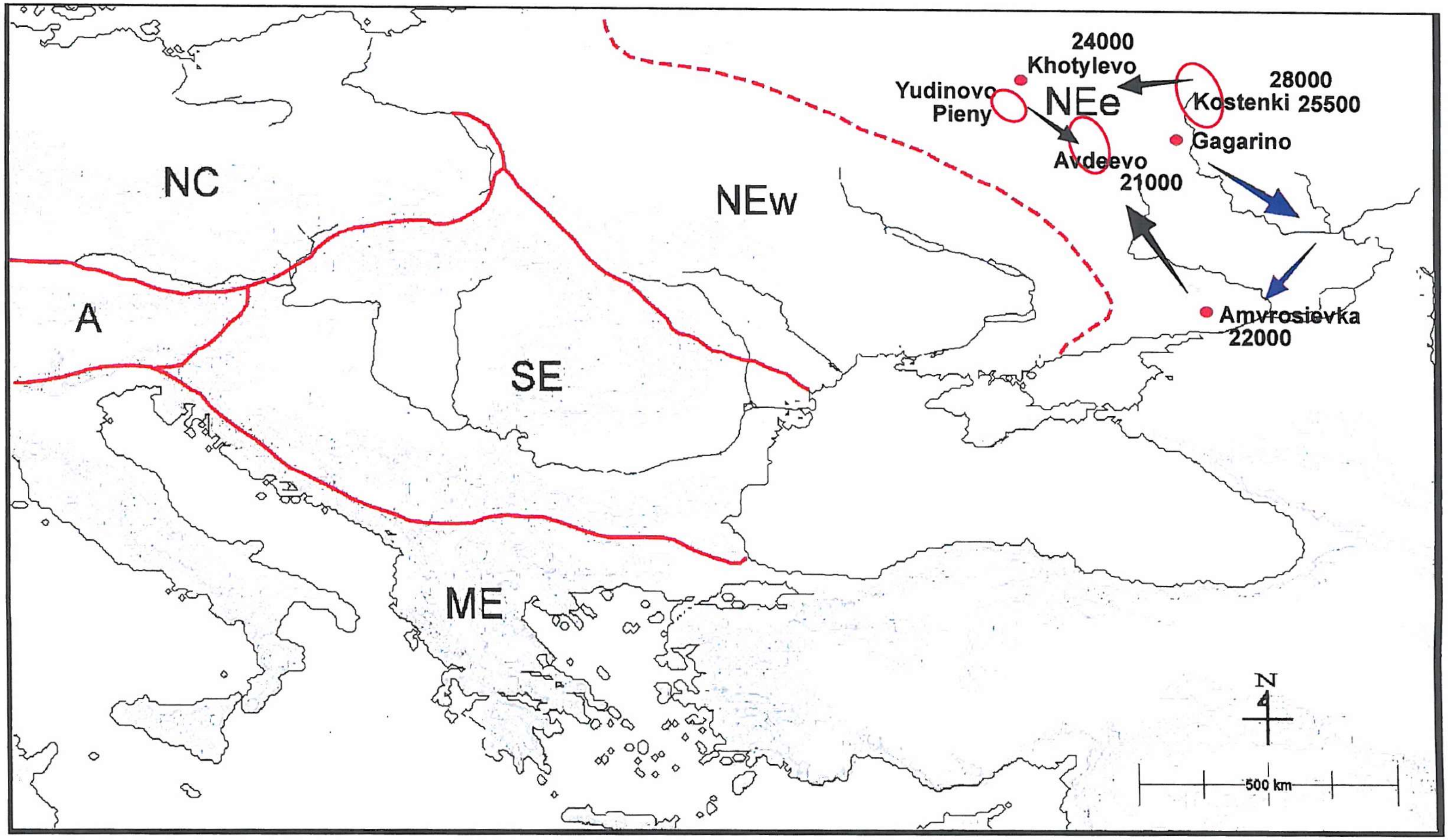
Spatial dispersal is visible about 24000 cal BC when the Khotylevo-Yudinovo-Pieny group is first occupied. At the height of the LGM, only the Kostenki group is represented, with the exception of the initial occupation of Amvrosievka at the mouth of the Don River.

By 21000 cal BC the emergence of the Avdeevo culture complex takes place. The Khotylevo-Yudinovo-Pieny complex is re-established by 18000 cal BC. Amvrosievka is in use prior to the onset of the Oldest Dryas, when the data suggests that this area is abandoned in favour of northern latitudes.

Following the Oldest Dryas, population increase once again takes place within single locales, rather than spatially. This is evidenced by the concentration of data points located in the Kostenki-Borshchevo and Pieny-Yudinovo regions.

One potential interpretation of movement within the North East Eastern region is illustrated in Figure 4.29. The routes identified are suggested on ecological and climatic assumptions that suggest that people would move south in response to climate deterioration, and that they move within the same ecosystem they are used to exploiting.

Figure 4.29: North East Eastern Region identifying the major culture groupings and potential settlement patterns.



4.4.4 Alpine Region

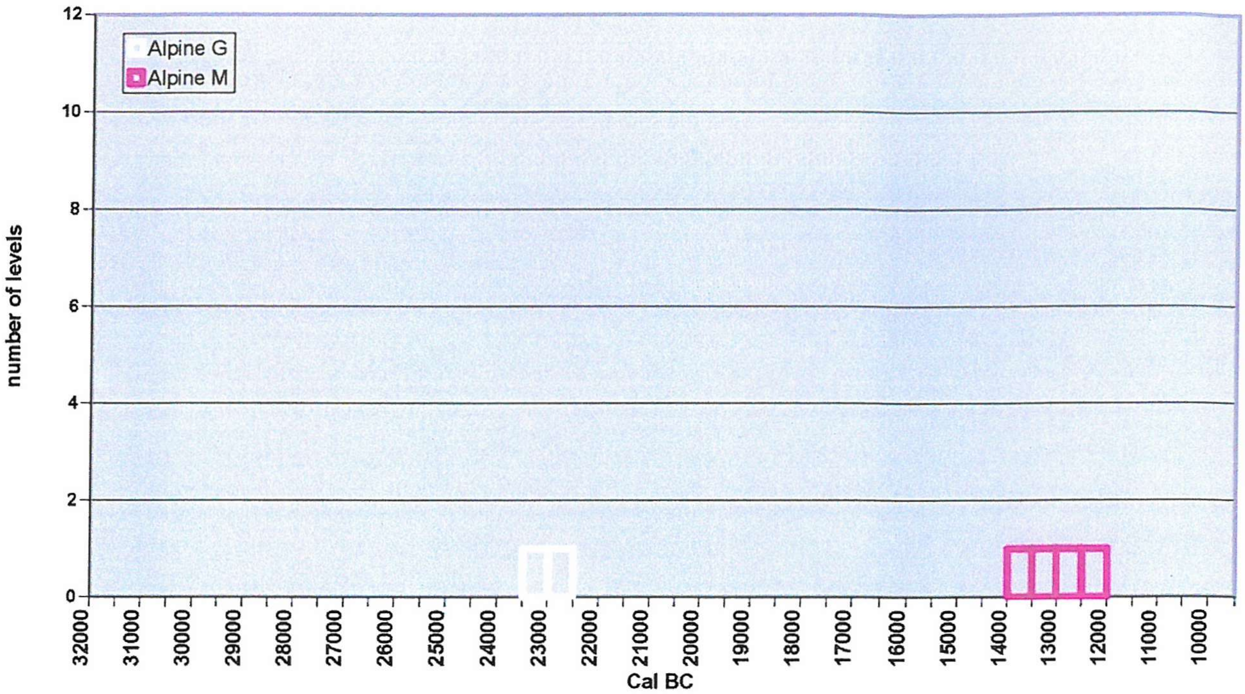


Figure 4.30: Moving sum distribution of dated archaeological levels for the Alpine Region (adapted after Gamble 1986, figure 3.1) by technocomplex. G=Gravettian M=Magdalenian

There is a definite lack of archaeological visibility in the Alpine Region (Figure 4.30). This is attributed to either a lack of research in the region, or more likely, to the presence of glacial ice in the Alps Mountains throughout the Late Glacial Maximum. As a result, this region cannot be properly assessed, except to point out that the available data suggests that the region was occupied prior to the Cold Maximum, and then abandoned until the end of the Oldest Dryas – which correlates well with the most inhospitable climate conditions of the late Upper Palaeolithic (see Chapter Three, figure 3.6).

4.4.5 South East Region

The earliest East Gravettian data in the South East region comes from the site of Mitoc-Malul Galben in Romania. Level six is dated at 27925 cal BC. Level five is dated at 25985 cal BC. This marks the beginning of an increase in the number of East Gravettian sites in the region.

By 25000 cal BC there is a new occupation at Trencianské-Bohuslavice, Slovakia. The most significant observation about this region is that at the height of the LGM, there is new occupation at the open-air sites of Balatonszabadi and Tojak, Hungary (Carpathian Basin), and Temnata Cave, Bulgaria. Between the LGM and the Oldest Dryas, intensity of occupation of the Carpathian Basin region increased to include Jaszfelsoszent Gyorgy, Sávgár, Mogyorósbánya and Madaras in Hungary; Garla Mare, Mitoc-Malul Galben and Stanistea in Romania; Grubgraben, Austria and Pecine u Brini, Croatia. The Oldest Dryas is marked in the data by two sites in Hungary: Pilismarót-Palrét and Esztergom-Gyurgyalag. The post – Oldest Dryas coincides with an increase in the number of Epigravettian and East Epigravettian sites throughout the region.

The rapid increase of a large number of occurrences of dated archaeological levels immediately following the Cold Maximum of the LGM, and the Oldest Dryas (Figure 4.31), in conjunction with kriging interpolation (Chapter Four, figure 4.2) and moving sum distributions suggest that the Carpathian Basin may well have been a migration route for colonising populations and/or might even represent an area of refuge. Figure 4.32 identifies some major sites in the region and their timing of occupation. It illustrates potential settlement patterns in the region including two possible directions of dispersal.

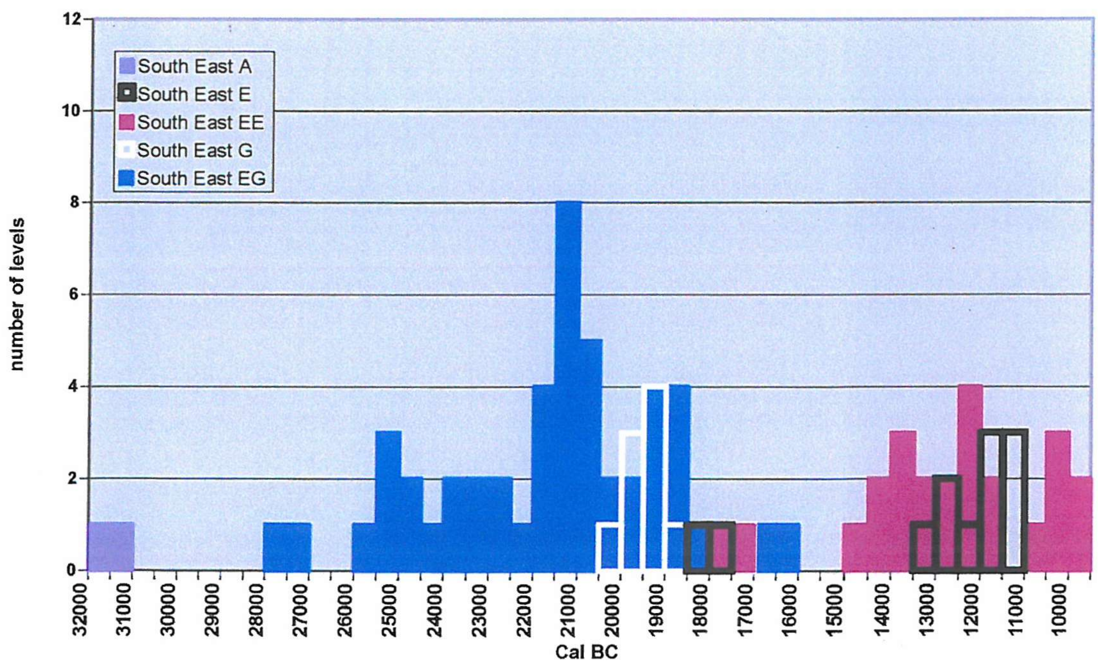
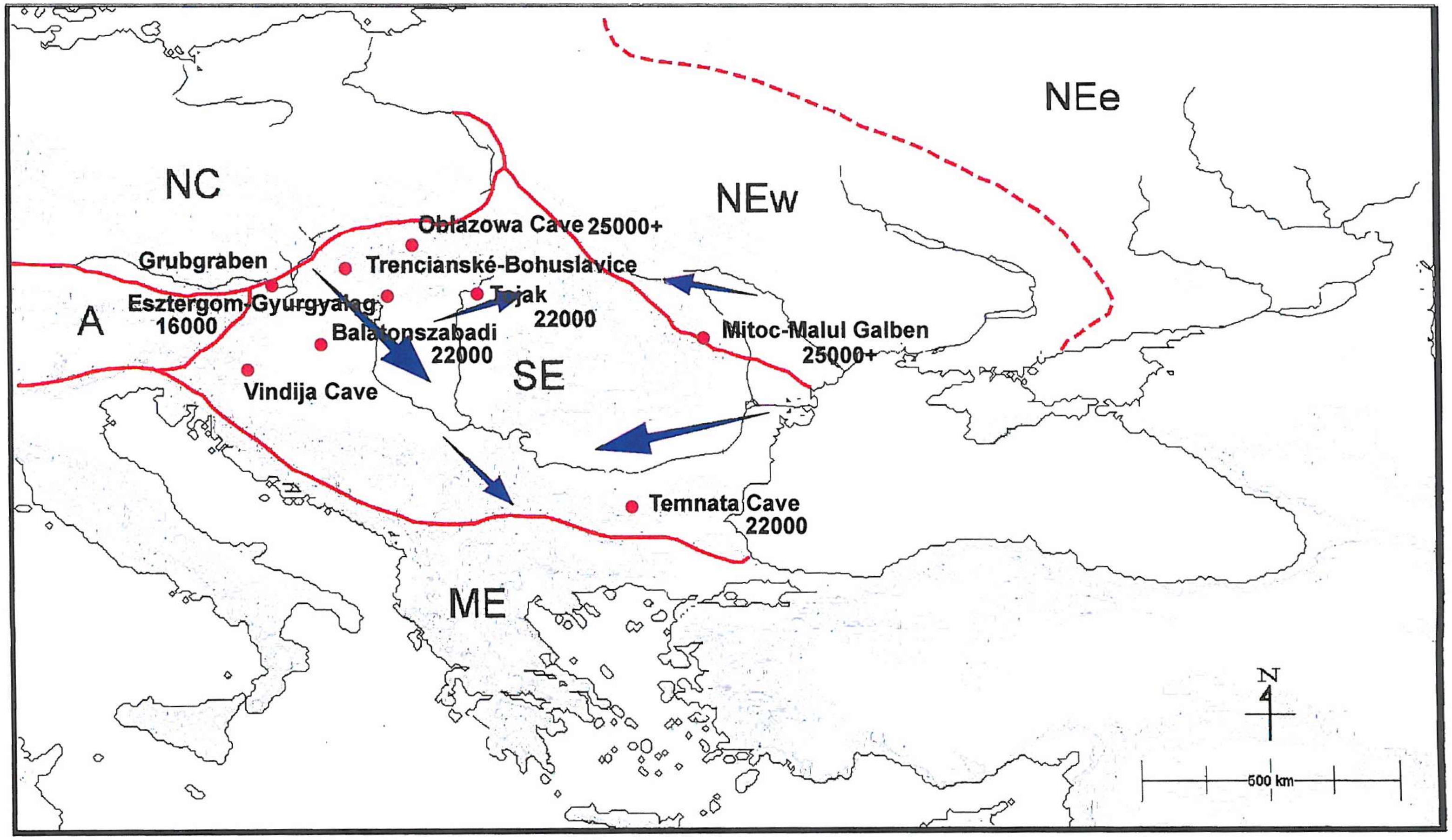


Figure 4.31: Moving sum distribution of archaeological levels in the South East Region (after Gamble 1986, figure 3.1) by technocomplex. A=Aurignacian G=Gravettian EG=East Gravettian E=Epigravettian EE=East Epigravettian M=Magdalenian

Figure 4.32: Settlement in the South East Region showing the location of important sites and potential migration routes through the Carpathian Basin.



4.4.6 Mediterranean Region

The Mediterranean region is dominated by rockshelters. Most of the data is obtained from Klithi Rockshelter, and from Boila, Kastritsa, Asprochaliko and Megalakkos in northwestern Greece, Most LGM data is obtained from Franchthi Cave in southern Greece. Data also comes from Šandalja II and Druška peć in Croatia, Ovča Jama, Savudrija and Županov Spodmol in Slovenia, and Abri Tagliente, Italy.

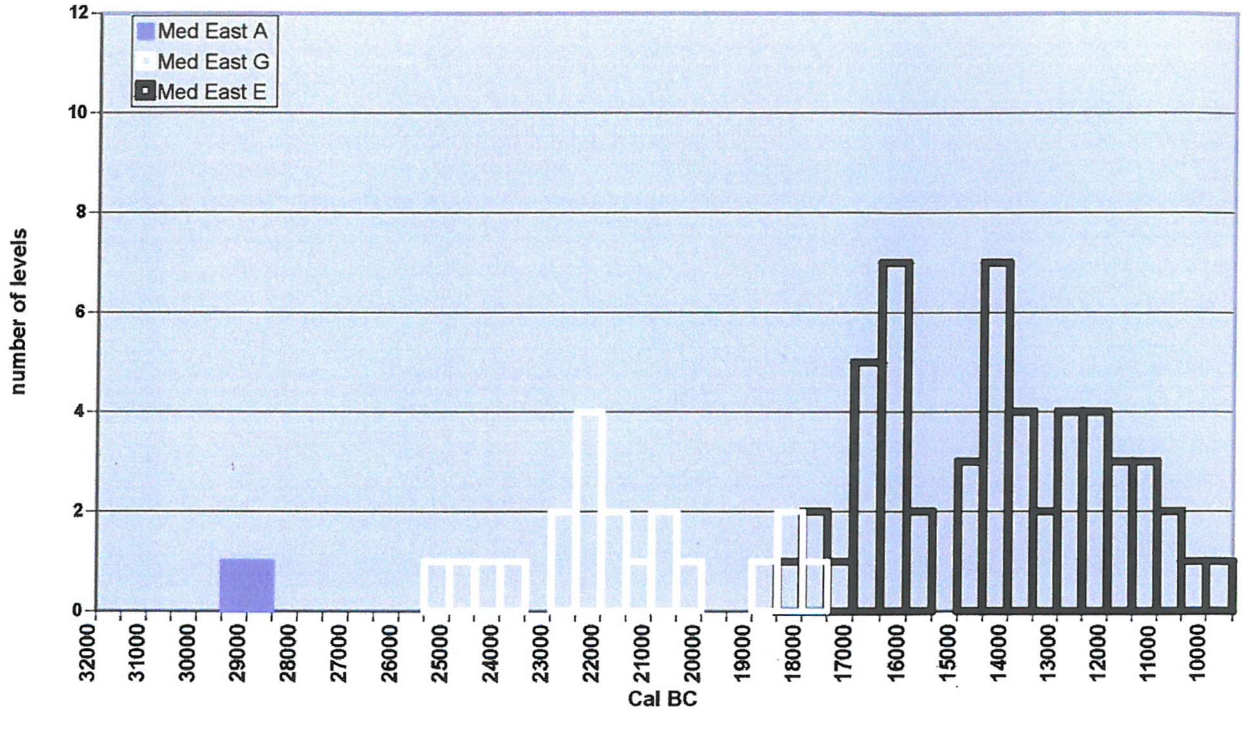
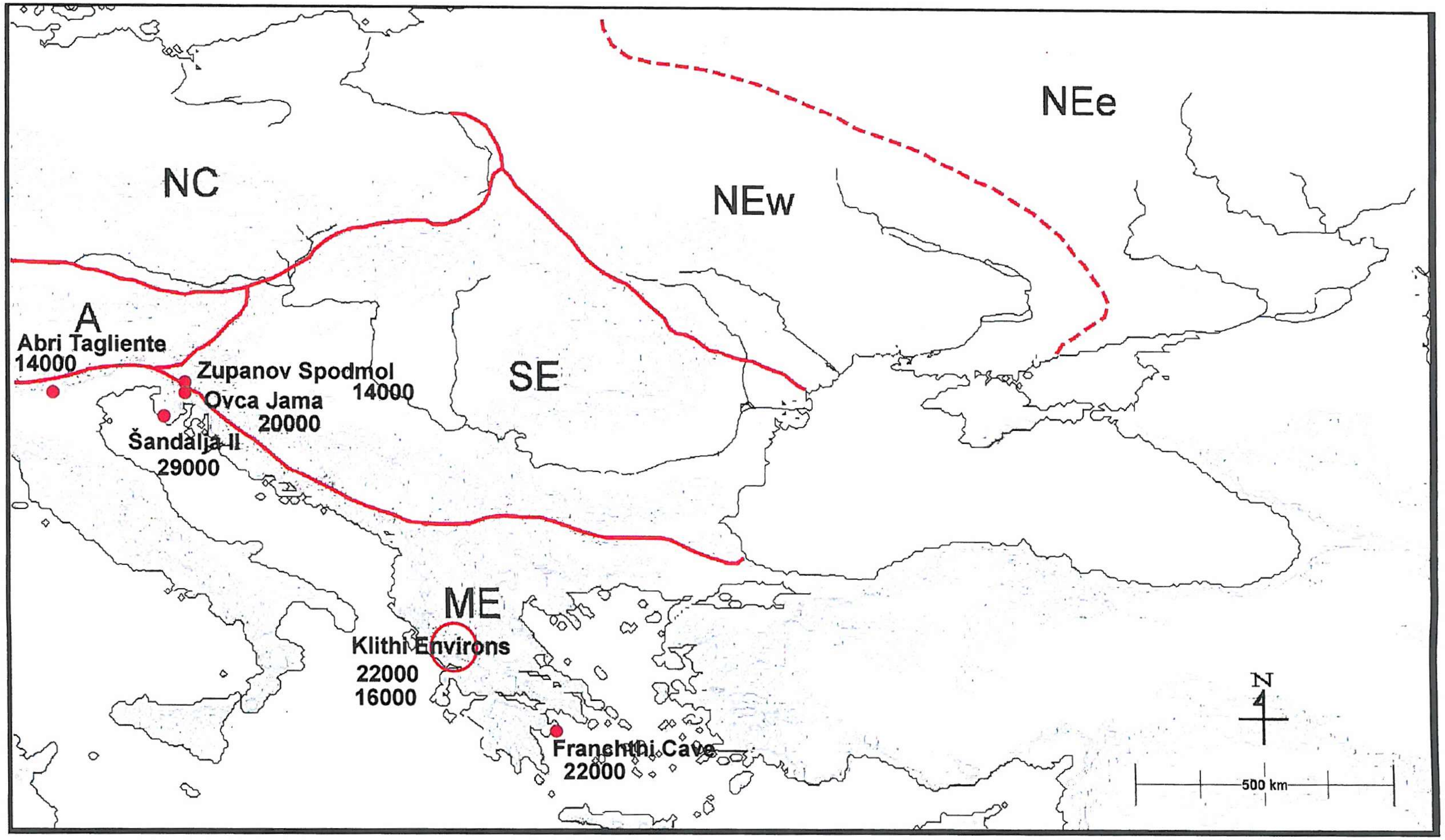


Figure 4.33: Moving sum distribution of dated archaeological levels for the Mediterranean Region (after Gamble 1986, figure 3.1) by technocomplex. A=Aurignacian G=Gravettian E=Epigravettian

Figure 4.34: Location of important sites in the Mediterranean Region.



The earliest Aurignacian data in the region is at Šandalja II. At the height of the LGM there is an increase in the number of dated archaeological levels in the Mediterranean, primarily attributed to data from Franchthi Cave and Klithi Rockshelter. Following the LGM there appears to be lack of settlement in the region most likely attributed to population movement out of marginal areas in response to climate ameliorations. Šandalja II is occupied once again by 19000 cal BC.

The beginning of the Oldest Dryas, around 17500 cal BC, is identified by data from Klithi and Megalakkos. No other sites appear to be occupied at this time. Following a brief hiatus in the data at about 15000 cal BC (Bölling interstadial), once again attributed to population movement back into northern latitudes in response to climate, there is increased intensity of occupation. Settlement in the south of the region is sustained while dated archaeological levels appear at Abri Tagliente, Italy and Županov Spodmol, Slovenia among others in the northern coastal zones.

4.5 SUMMARY

In their discussion about the archaeological significance of using the moving sum method as it was applied to southwest Tasmanian sites, Holdaway and Porch (1995, 77-78), offered plausible explanations to account for the cyclic trends visible in the data. One conclusion is that some sites may have been abandoned while others were used less frequently during periods of cold and dry climate. A second conclusion was that the patterns in the data might reflect changes in the choices about site types in response to climate conditions and/or social behaviour. Finally the authors' postulated the idea that populations may have moved away from inland regions to coastal margins during periods of cold and dry climate. The analyses in Chapters Three and Four certainly support similar speculations, and make it possible to begin to develop plausible explanations or interpretations about the settlement patterns of late Upper Palaeolithic hunter-gatherers in Central and Eastern Europe.

There are cautions however. The moving sum method used to analyse dated archaeological levels is prone to bias where multiple levels of a single site dominate in the database. Despite this however, the timing of settlement or abandonment of the chronological and spatial landscape is visible at the large scale, sufficient for this research. A second caution is that the kriging interpolation does not account for the timing of settlement or abandonment as it takes place on a flat surface. It does however, allow for visualisation of probable directions of population movement through that space. The results of the analyses have shown that it is possible to use radiocarbon data to begin to understand large-scale settlement patterns and population dispersals.

In Chapter Five, spatial modelling techniques and GIS are used to develop a predictive model for determining the colonisation / recolonisation of Central and Eastern Europe. The output can be compared and evaluated against the chronological and spatial analyses presented so far in this thesis.

Chapter Six will evaluate the predictive colonisation model and synthesise the results of this research to produce a large-scale colonisation model that meets the goals and objectives as they are outlined in Chapter One.

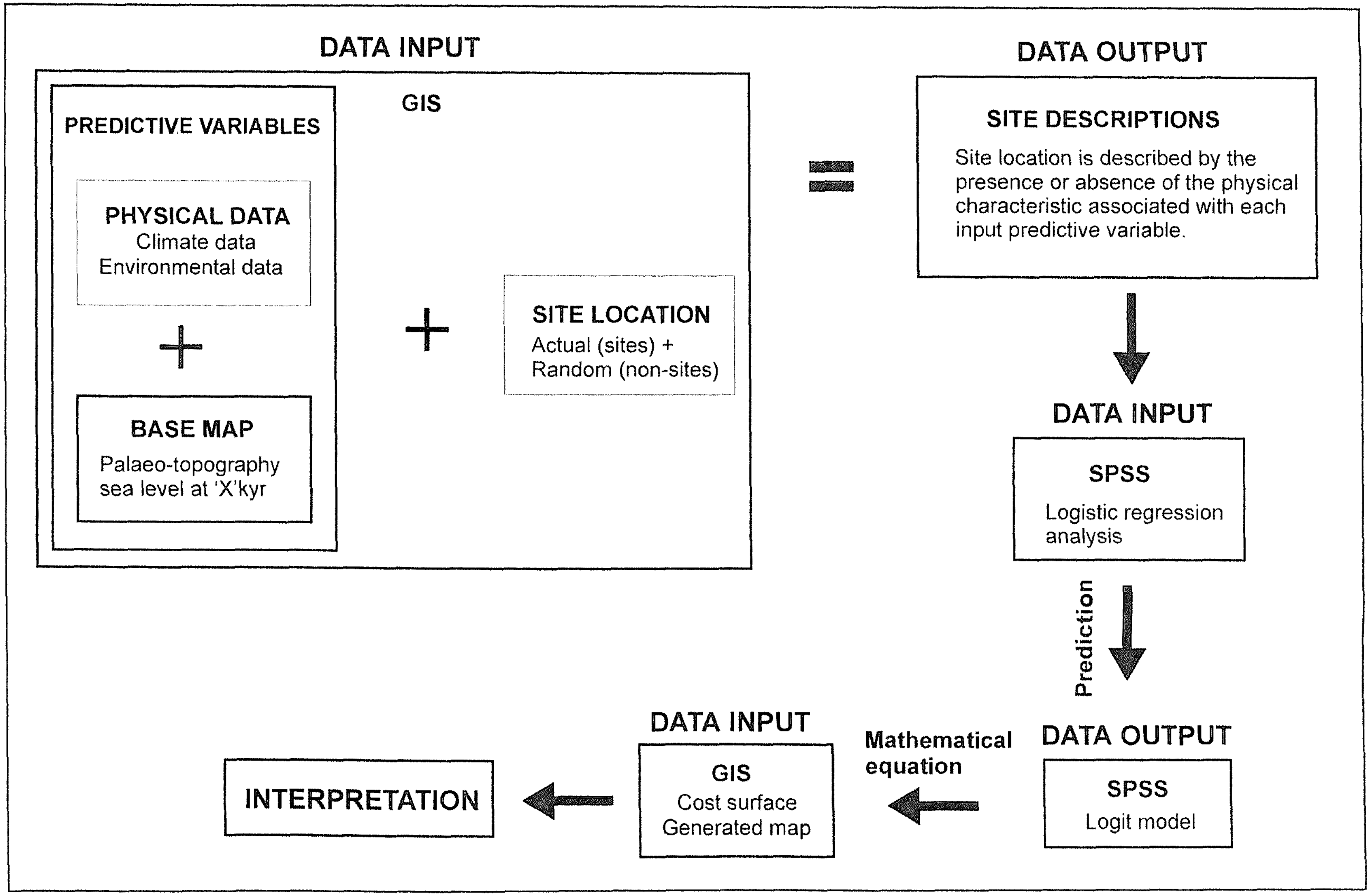
CHAPTER FIVE

PREDICTING PAST PROCESSES OF COLONISATION

"Archaeological data is spatial and temporal in nature, and therefore especially suited to the basic principles driving the development and use of GIS" (Westcott and Kuiper 2000, 1). Archaeologists have adopted geographic information systems (GIS) as a tool for conducting complex analyses of spatial and temporal data, and for the visualisation of chronological and spatial patterns in the archaeological record. One significant benefit of GIS is its application toward building predictive models and/or simulation models. The development of predictive models to assess archaeological visibility and potential site location, in particular, has become increasingly popular (Fedje and Christensen 1999). Recent applications to colonisation research have illuminated the prospective advantages of using GIS to extract information about spatial and temporal characteristics, which may otherwise remain speculative (Young and Bettinger 1995; Steele et al. 1998). GIS offers a systematic means of controlling large amounts of spatial data. It also provides the user with versatile data input, storage and management, and output applications. Data is registered by the system as an infinite number of spatial surfaces (map layers), which can be added to, or subtracted from, queried and analysed. Virtually any form of data can become quantifiable, allowing the user to achieve results that may otherwise not be available. Hypotheses about human movement through both space and time can be challenged more robustly since GIS allows the researcher to query the unknown in a systematic way.

In this chapter a geographic information system is used to produce a predictive model for determining the spatial-temporal processes of colonisation in Central Europe during the late Upper Palaeolithic. The purpose of this project is to compare the results obtained in Chapters Three and Four, and to test predictive modelling as a strategy in colonisation research. It is expected that the outcome of this work will have significant implications for the future of Palaeolithic archaeology and colonisation research.

Figure 5.1: Schematic representation of methodological phases.



The goal of this chapter is to develop a simple predictive model for determining the colonisation processes of late Upper Palaeolithic hunter-gatherers. The procedure for building the model can be subdivided into four main sections. The first part involves reconstructing palaeo-topography. These reconstructions are used as base maps over which the predictive analysis will be conducted. The second step is to input potential climate and environmental data, which represent the physical elements that may have influenced the types of palaeo-habitats occupied by the colonisers. When combined with geographic and topological data derived from the base maps, these output form the physical data on which the predictive model is based. The locations of the radiocarbon data points, input as site locations, are described on the basis of which physical characteristics are present at each site location. The third part of the method involves the analysis of these site location characteristics using logistic regression and the statistical package SPSS (SPSS Inc., 1989-1999). Logistic regression produces the predictive output in the form of cost surface data that can then be input back into the GIS using a mathematical equation. Output raster maps are produced which must then be interpreted. A schematic representation of the methodological phases of development is presented in Figure 5.1.

This process is conducted for each 1000-year interval for the chronological time frame of the study. The output at each interval is assessed for the probability of archaeological site location and evaluated against existing knowledge. Finally, the results of these analyses are used to interpret predicted colonisation processes, spatially and temporally throughout the late Upper Palaeolithic. All aspects of these analyses are carried out using the raster-based Geographic Information System (GIS) GRASS 4.3. This versatile GIS package can be freely obtained via public domain at URL: http://www.geog.uni-hannover.de/grass/ (GRASS Development Team, 1997-2000). Statistical analysis is provided through the SPSS statistical system. Documentation is available via URL: http://www.spss.com. A glossary of the GIS modules used in the modelling process is provided in Appendix E.

5.1 BASE MAPS

The first step in developing the predictive colonisation model is to produce base maps. Maps of late glacial palaeo-topography and palaeo-shorelines are reconstructed for each 1000-year interval of the period of study. This chronological interval has been selected for two reasons. First, it provides the least opportunity for error since this interval matches that of the palaeo-topographic data set on which these reconstructions depend (provided by Peltier 1993 and described in section 5.1.1 of this chapter). Second, the selected interval is at a large enough scale to accommodate the large temporal and spatial scale of the research. Because the number of site locations in the radiocarbon dataset is limited (to the degree that fine resolution analysis would yield questionable results) this allows for a large enough site location dataset to be explored for temporal and spatial patterns. In this section, the data and methods used to produce these base map reconstructions are discussed. The output is used in the process to determine and/or interpret archaeological visibility, site prediction, population movement (rates and directions of dispersal) and potential refugia.

Lambeck (1996) supports the idea that reconstructions of the contemporaneous geography should be integral to discussion of early coastal colonisation in his paper *Sea-level change and shore-line evolution in Aegean Greece since Upper Paleolithic time*. He suggests that his presentation of the reconstruction of the palaeo-coastlines is consistent with the archaeological record for the Palaeolithic and Neolithic contexts of Aegean Greece. In my research the reconstruction of palaeo-topography and palaeo-shorelines is attempted for similar purposes. Each base map functions as both input data into the modelling procedure, and as a contemporary landscape over which the model colonisation processes are explored. Ross and Steele (1998) who reconstructed the palaeo-topography and palaeo-shorelines of North America in an effort to build on research strategies for the resolution of colonisation issues on that continent, agree that palaeo-environmental variables, radiocarbon data and known geographic locations of archaeological sites must be brought into the modelling equation. This is attempted in the work presented in this chapter.

The output enables the interpretation of the predictive model to be calculated according to contemporary land surfaces that today are below sea level, allowing for changing sea levels and conditions associated with such changes (e.g. climate) to be incorporated into the predictive modelling process. The results should theoretically be less exposed to the biases that would be inherent in a model based on a singular modern landscape. The value of these reconstructions is shown to be significant in large-scale spatial-temporal analyses.

5.1.1 Data

The data used to produce the palaeo base maps have been obtained from a variety of sources. They have been selected for use on the basis of availability and quality; the latter is accepted primarily on this author's interpretation of the associated literature and with respect to the usefulness of the data for this research.

The GTOPO30 dataset is made available by the United States Geological Survey (USGS 1996) and can be obtained via their Distributed Active Archive Center (DAAC). GTOPO30 represents modern digital elevation data at a resolution of 30 arc seconds, or 1km. This fine resolution elevation data is currently the most reliable dataset available for use in large-scale spatial analysis. Documentation for GTOPO30 is readily available on the Internet at URL: http://edcwww.cr.usgs.gov/landdaac/.

Since GTOPO30 does not include bathymetry, the widely accepted TerrainBase Global 5-Minute Ocean Depth and Land Elevation digital dataset (Row and Hastings 1994) is used. The data for TerrainBase have been compiled from ongoing new and improved topographic and bathymetric data sets from varied sources around the world, ranging from 30-second to 10-minute grid intervals (Row and Hastings 1994). Until GTOPO30 was produced, this was considered the most complete quality set of global data. Much of the land elevation data from this Digital Elevation Model (DEM) has been incorporated by the USGS in GTOPO30 (USGS 1996). The resolution of this data is 5-arc minutes, or approximately 10km. The dataset can be obtained on the Internet via URL: http://dss.ucar.edu/datasets/ds759.2. Documentation is also available.

The foundation for developing the palaeo base map reconstructions is dependant on the palaeo-topographic and ice sheet data obtained from Peltier's ICE-4G model (Peltier 1993, URL: ftp://ftp.ngdc.noaa.gov/paleo/ice_topo/) and described in *Time Dependent Topography Through the Glacial Cycle*, (Peltier 1993). The dataset contains 22 separate sets of gridded global elevation and bathymetry data, and of presence/absence data for ice sheets, at coarse 1-degree resolution, and at 1000-year intervals from present to 21000 years ago.

The Peltier dataset is the culmination of a series of deglaciation models produced on the basis of global eustatic and isostatic processes. These processes and their quantitative effect on palaeo-topography have been modelled mathematically and tested against empirical curves of relative sea level change since the LGM at a number of locations worldwide (Peltier 1993, 1996a, 1996b). Such changes in the levels of land and sea are a reflection of the interplay between eustatic (global) changes in sea level and the vertical displacement of land (isostatics) (Lowe and Walker 1997, 54-55). These changes can be complex (influenced by activity such as tectonic uplift), as the "state of balance" in the Earth's crust is dependent on the processes of glacial movement. Sea level changes, as a result of glacio-eustatic and glacio-isostatic changes interacting, lead to a change in the position of sea level, relative to the land, affecting shoreline sequences. This means that modern coastal topography, for example, may be quite different than the same coastline in the Quaternary (Lowe and Walker 1997, 62).

With the introduction of the extended radiocarbon calibration curve, Tushingham and Peltier (1993) re-examined eustatic relative sea level data. The ICE-4G deglaciation model is the result of this work, and the source of the palaeo-topography and ice sheet data used in this research. The model includes variations in glacial ice thickness derived by "inverting glacial rsl [relative sea level] histories..." (Peltier 1996a, 1359), and was tested for validity and stability (refer to Peltier, 1996a for a complete discussion). Peltier concluded that the ICE-4G model and the resulting palaeo-topographic maps are highly stable. The results suggest that on a larger global scale, a model for relative sea level change is also consistent. Large-scale models of palaeo-coastlines must also then be stable. Repeated efforts to test and refine global sea level curves have resulted in data that can be used to model palaeo-coastlines at the global scale, with confidence.

In this research, palaeo-topography and ice sheet data has been extracted from the Peltier dataset for intervals of 1000 years from 21000 – 11000 B.P. These data will act as a barrier to movement in the colonisation model.

5.1.2 Method

In this section, the method used to reconstruct the palaeo base maps has been adapted from Ross and Steele (1998) where modern digital datasets of elevation and bathymetry were used to reconstruct the sea levels and palaeo-shorelines of North America by modifying these data to take account of eustatic and isostatic processes. The method is illustrated using conditions at 18000 cal BC as an example.

Importing the data

Since the resolution of the input datasets varies, the data must be interpolated for smoothness of results with consideration to the spatial scale of the project. For this reason, the 10km resolution of TerrainBase Global 5-Minute Ocean Depth and Land Elevation digital dataset is deemed acceptable as it acts as a median between the finer GTOPO30 dataset and the coarser Peltier dataset. The nature of this research does not allow for finer intensity. The interaction between the large spatial and temporal scale of the project and the limited number of archaeological site locations indicates that a finer spatial resolution would not be conducive to the objectives of this research. The 10 km resolution is therefore regarded as sufficient for the purposes of this work.
GTOPO30 was imported into the GRASS GIS. Because there is no bathymetric data available in this dataset, all values below sea level have been given an untrue value of greater than 55000 by the authors of the original data set (USGS 1996). This presented a problem for this research since true bathymetric data was necessary in order to reconstruct palaeo-shorelines. To solve the problem, the below sea-level values were to a value of zero (no data). This was done using the GRASS map calculator by masking the true digital elevations and subtracting the untrue value. This would allow the bathymetric data of TerrainBase to be added to the finer-resolution data of GTOPO30. The result of the GTOPO30 adjustments is shown in Figure 5.2.

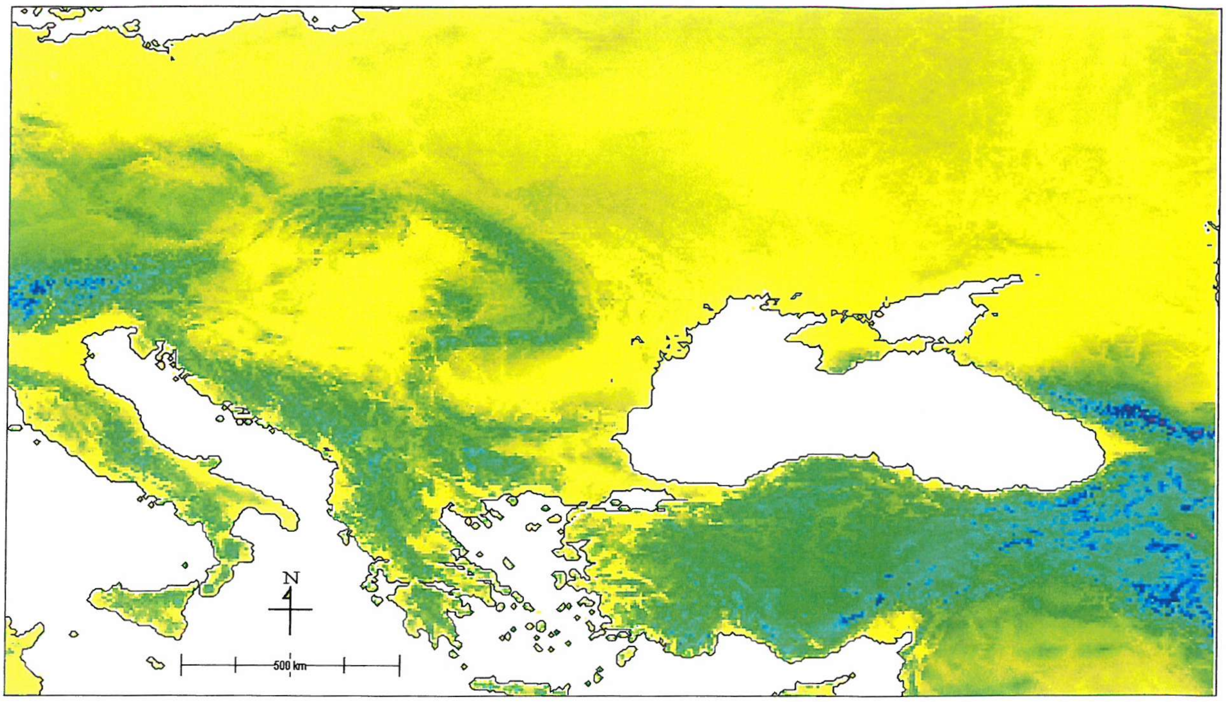
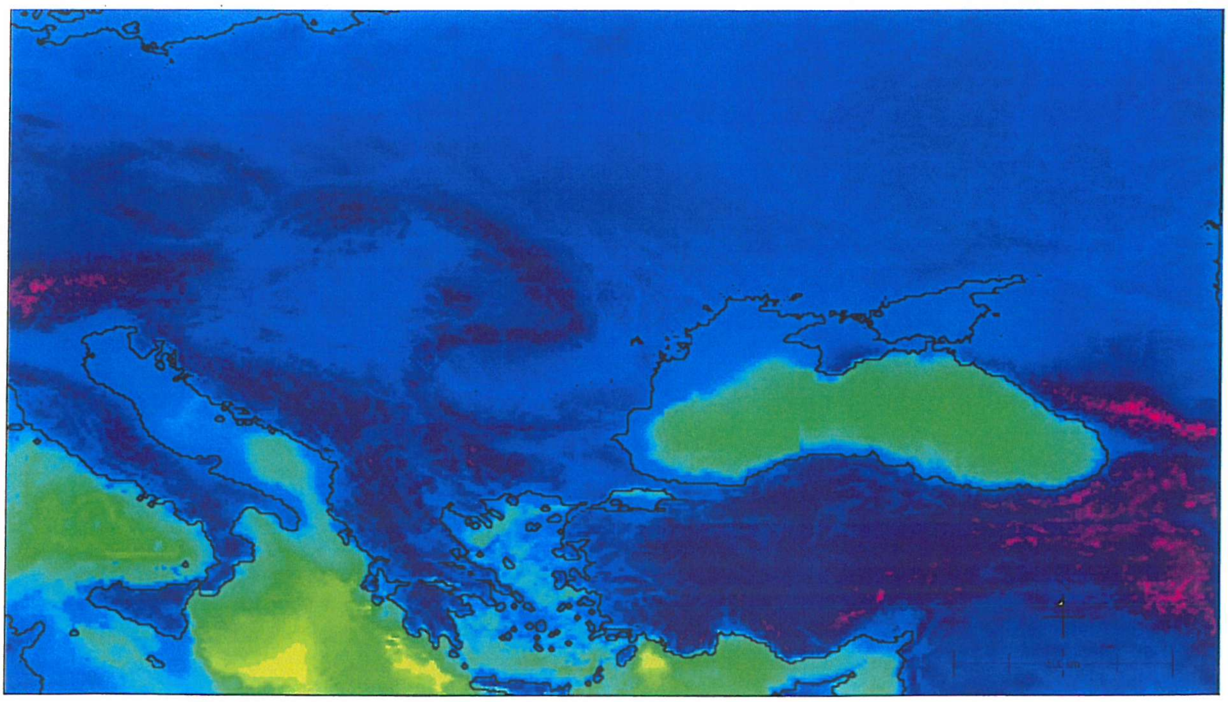


Figure 5.2: Raster map representing the GTOPO30 DEM land elevations (from USGS, 1996).

Figure 5.3: Modern digital elevation and bathymetry at 5-arc minute resolution (10km/grid cell).



Peltier's palaeo-topography and ice sheet data were imported into the GIS in the same way as TerrainBase. Both land and bathymetric elevations were maintained for these data. Because the Peltier data set presents the data in real years B.P. (before present), it is recognised that Peltier's 'X' maps must be correlated to correspond to the cal BC timescale used in the working radiocarbon database. In essence, each 1000-year B.P. interval of the palaeo-topographic data set was assigned a corrected identification for correlation to kyr BC (i.e. 'X'kyr B.P. becomes 'Y'kyr BC).

Constructing the Base Maps

To produce the finer resolution palaeo-topographic base maps, raster maps that represented the difference between *each* of Peltier's 1-degree resolution palaeo-topography maps and modern topography were determined by subtracting modern elevations from each of the palaeo 'X' kyr intervals. This reveals the difference in elevation due to sea level rise. These difference maps represent the relative changes in sea level for each 1000-year interval, from the modern shoreline.

Because the ICE-4G model of palaeo-topography represents elevations *during* deglaciation, elevation values in this data set *include* thickness of ice where ice is present. As a result, the difference maps show extremely high elevations in areas where ice is present (Figure 5.4). The presence of ice will later be masked off to present these areas as barriers to colonisation, assuming that large glaciers are inhospitable environments. These difference maps were interpolated to the 5-arc minute resolution, equivalent to TerrainBase.

One problem for the reconstruction of the base maps is that the Peltier (1993) data set has only been constructed for the period *since* the LGM. There is no palaeo-topographic data available that can be correlated to the earliest calibrated radiocarbon dates to be used in the modelling process. To account for the missing data, the existing palaeo-topographic maps were examined to determine the average difference in sea level per 1000 years. In other words, the reconstructed *difference* maps were averaged together to produce a raster map representing the mean relative sea level rise. This mean was added consistently to the palaeo-topographic data for 21kyr B.P. until representation was achieved for 1000-year intervals corresponding to 22000 cal BC.

Figure 5.4: Difference between ICE- 4G data for 18000 cal BC and modern elevation and bathymetry. Black = modern sea level; Red = sea level at 18000 cal BC.

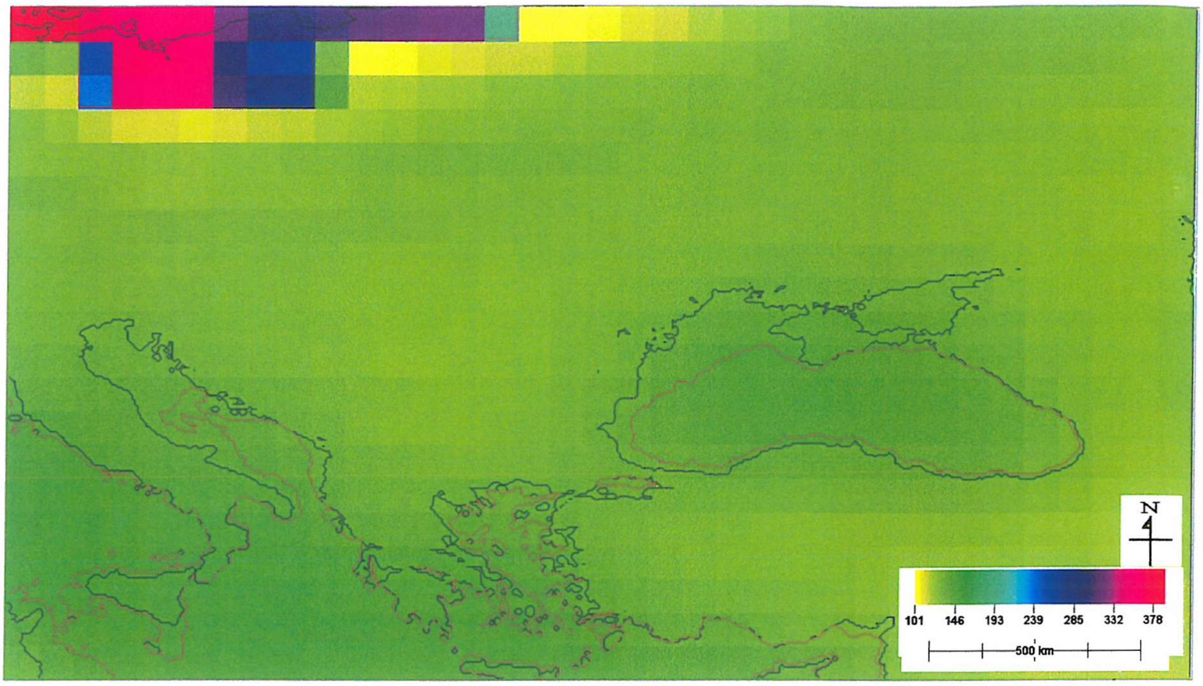
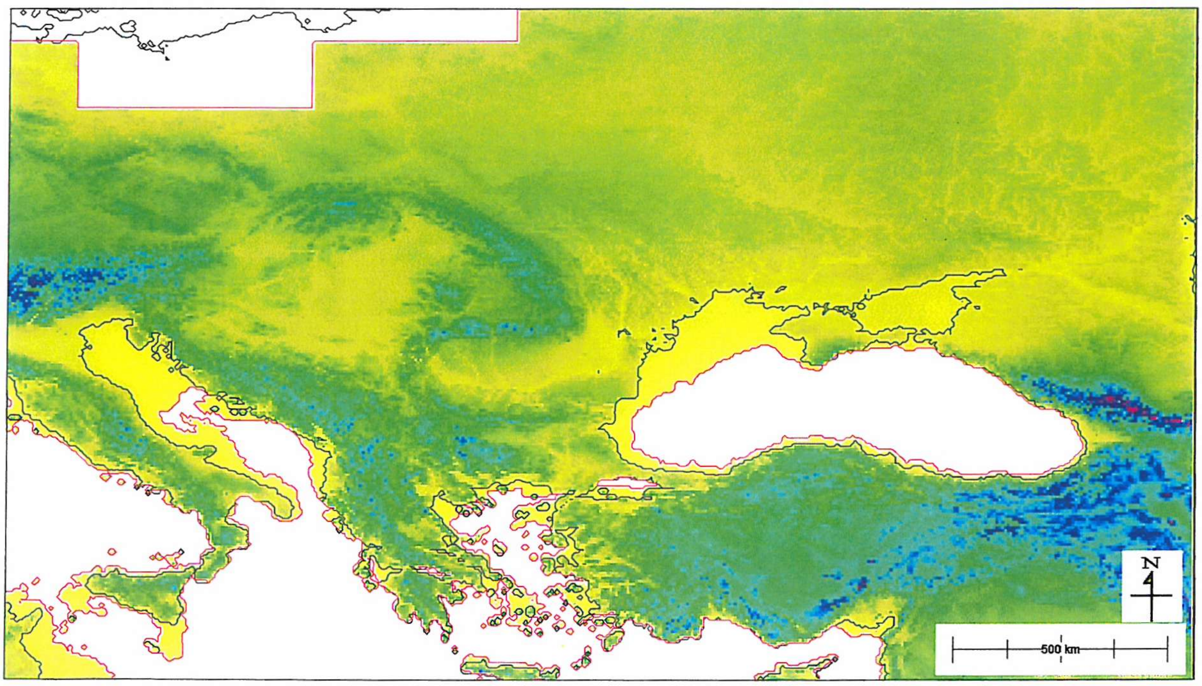


Figure 5.5: Cal18 – Palaeo-topography elevation and palaeo-shorelines for 18000 cal BC. Black = modern sea level; Red = sea level at 18000 cal BC.



According to the GISP2 data (Jöris and Weninger 1999) and the Summit ice core (Djindjian et al. 1999, figure 2.3), the onset of the LGM begins c. 25000 cal BC and reaches its coldest point at 22000 cal BC. The method used to assume palaeo-topography past the limitations of the Peltier data set, as described above, cannot be used on data earlier than 22000 cal BC for the following reasons. Following the cold maximum sea levels can be assumed to have been continually rising as the climate warmed. This assumption is safe since the GISP2 data shows distinct climate warming from 22000 cal BC to the point where the Peltier (1993) reconstructions begin. Difference maps were therefore reconstructed for 1-degree resolution to 22000 cal BC.

Prior to 22000 cal BC however sea levels would have been falling as ice accumulated during the onset of the glacial maximum. While it is acknowledged that the ideal solution here would be to produce a method for accurately reconstructing lowering sea levels, this is not feasible within the constraints of my research. Therefore, to assume some degree of climate stability for the maximum glacial is regarded as the sole, most appropriate, option. Maximum glaciation is thus assumed in this research to be stable and constant for the duration of the LGM, from 25000 cal BC to 22000 cal BC. The 22000 cal BC palaeo-topographic reconstruction will be used for each of the 1000-year intervals prior to the 22000 cal BC cold maximum.

While the reconstructed base maps from 19000 cal BC to 25000 cal BC have not been derived through formal methodology, the procedure used to achieve these results can be considered sound since the average differences in elevation used to resolve the missing data are consistent with accepted palaeo-topographic and observed climate data.

All the radiocarbon data in the working database for sites earlier than 25000 cal BC are represented by the Aurignacian. As discussed in previous chapters, this data set is incomplete. These data are therefore only used in this research in the context that they represent the knowledge that colonisation in Europe had occurred prior to the LGM. Recognising this limitation, these data can be excluded in this chapter to minimise error both in the reconstruction of the physical data, and error in the predictive modelling process.

Finally, in order to produce the finer, 10km, resolution palaeo base maps, the difference maps were added to the modern dataset obtained from GTOPO-30 and

TerrainBase. Presence / absence of ice was masked off each base map, and a value of zero (no data) was assigned these areas. All below sea-level values in the resultant raster maps were to a value of zero (no data) to determine palaeo-shorelines.

5.1.3 Output

The output is a set of palaeo-topographic maps that show land elevations and palaeo-shorelines for each 1000-year interval from 25000 cal BC – 11000 cal BC, where contemporary archaeological sites could be located (Figure 5.5). It has been pointed out earlier in this thesis that radiocarbon data prior to 25000 cal BC and later than 11000 cal BC are incomplete due to the temporal framework of my research. For this reason, these outlier data are left out of the modelling procedure to reduce the potential for error when evaluating the spatial movement of Upper Palaeolithic colonisers.

These base maps act as contemporary surfaces over which the calibrated radiocarbon data can be modelled, as well as acting as a potential source of predictive input data. Data that can be obtained from these base maps include elevation, slope, aspect and watershed basins. These are examined in the following sections for their applicability as predictive indicators in the modelling process.

5.2 DETERMINING PREDICTIVE INDICATORS

The objective of this section is to output the radiocarbon data site locations, and characteristics of their locations, in the form of a table that can be input into the statistical package SPSS for logistic regression analysis. Logistic regression is then used to analyse these data. The results are output mathematically and returned as input back into the GIS for interpretation. Each output map represents a cost surface for each 1000-year interval that shows the predicted likelihood that sites might be located in preferred conditions relative to the input variable data. The whole of the output data and reconstructed maps are then used to explore the processes of colonisation including the potential timing and direction of movement, and the colonisation or abandonment of regions in Central Europe. A detailed discussion of the logistic regression method is provided in section 5.3. Section 5.4 provides the analyses and interpretation of the GIS cost surface output.

5.2.1 Site Locations

Site locations of the radiocarbon data points are obtained from the working database and are input into the GIS. The format for the input site list is illustrated in Table 5.1. Because the data is to be analysed in steps of 1000-year intervals, sites are categorised into 1000-year ranges. Where more than one radiocarbon data point is located at the same site within a given 1000-year range, they are counted only once. This is due to the fact that, at each step, the model is assumed spatial in nature. Since the temporal modelling is limited to 1000-year steps, each site is assumed occupied for the 1000-year duration. Though in reality this is not the case at most locations, the assumption is justified on the basis of the nature and scale of the analysis. This will become clear in the methods described in this chapter. Raster maps of the point data are created.

Table 5.1: Sites input data. This example shows actual site locations to be used to for 18000 cal BC. Latitude/Longitude coordinate system.
Column 1 = easting Column 2 = northing Column 3 = site

```
39.02 47.30 #1
28.17 48.13 #1
39.01 51.24 #1
31.65 49.54 #1
33.17 52.11 #1
17.45 46.50 #1
40.26 47.85 #1
19.55 50.05 #1
19.53 50.58 #1
13.90 45.10 #1
16.02 46.17 #1
13.89 44.82 #1
```

The next step is to generate an equivalent number of *random* site locations based on the *actual* number of site locations per each 1000-year interval. "All things being equal", is the basic premise for the generation of these non-sites. There is an equal chance that a site will occur at any given point in space. These random sites act as control data in the predictive modelling process. Palaeo base maps are used to mask areas where sites cannot be located (i.e. water and glacial ice). No influencing variables are used in this process except the barriers assumed to be produced by palaeo-shorelines and glacial ice. The random non-sites are then generated against known sites using the masked map for each interval. This procedure allows the non-sites to be located on contemporary palaeo-surfaces that are submerged today. These random sites are output as a sites file list in the format shown in Table 5.2.

The known sites list and the random sites list are then combined using a text editor. Table 5.3 shows this output for 18000 cal BC. Known sites are given an attribute of '1' and random sites are given an attribute of '0' to differentiate between them. This step is repeated for each 1000-year interval. These data are then input back into the GIS and converted to raster format for the next stages of the methodology.

Table 5.2: Sites input data. This example shows random sites for 18000 cal BC generated using the r.random module. Latitude Longitude coordinate system. Column 1 = easting Column 2 = northing Column 3 = random site (non-site)

```
35.74 54.19 #0
33.15 53.64 #0
10.60 52.97 #0
20.11 49.55 #0
13.45 48.35 #0
40.40 48.13 #0
38.97 48.02 #0
12.51 46.18 #0
40.01 45.32 #0
41.22 43.84 #0
36.25 41.19 #0
26.64 40.58 #0
```

Table 5.3: Sites input data. This example shows actual and random sites to be used to generate r.what output for 18000 cal BC. Latitude/Longitude coordinate system. Column 1 = easting Column 2 = northing Column 3 = 1 = actual sites; 0 = random non-sites.

```
39.02 47.30 #1
28.17 48.13 #1
39.01 51.24 #1
31.65 49.54 #1
33.17 52.11 #1
17.45 46.50 #1
40.26 47.85 #1
19.55 50.05 #1
19.53 50.58 #1
13.90 45.10 #1
16.02 46.17 #1
13.89 44.82 #1
35.74 54.19 #0
33.15 53.64 #0
10.60 52.97 #0
20.11 49.55 #0
13.45 48.35 #0
40.40 48.13 #0
38.97 48.02 #0
12.51 46.18 #0
40.01 45.32 #0
41.22 43.84 #0
36.25 41.19 #0
26.64 40.58 #0
```

5.2.2 Modelling Variables

Predictive modelling of past human movement requires careful consideration of the variables that may have influenced those processes. It has been shown in this research that colonisation was not environmentally determined, but rather, must have been socially driven. Yet, environmental factors cannot be excluded from consideration in terms of the spatial movement of populations. For example, access to water is essential for survival, and just as you or I might choose to go around a glaciated high mountain than go over it (while at the same time wondering about where our next meals will come from), it can be assumed that such concerns may have influenced the immediate decisions made by Palaeolithic hunter-gatherers when choosing where they would settle and in which directions they would move.

In this section, selected variables that may have influenced these choices are explored for their applicability to colonisation research, and use in predictive modelling. These data have been chosen for their availability, potential value and simplicity. This latter requirement is important since this is work in development and the results produced in this thesis will represent a very basic model that can then be adapted and refined in future research.

Climate

Climate data to be used in this research was obtained from the World Data Center for Paleoclimatology Data via public domain at URL: http://www.ngdc.noaa.gov/paleo/model.html.

Kutzbach et al. (1998) produced the coarse resolution (7.5 degree) CCM1 General Circulation Model Output Data Set representing seasonal palaeo-climates (perpetual January and perpetual July) at 21k, 16k, 14k, 11k, 6k and 0k B.P. The simulated climate model incorporates multiple variables such as humidity, solar flux, temperature and snow, and includes ice extent and palaeo-topography data input from the ICE-4G model (Peltier 1993). Refer to URL: http://ccr.meteor.wisc.edu/model/vars/vardesfram.html for a list of variables and further details. The output dataset results from experiments to model past changes in the earth's environmental history, by examining the earth's climate response to orbital changes (including sea-level rise, glaciation and vegetation). The authors consider the ever-increasing availability of dated historical sources, dendrochronology, lake sediments and ice-cores to support the view that such modelling experiments are useful for examining the interrelationships between past cultures and climate. The dataset has been compared to observational measurements to test the overall reliability of the model, providing a "measure of validation" for predicting future climate scenarios (Kutzbach et al. 1998). The output of the model is such that the user may examine the results for individual variables as they apply to the user-specific needs.

Because this research is constrained by limited time and data availability, this climate data set is considered the most useful of available data for use in this work as it models palaeo-climate at specific intervals contemporary with the temporal framework of the project. Despite the coarseness of the data, it will be effective as input in the predictive model.

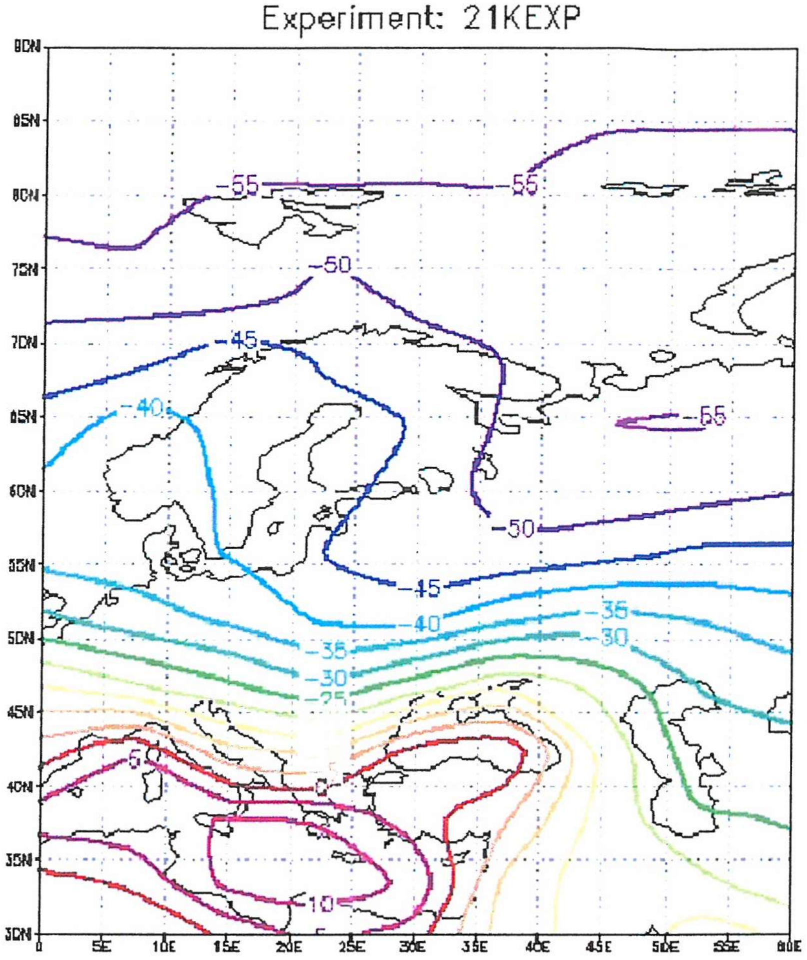


Figure 5.6: Contour map of surface radiative temperature for January at 21kyr (Kutzbach *et al.*, 1998). Contours in degrees Celsius.

For the purposes of this project, climate data input is limited to surface temperature obtained from the Circulation Model Output Data Set (e.g. Figure 5.6). Since the CCM1 model is a result of complex interactions between numerous variables, this is deemed to be the most appropriate course of action. This limitation is applied in order to maintain simplicity in the model, such that method and interpretation of this initial stage process might be more easily and accurately achieved.

The data are input into GRASS as a raster map. Again, the climate data is presented in terms of years "before present" which required correlation to the cal BC time scale. All below sea-level values and presence of ice values are masked off, leaving only those data associated with areas where sites could be located at each 1000-year interval.

To compensate for those 1000-year intervals where no data is available, the above data are distributed in close approximation with the GISP2 data (Jöris and Weninger 1999). In this case, the CCM1 data for 21k is used for those intervals corresponding to 18000 cal BC through the LGM, the 16k data is used for the Oldest Dryas, the 14k data is associated with the initial warming at the end of the Oldest Dryas and the 11k data is used to correspond to the pre-Holocene.

Geology

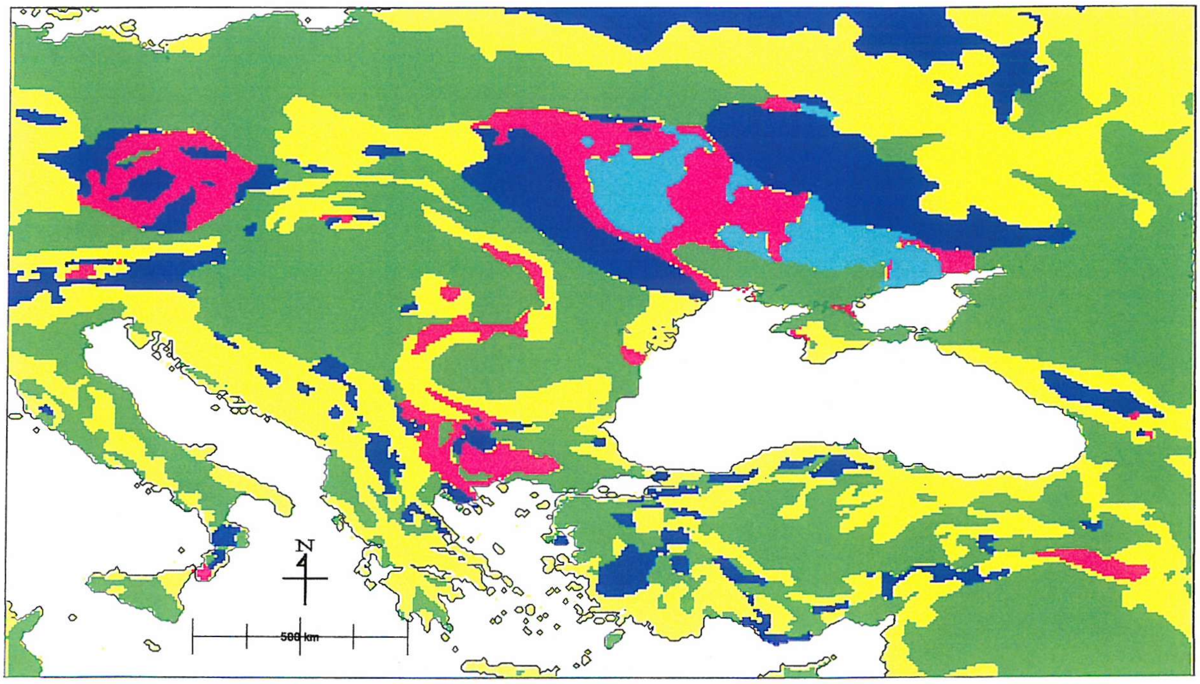


Figure 5.7: Generalised structural geology map of Central Europe (after Kirkham 1995). Yellow=Mesozoic – mainly volcanic terrain, Green=Cenozoic – sedimentary, Dark Blue=Paleozoic – sedimentary, Pale Blue=Archaen-metamorphic and/or plutonic terrain, Red=Proterozoic-metamorphic terrain

In some areas, such as the Carpathian Basin, rapid post-glacial deposition took place after the LGM. Modern soil maps that might otherwise be useful in predictive modelling of this nature may therefore be increasingly *inaccurate* as they are used to represent palaeo data. As a control for this, generalised structural geology is used as input data instead (Figure 5.7). Though geology is a generally a constant variable due to its structural nature, its relationship to topographic variables (i.e. mountains vs. plains) and its potential influence on the direction of movement of colonising populations make this a significant variable for inclusion in this model. For example, drainage, supported soil types and terrain are among those variables associated with geology that directly influence vegetation. This in turn would have influenced hunter-gatherer subsistence patterns and regional behaviour.

Watersheds

Another form of input data, which may have had a considerable affect on the directions of movement of Palaeolithic colonisers, is the location of watershed drainage basins. Watershed basins are associated with the location of major water resources and can be directly associated with ecosystem habitat types. For this research, watershed basins are reconstructed for each 1000-year interval. To do this, slope and aspect raster maps are generated for each 1000-year interval. These data, along with elevation data, provide the watershed analytical module with necessary input to determine flow and drainage patterns. The module is designed to produce watershed basins based on user-specified conditions such as minimum basin size, accumulated surface flow and barriers to the direction of drainage. For this research, watersheds are extracted at a minimum size suitable for modelling a small dependent dataset over a large spatial scale (i.e. the basin size is set large enough to include enough site locations that spatial patterning would be visible).

This research is interested only in defining watershed basins as potential subsistence regions for Upper Palaeolithic groups (e.g. Figure 5.8). The rationale for using these data is derived from the assumption that human populations are attracted to life-sustaining needs including water and regions of high resource abundance. These populations are more likely to keep as close as possible to such areas whether they are "settled" or on the move. The application of watershed basins as one variable in the modelling procedure allows the output model to recognise potential for more localised intra-regional movement should it indeed play a significant role in colonisation processes.

A further output provided by watershed analysis is directional movement is based on the drainage systems. This drainage output provides aspect for the direction, in degrees, that surface runoff will travel (Figure 5.9). One concern of the watershed analytical module is that it assigns a "no data" value to those basins that drain out of the defined region. Large areas were therefore relegated to a zero (no data) value. As a result, use of the drainage data as input might enable a more detailed observation of site location to water. Proximity of site locations to drainage patterns could provide more accurate results in the general model. Both drainage and watershed basins are reviewed in this chapter and are compared against one another to determine which, if any, are appropriate for predictive modelling.

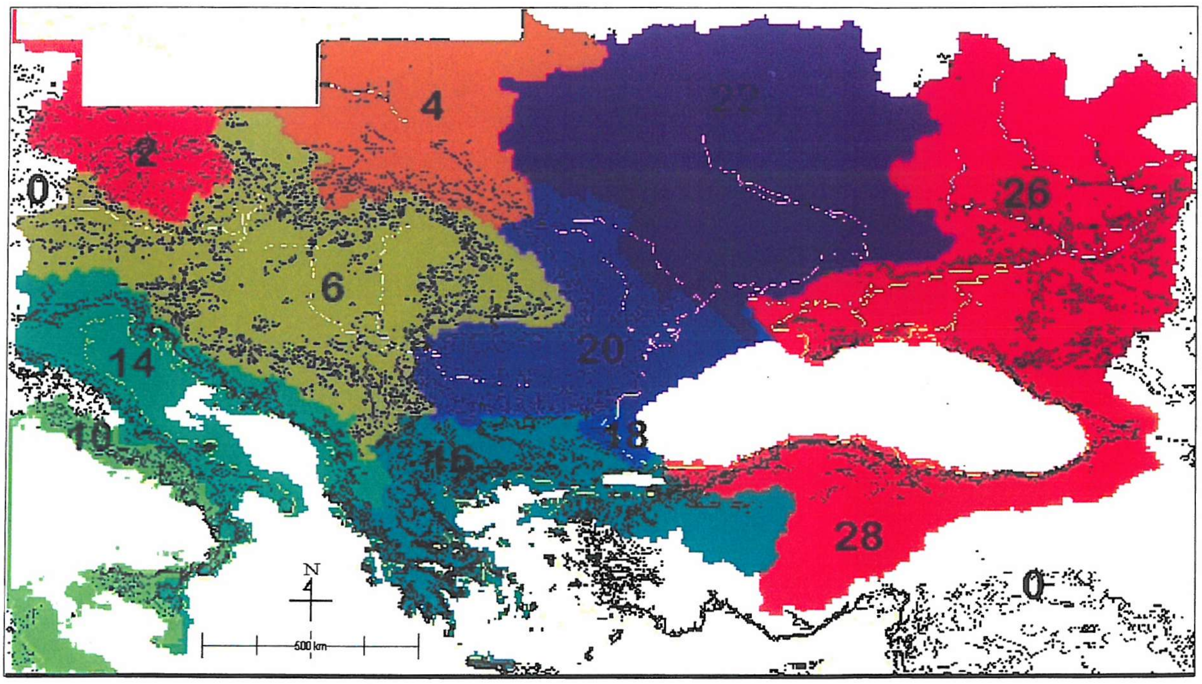


Figure 5.8: Watershed map for 18000 cal BC. Each basin is assigned a numeric identifier. Those basins that flow out of the mapped area (i.e. basins 8, 12 and 24 are assigned as no data and given an identifier of 0).

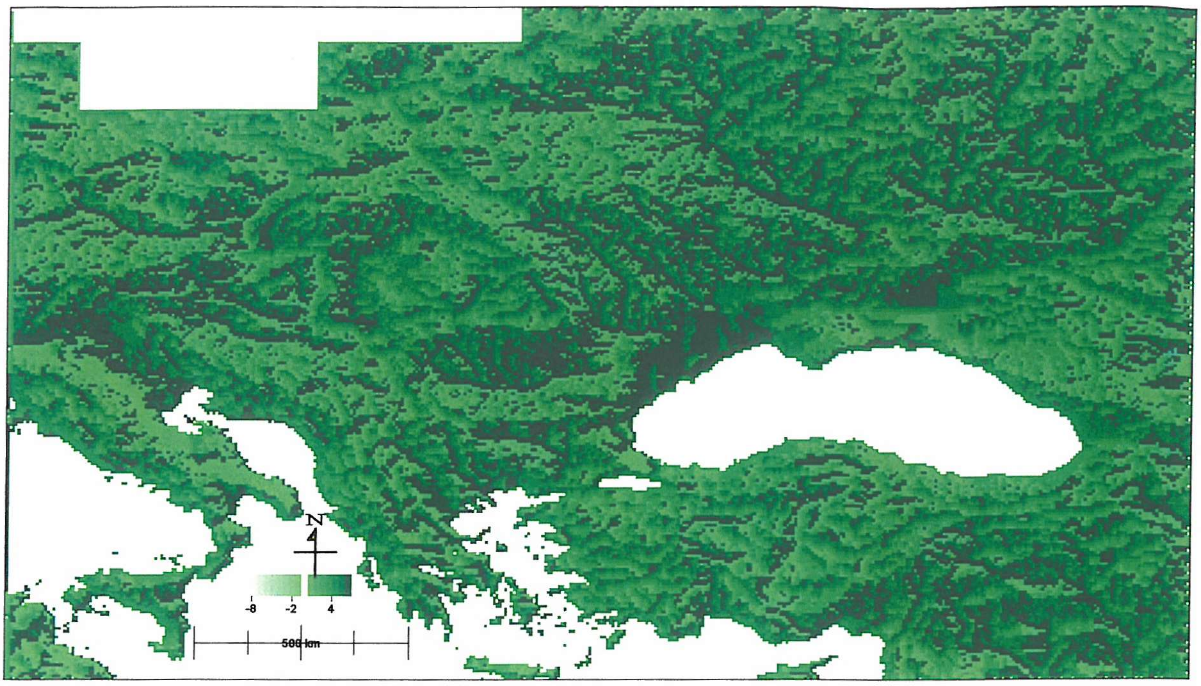


Figure 5.9: Drainage map for 18000 cal BC.

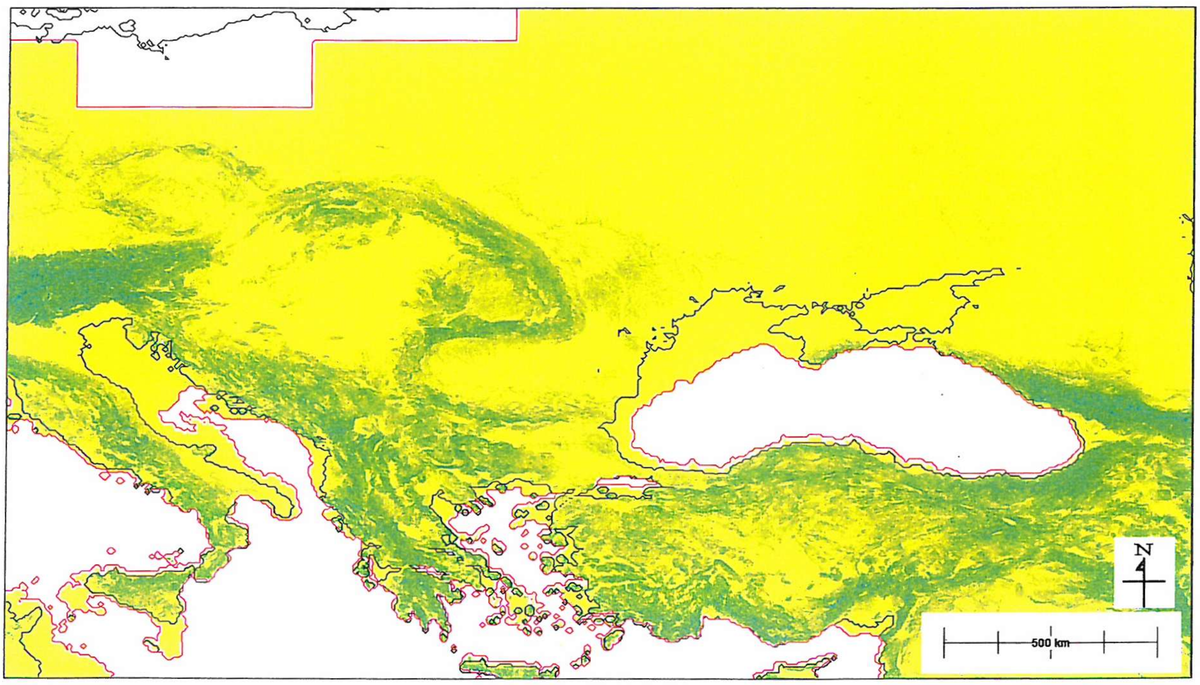


Figure 5.10: Slope map for 18000 cal BC. Slope is 5 - 90 degrees. Black = modern sea level; Red = sea level at 18000 cal BC.

Slope

The slope data (Figure 5.10) produced for the watershed basin analysis are also examined as a separate variable for input since steepness of slope would most certainly have played some role in the direction of movement, and settlement location of colonising populations, particularly in mountain regions.

Aspect

Aspect is derived in conjunction with the slope from elevation data and is also explored as a predictive indicator of colonisation processes (Figure 5.11). Aspect output provides the direction of slope of the landscape and is presented in 0 – 360 degrees from East. In terms of their application to this model, the location of sites with respect to both slope and aspect enable interpretations to be made about where sites are located in relation to environmental variables (i.e. the assumption could be made that sites on southerly slopes receive more sunlight than those on north facing slopes).

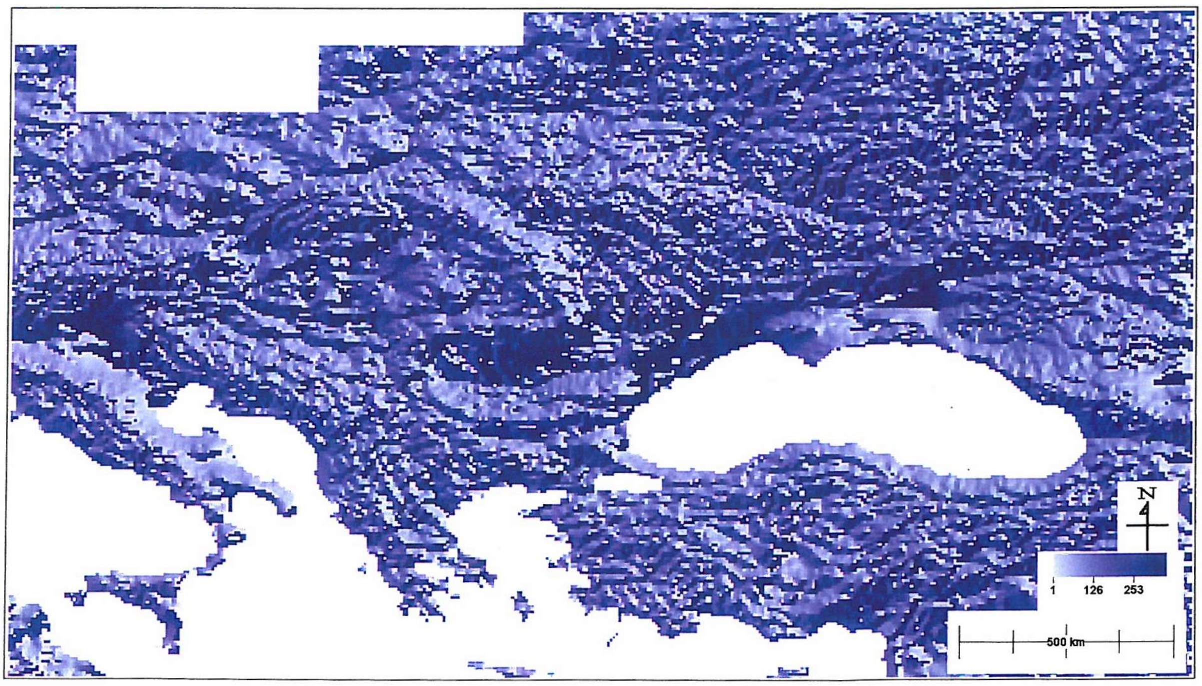


Figure 5.11: Aspect map for 18000 cal BC.

DEM

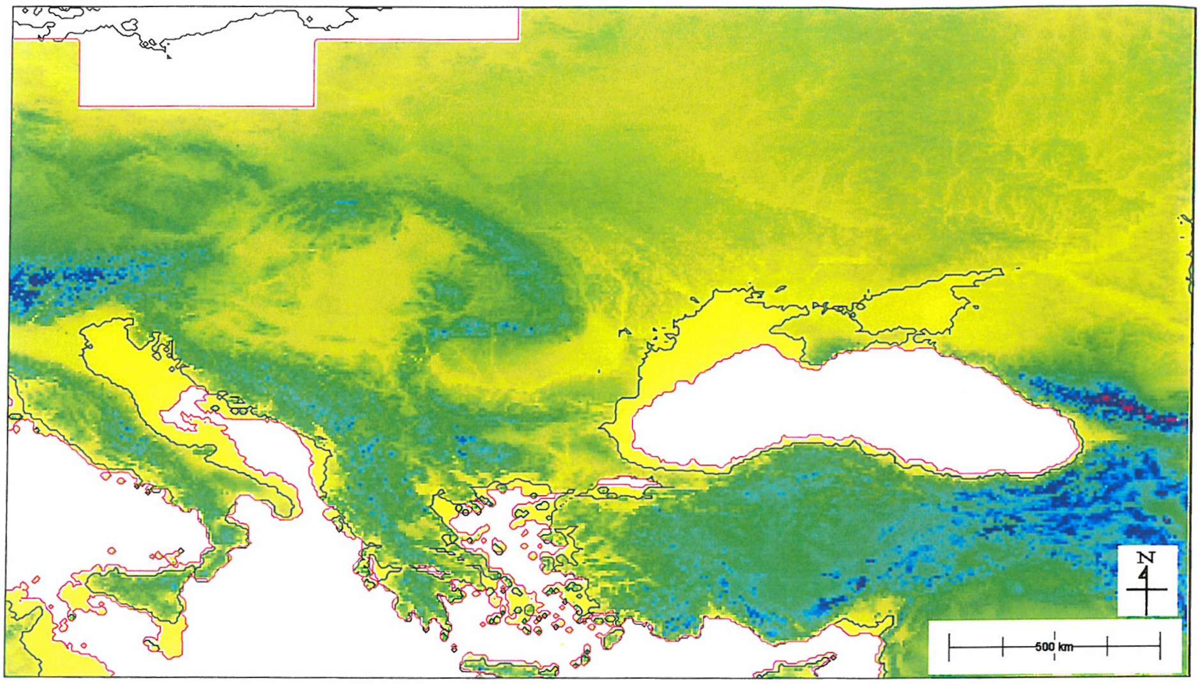


Figure 5.12: Palaeo-topography and digital elevation for 18000 cal BC. Black = modern sea level; Red = sea level at 18000 cal BC.

Finally, the digital elevation data, derived from each of the palaeo-topographic base maps, are examined as input for the predictive model (Figure 5.12). Each 1000-year interval base map provides the elevation for that particular time slice. Since elevation can be correlated with environmental conditions such as vegetation and temperature, this variable is considered a potentially important factor in site location.

Summary

There are seven variables to be tested for their value as input physical data on which the colonisation model is dependent. These are elevation, slope, surface temperature, aspect, drainage maps, watershed basins and geology.

The primary aim behind the selection of these variables was to use those data most likely to influence the colonisation processes. These variables have been further selected so as to allow the model to maintain a degree of simplicity such that both the method and results could be interpreted easily within the developmental framework of colonisation modelling. Also, these data can be correlated to palaeo-environmental conditions and thus are not dependent on present day data. This is important in order to keep consistency between the input predictive factors, and the radiocarbon data. In the following section, the variables are tested for their usefulness in the predictive modelling process and a final procedure, defining the appropriate input data, is developed.

5.2.3 Determining the Environmental Indicators

GIS, logistic regression and log linear analyses were used by Westcott and Kuiper (2000, 59-72) to predict the potential occurrence of sites in the coastal areas of Upper Chesapeake Bay on the basis of known environmental variables recorded from 572 prehistoric sites. Environmental data included topography, elevation, slope, aspect, distance to water and water type, and geomorphic setting, including soil type. Knowledge about the sites included site type, size, content and chronology that ranged from Palaeo-Indian to Late Woodland / European Contact. Climate changes were assumed to be uniform throughout the region. Two models were produced that separated sites into those with shell middens and those without, which were predominately lithic scatters.

Westcott and Kuiper (2000, 69) identified problematic issues with their models that are relevant to the outcome of this research. First, available data was limited by a dependence on data collected in previous surveys and the quality of the recording of the data. Secondly, data were obtained directly from secondary sources rather than field survey. Thirdly, a considerable amount of data about the site content was missing. Despite these concerns, the authors suggest that their model "still provides a useful predictive map that significantly refines and reduces areas of potential high probability for sites" (Westcott and Kuiper 2000, 70). The authors further found that specific environmental variables proved to be unreliable as predictors of site location. Using frequency tables, these data were eliminated from use in the predictive model. Among the discarded selections pertinent to the previous section of this chapter were slope, aspect and climate (surface temperature in this case). The variables selected for use in their model were elevation, distance to water, water type, and topographic setting.

It is important to point out the differences between the methods of Westcott and Kuiper (2000, 59-72) and those presented in this thesis. Foremost is that the full chronological range of the data is used by Westcott and Kuiper to develop a single model. In my research the data are modelled at several different time slices (at 1000 year intervals). The results are then re-examined and interpreted across the entire time frame. Secondly, unlike Westcott and Kuiper whose data was obtained from the site sources themselves, available environmental data is obtained via previous reconstructions of palaeo-topography and palaeo-climate because of the large spatial scale of my research and the inconsistent recording history of archaeological data in the area. This allows not only for consistency, but simplicity. Likewise, where Westcott and Kuiper are able to assume a uniform climate, this research must assume a variable climate in both space and time.

Westcott and Kuiper also simplified by avoiding using site size and content and only differentiating between site types. In my initial model there is no classification between sites. While in the future, it will be necessary to examine the differences particularly between rockshelters and open-air sites in a smaller regional analyses, this model must be produced using only 165 site locations over a much larger spatial and temporal scale.

Both projects are similar however, in that the sample of site and non-site data is not of sufficient size to "meet all of the statistical assumptions of these models ... " (Westcott and Kuiper 2000, 66). For example, when performing a watershed analysis, if a smaller basin size is set (increasing the total number of basins), the frequency distribution of basins compared to site and non-site locations results in a constant uniform surface. This is due to the greater distance between site locations, such that each site falls within a different basin. To resolve this issue, watershed basin size had to be larger in order to produce meaningful results without exponentially increasing potential error. The size of the basin is up to the researcher. In this research, each set of environmental data (except palaeo-temperature data) was found to be most useful when the data were reclassified into range categories, rather than single values. This resulted in an increased sample size per category that could then be analysed with increased clarity in the results. Elevation data were reclassified at 200m ranges beginning with 1 – 200 = 1. Elevations over 3000 were given a range category of 500m. The total number of categories is 19. Drainage data were reclassified so every 3 degrees of direction formed a single category (e.g. 1 – 3 = 1) for a total of 8. Aspect data were reclassified so that every 36 degrees from East is represented by a single category (e.g. 1 – 36 = 1) for a total of 10. Slope data were reclassified so that every 5 degrees of slope equals a single range, yielding a total of 11. '0 data' is not included.

With these considerations in mind, the model produced by Westcott and Kuiper (2000, 59-72), and work presented by Warren and Asch (2000, 5-32) can be used to compare and evaluate the methodology produced in the remainder of this chapter.

To begin the analyses, the environmental characteristics (based on raster maps of the selected variables) of the site and non-site locations at each 1000-year interval were queried and output mathematically from GRASS 4.3 GIS (r.what) for input into the statistics package SPSS. Because a site may be occupied at more than one time slice, it may be counted more than once during the analysis presented in this section.

The following format is used to obtain the environmental characteristics for each site location at each 1000-year interval:

r.what input=elevation, aspect, slope, drainage, basin, geology, temperature < 'sitesfile' > 'outputfile'

The output table (sites list) is in tabular format for input into SPSS for logistic regression analysis (Table 5.4).

Table 5.4: 'r.what' output file for 18000 cal BC – generated for regression analysis.

east	north	site	elev	slope	drain	basin	geol	temp
39.02	47.30	1	2	1	7	26.0	2	-6.00
28.17	48.13	1	2	1	5	22.0	5	-5.00
39.01	51.24	1	2	1	7	26.0	1	-11.00
31.65	49.54	1	2	1	1	22.0	5	-11.00
33.17	52.11	1	2	1	8	22.0	5	-11.00
17.45	46.50	1	2	1	5	6.0	2	-6.00
40.26	47.85	1	2	1	5	26.0	2	-6.00
19.55	50.05	1	2	1	8	4.0	2	-13.00
19.53	50.58	1	3	1	4	4.0	1	-13.00
13.90	45.10	1	2	1	5	14.0	1	-9.00
16.02	46.17	1	3	1	5	6.0	2	-6.00
13.89	44.82	1	1	1	8	14.0	0	1.00
42.37	54.37	0	2	1	3	.0	1	-16.00
19.06	53.61	0	0	1	0	.0	2	.00
21.14	52.06	0	2	1	1	4.0	2	-13.00
27.89	48.86	0	2	1	5	20.0	3	-5.00
12.00	47.76	0	5	2	1	6.0	2	-9.00
25.05	45.38	0	6	3	7	20.0	5	-5.00
14.75	43.28	0	1	1	5	14.0	0	1.00
22.39	43.01	0	4	1	4	6.0	1	3.00
21.14	42.00	0	3	1	8	16.0	4	3.00
30.40	40.27	0	5	1	3	16.0	1	1.00
43.53	39.83	0	12	1	5	.0	2	.00
42.25	37.81	0	7	4	4	.0	2	.00

The validity of the selected variables as predictive indicators was then tested. Frequency tests were performed on the actual site location data (excluding random locations) for the *whole* of the temporal range (i.e. the total number of actual locations). In each of the frequency diagrams, the *x*-axis is labelled according to the value assigned to the ranges of data as they are described previously in this section. The *y*-axis represents the number of sites corresponding to the particular environmental characteristic.

The statistical significance of each variable was then assessed using the 1-sample chi-squared test (Shennan 1997, 104-109). This is done to compare a sample (in this case the sites associated with a particular environmental variable) against a specified theoretical population (the site locations calculated according to the distribution of a categorical variable). A test is made of how good the correspondence or 'fit' is between the two distributions (Shennan 1997, 104). The test compares the differences between observed (actual) distributions and anticipated distributions, based on the researcher's theoretical expectations, across "mutually exclusive categories".

The value for chi-squared is calculated based on the sum of the differences between the observed (O) and expected (E) distributions. The formula for chi-squared is given by

$$\chi^2 = \sum_{i=1}^{k} \frac{(O_i - E_i)^2}{E_i}$$

where k is the number of categories, O_i is the observed number of cases in category i, E_i is the number of expected cases for category i, and χ^2 is symbol representing chi-squared.

This value, in turn, is compared to the minimum value required to reject the null hypothesis at the level of significance set for the test (see Shennan 1997, Appendix F). The number of degrees of freedom, used in the test for statistical significance, are determined by the number of categories in the sample, minus one. The formula is given by

$$\nu = k - 1$$

where ν is the number of degrees of freedom and k is the number of categories. For example, the geology data used in this research consists of 5 categories (the category for 'no data' is not included in the chi-squared test as it either represents missing values, or regions that cannot be occupied such as water or glacial ice). The degrees of freedom are therefore set to 4 when applying the chi-squared test to geology. In this research, the level of significance is set to 0.05 – in other words, to reject the null hypothesis, the result would have to be so unusual as to only occur by chance 5 times in every 100.

The theoretical expectation is defined by the *null hypothesis* (H_0). In this case, H_0 states that there is not a significant difference in the distribution of sites across the categories. The expected distribution is based on the null hypothesis assumption (e.g. if 25% of the total number of categories is category 1, then 25% of sites can be expected to occur in category 1). Once the three factors are known (chi-squared value, level of significance and degrees of freedom) the chi-squared value can be compared to the minimum value required to reject H_0. If H is accepted, the test indicates that the selected variable is unlikely to be of use in the modelling process as the distribution of sites would be constant, or evenly spread, across the categories. If the H_0 is rejected, then the alternative hypothesis (H_1) is accepted – in other words, there is a significant difference in the distribution of sites across the categories that must be investigated. The variable is considered useful for predictive modelling purposes.

Geology

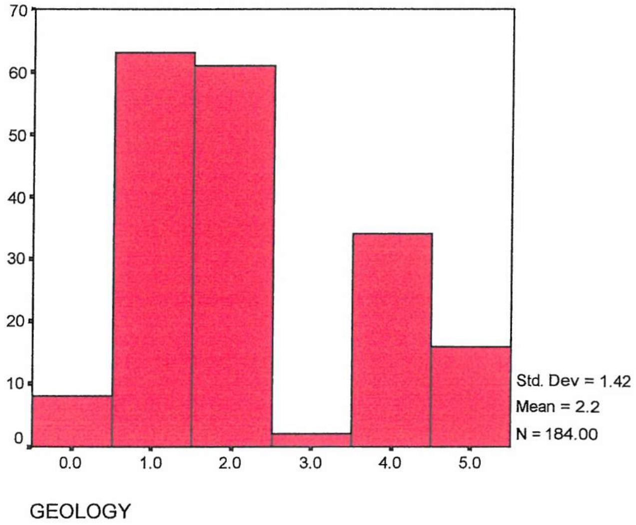


Figure 5.13: Frequency distribution of geological classifications for all known site locations. 0=no data, 1=Mesozoic-volcanic terrain, 2=Cenozoic-sedimentary, 3=Archaen metamorphic and/or plutonic terrain, 4=Paleozoic-sedimentary, 5=Proterozoic-metamorphic(adapted from Kirkham 1995).

GEOLOGY

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	8	4.6	4.6	4.6
	1	56	32.2	32.2	36.8
	2	60	34.5	34.5	71.3
	3	2	1.1	1.1	72.4
	4	32	18.4	18.4	90.8
	5	16	9.2	9.2	100.0
	Total	174	100.0	100.0	

Table 5.5: Frequency distribution of geological classifications for all known site locations. 0=no data, 1=Mesozoic-volcanic terrain, 2=Cenozoic-sedimentary, 3=Archaen metamorphic and/or plutonic terrain, 4=Paleozoic-sedimentary, 5=Proterozoic-metamorphic (adapted from Kirkham 1995).

Geology Type	Observed	Geologic Area (%)	Expected	χ^2
Mesozoic volcanic terrain (1)	64	33.24	58.83	0.45
Cenozoic sedimentary (2)	59	45.10	79.83	5.44
Palaeozoic sedimentary (3)	3	2.57	4.55	0.53
Archaen metamorphic/plutonic terrain (4)	36	12.67	22.43	8.21
Proterozoic metamorphic terrain (5)	15	6.42	11.36	1.17
Total	177	100	177	**15.8**

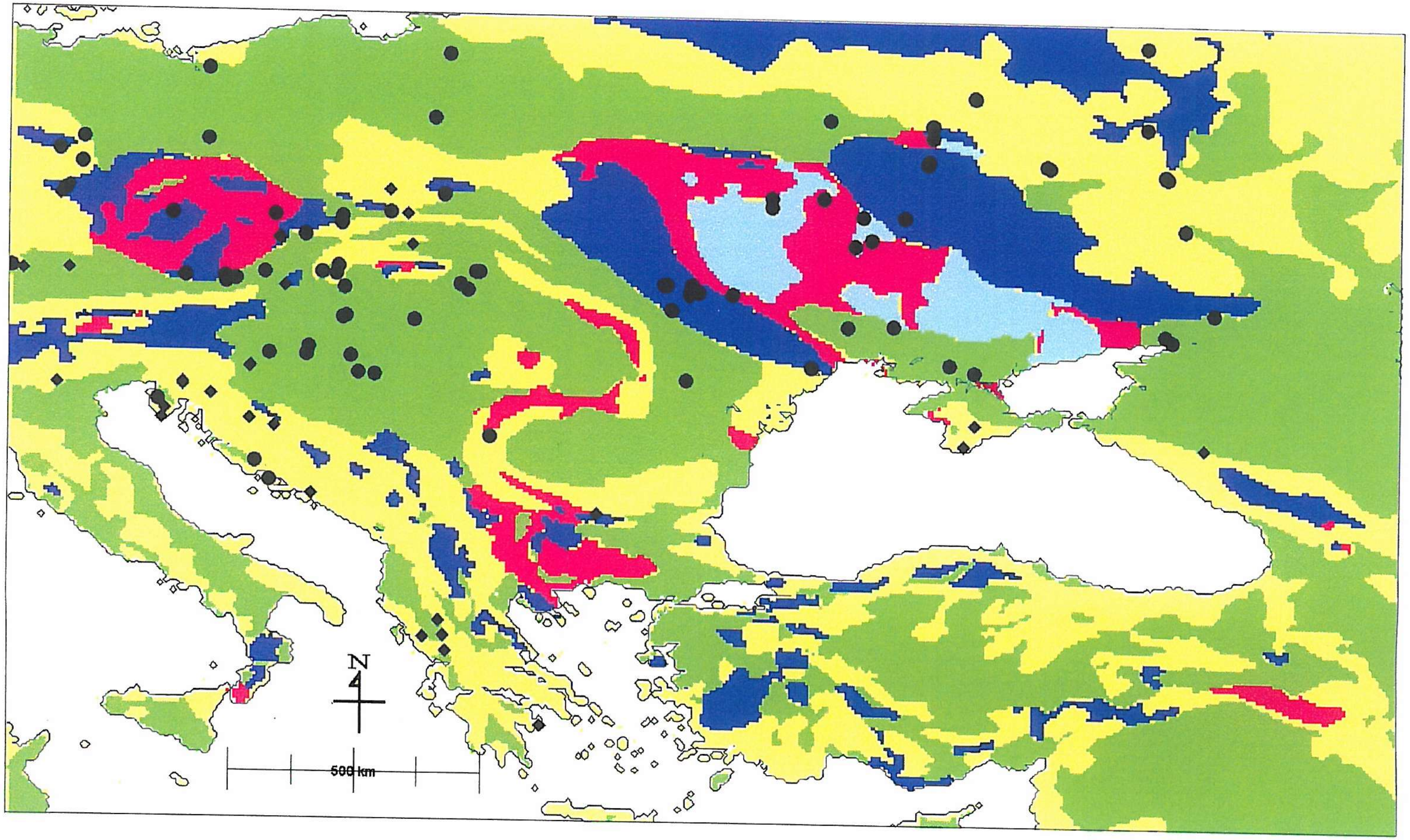
Table 5.6: Chi-Squared Test results for geology showing observed actual site locations, the percent of the total area characterised by each geology type, the expected distribution and chi-squared results.

Significance testing supports the employment of the geology variable as a predictive indicator. Figure 5.13 and Table 5.5 show the output of the frequency distribution. Table 5.6 shows the results of the significance test. Seven observed sites fell into the 'no data' category and were eliminated from the test.

H_0 states that there is not a significant difference in the distribution of sites across the categories. Using a significance level, $\alpha = 0.05$, with 4 degrees of freedom ($k - 1$), the significance table (Shennan 1999, Appendix F) states that the minimum significance level (χ^2_{α}) for geology is 9.48773. The calculated chi-squared value (χ^2_{calc}) is 15.8. In this case, $\chi^2_{calc} \geq \chi^2_{\alpha}$ ($15.8 \geq 9.48773$) means that H_0 is rejected. H_1, which states that there is a significant difference in the distribution of sites across the categories, is accepted.

The correlation between geology and the presence or absence of sites is significant (Figure 5.14). The results show that 32% of actual site locations are found on Mesozoic- volcanic terrain (category 1). Approximately 53% are located on sedimentary terrain (categories 2 and 4). More than 66% of all rockshelter sites are associated with category 1, while more than 66% of open-air sites are located in categories 2 and 4. The expected number of sites (79.83) is significantly higher than the observed (59) for sedimentary terrain. This is an important consideration in terms of archaeological visibility and the issue of refugia in this region. The same type of sedimentary geology found in the Carpathian Basin is also found in the possible refuge zones north of the Black Sea and the Russian Plain (Jochim 1987; Housley et al. 1997, 50). Likewise, this geological differentiation between the locations of open-air sites and rockshelters may also be included in explanations about the chronological differences as presented in Chapter Three of this thesis.

Figure 5.14: Generalised structural geology map of Central Europe (after Kirkham 1995).
Dots = open-air sites; Diamonds = rockshelters



Elevation

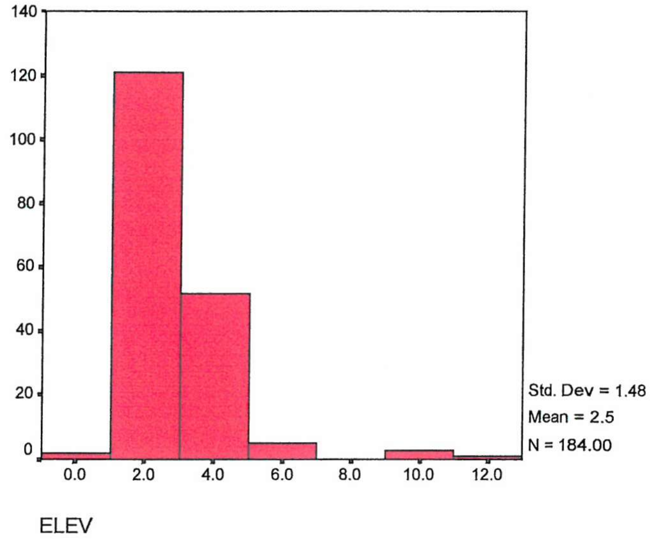


Figure 5.15: Frequency distribution of elevation data. Elevation data were reclassified at 200m ranges beginning with 1 – 200 = 1.

ELEV

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	2	1.1	1.1	1.1
	1.0	20	11.5	11.5	12.6
	2.0	93	53.4	53.4	66.1
	3.0	38	21.8	21.8	87.9
	4.0	12	6.9	6.9	94.8
	5.0	5	2.9	2.9	97.7
	10.0	3	1.7	1.7	99.4
	11.0	1	.6	.6	100.0
	Total	174	100.0	100.0	

Table 5.7: Frequency distribution of elevation data for all known site locations.

Elevation	Observed	Area (%)	Expected	χ^2
1 - 200 (1)	29	46.97	85.49	37.33
201 - 400 (2)	91	19	34.58	92.05
401 - 600 (3)	38	8.11	14.76	36.59
601 - 800 (4)	17	5.2	9.46	6.01
801 - 1000 (5)	1	4.71	8.57	6.69
1001 - 1200 (6)	5	4.29	7.81	1.01
2001 - 2200 (11)	1	1.08	1.97	0.48
12 cats w/ sites	0	10.64	19.36	19.36
total	182	100	182	**199.52**

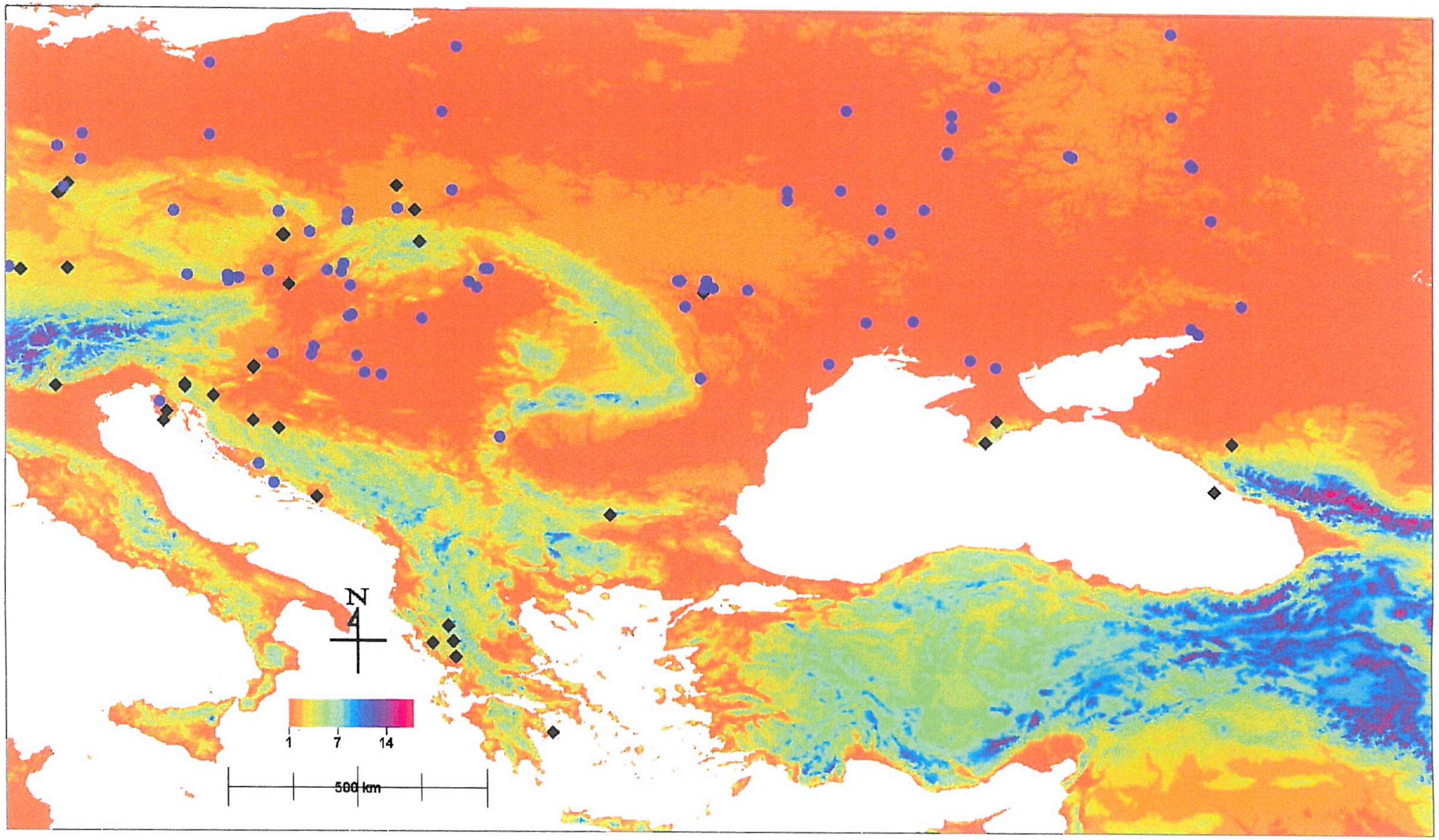
Table 5.8: Chi-Squared Test results for elevation ranges showing observed actual site locations, the percent of the total area characterised by each elevation range, the expected distribution and chi-squared results.

Because elevation data varies between 1000-year intervals due to sea level rise, the frequency distributions of observed sites are correlated to their contemporary sea level. The frequency distribution (Figure 5.15; Table 5.7) shows that 53% of all known sites are located at elevations 200m – 400m above their contemporary sea level. 21% are located between 400m and 600m, and 11.5% are located below 200m above sea level (asl).

The site sample size at each 1000-year interval is too small to achieve adequate results with the 1-sample chi-squared test. Therefore the test was performed using all known site locations as they are distributed across modern elevation data. This is considered the most accurate means of testing the data since the actual site locations (observed data) are, in fact, observed on the modern landscape. Two sites fell within the 'no data' range and were eliminated from the test.

Again H_0 states that there is not a significant difference in the distribution of sites across the categories. In this case, the degrees of freedom = 18 ($k - 1$). With a significance level of 0.05, $\chi^2_{calc} = 199.52$ (Table 5.8). Because $\chi^2_{calc} \geq \chi^2_{\alpha}$ (28.8693), H_0 can be rejected. There is a significant difference in the distribution of sites across the categories (H_1).

Figure 5.16: Reclassed elevation map showing the distribution of open-air sites (blue) and rockshelters (black).



An important observation that can be made as a result of this test is illustrated for the ranges 1 – 200m (category 1) asl and 201 – 400m asl (category 2). The test shows that the expected distribution for category 1 is considerably higher than the observed. In contrast, the expected distribution for category 2 is considerably lower than the observed. The average difference in elevation between the ICE-4G palaeo-topography data for 21kyr BP and modern elevation is approximately 120m (interpreted from the Peltier palaeo-topographic data set 1993). It is conceivable then that the expected values for categories 1 and 2 reflect the rise in sea level. Likewise, Figure 5.16 shows the distribution of open-air sites and rockshelters across the category ranges. It is clear that open-air sites are primarily located below category 2, while rockshelters are primarily located above category two. Though some sites of both types are located within category 2, the results suggest that elevation may be considered a good predictive indicator. Because the test could not be performed for each 1000-year interval, however, this is a cautious assumption. Nevertheless, elevation must be investigated for its applicability to the spatial modelling of colonisation processes.

Watershed Basins

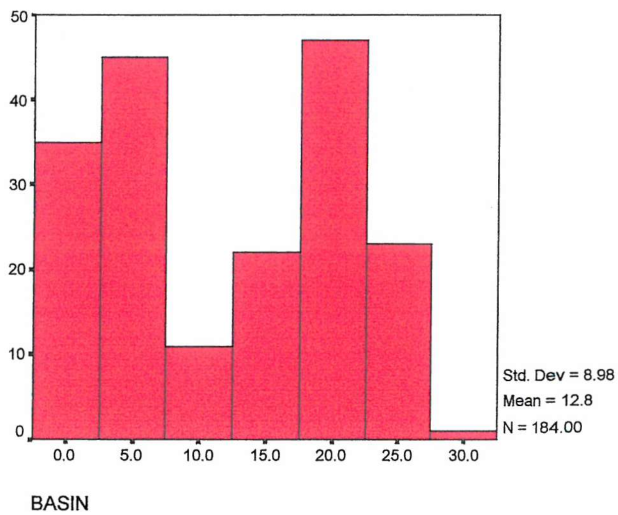


Figure 5.17: Frequency distributions of watershed basins for all known site locations.

BASIN

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	.0	15	8.6	8.6	8.6
	2.0	19	10.9	10.9	19.5
	4.0	7	4.0	4.0	23.6
	6.0	37	21.3	21.3	44.8
	10.0	6	3.4	3.4	48.3
	12.0	3	1.7	1.7	50.0
	14.0	6	3.4	3.4	53.4
	16.0	14	8.0	8.0	61.5
	18.0	1	.6	.6	62.1
	20.0	15	8.6	8.6	70.7
	22.0	27	15.5	15.5	86.2
	24.0	4	2.3	2.3	88.5
	26.0	19	10.9	10.9	99.4
	28.0	1	.6	.6	100.0
	Total	174	100.0	100.0	

Table 5.9: Frequency distributions of watershed basins for all known site locations.

The frequency distribution of watershed basins suggests that there is some correlation between these regional zones and site locations (Figure 5.17; Table 5.9). Of particular interest is the comparatively high percentage of sites located in basins 6 and 22 (see this chapter, Figure 5.8). Basin 6 represents the Carpathian Basin region, adding support for the hypothesis that this region may have been used as refugia. Basin 22 is in the North East region of the study area and is dominated by the well-documented sites of the East European Plain. The 1-sample chi-squared test was performed to assess the consideration of watershed basins as potential predictive indicators. 15 sites were located in 'no data' areas and therefore excluded from the analysis. Table 5.10 shows the results of significance testing where

H_0 = there is not a significant difference in the distribution of sites across the categories.

H_1 = there is a significant difference in the distribution of sites across the categories.

$\alpha = 0.05$

ν (i.e. $k - 1$) = 14

$\chi^2_\alpha = 23.6848$

$\chi^2_{calc} = 5501.88$

$\chi^2_{calc} \geq \chi^2_\alpha \therefore$ reject H_0

Basin No.	Observed	Area %	Expected	χ^2
2	19	3.32	5.08	38.14
4	7	6.97	10.67	1.26
6	37	16.32	24.97	5.8
8	0	0.04	0.07	0.7
10	0	3.72	5.69	5.69
12	3	0.05	0.08	106.58
14	6	8.17	12.5	3.38
16	14	9.97	15.25	0.1
18	1	0.55	0.84	0.03
20	15	8.24	12.61	0.45
22	27	16.49	25.23	0.12
24	4	0.002	0.003	5325.33
26	19	16.59	25.38	1.6
28	1	9.56	14.63	12.7
Total	153	100	153	**5501.88**

Table 5.10: Chi-Squared Test results watershed basins showing observed actual site locations, the percent of the total area characterised by each basin, the expected distribution and chi-squared results.

A close look at the χ^2 results clearly demonstrates one problem associated with using the chi-squared analysis (Table 5.10). Categories 12 and 24 for example, show expected values of less than one. Category 24 in particular shows an extreme χ^2 value of 5325.33. Shennan (1999, 108) points out that smaller sample sizes will result in low expected values, which in turn, will lead to inflated χ^2 values. The test will result in a skewed outcome. Generally, chi-squared testing should not be used in cases where more than about $^1/_5$ of the categories show expected values less than 5. In this case, almost half of the categories have resulted in very low expected values. Because a large percentage of the χ^2 values are inflated, the test is not reliable in this case, despite the acceptance of H_1. Consideration about the inclusion of watershed basins in the predictive model cannot be supported using the chi-squared test.

Though there are important concerns to bear in mind here, the frequency distribution (Table 5.9) indicates that watershed basins as a predictive indicator cannot be easily discounted. These can be compared to the regional explorations presented in Chapter Four (Section 4.4) to suggest that regional boundaries, whether defined culturally or ecologically, may have influenced Upper Palaeolithic colonisation processes. With this in mind, I am including this variable in the predictive model.

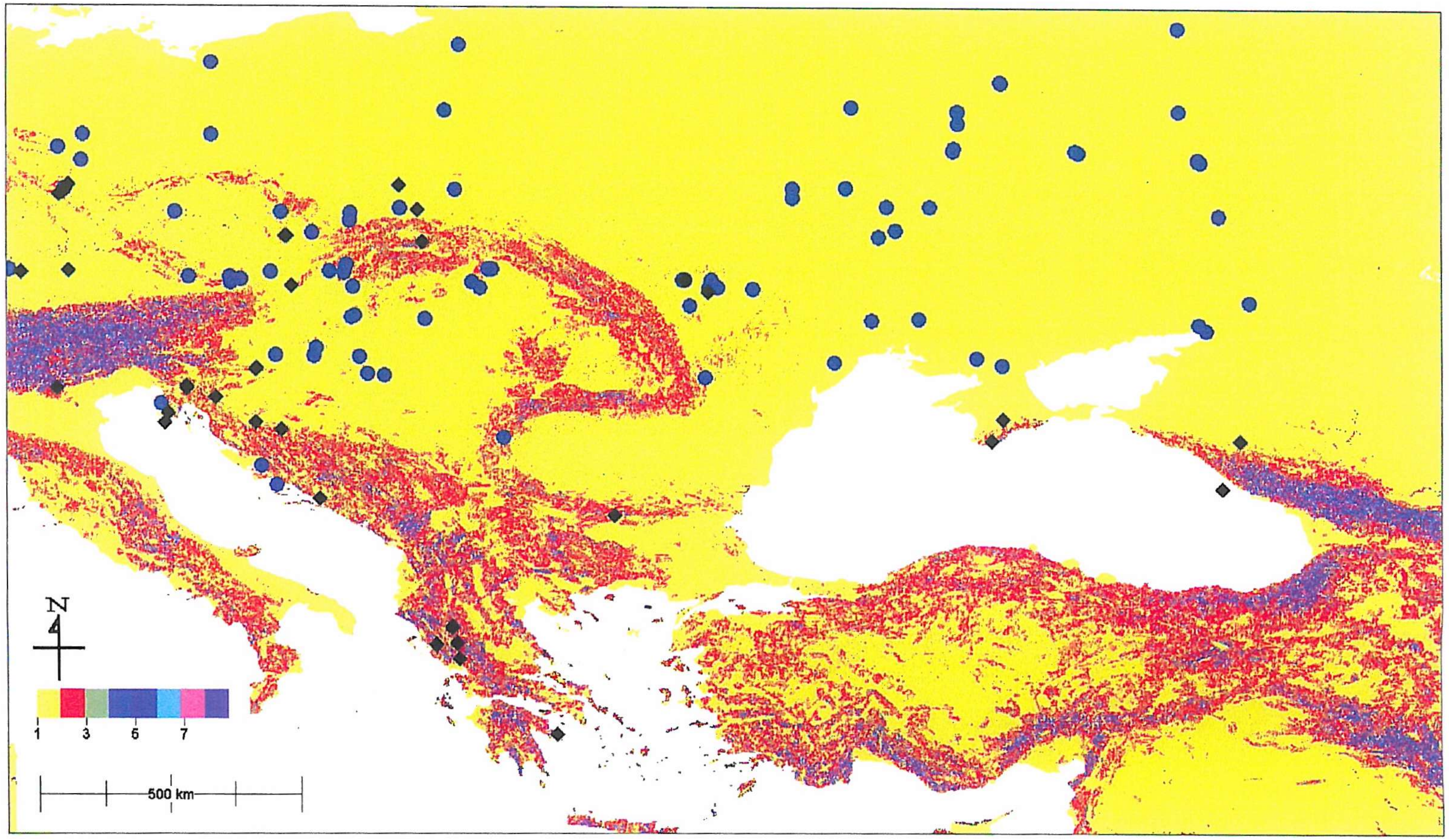
Because watershed basins were determined using the data from slope, aspect and drainage, these variables were also explored for their usefulness as separate predictive indicators for the modelling process.

Slope

The results of the frequency distributions of slope data show that more than 86% of all known site locations can be found at 0 – 5 degrees of slope (observed data in Table 5.11). Slope analysis was conducted on modern data, as this variable would have changed little through time except possibly for those palaeo-topographic areas that presently are submerged. Again, this was done to counter the problem of small sample size that would arise if the analysis were to be conducted for each 1000-year interval. Figure 5.18 shows the site distribution across the modern slope data.

Significance testing was performed on the slope data (Table 5.11). Three sites fell within the 'no data' category and were eliminated from the test. H_0 states that there is not a significant difference in the distribution of sites across the categories. H_1 states that there is a significant difference in the distribution of sites across the categories. The significance level is set at $\alpha = 0.05$, with 8 degrees of freedom (ν). The result of significance testing shows that χ^2_{calc} (6.23) *is not* $\geq \chi^2_\alpha$ (15.5073). In this case, H_0 is accepted (Table 5.11).

Figure 5.18: Re-classed modern slope data. Category 1 = less than 5 degrees Celcius. Slope categories represent 5 degree ranges. Black = rockshelters; Blue = open-air sites.



Slope Category	Observed	Area (%)	Expected	χ^2
1	148	81.96	148.35	0.0008
2	26	11.29	20.43	1.52
3	7	4.17	7.55	0.04
4 thru 9	0	2.58	4.67	4.67
total	181	100	181	**6.23**

Table 5.11: Chi-Squared Test results for elevation ranges showing observed actual site locations, the percent of the total area characterised by each elevation range, the expected distribution and chi-squared results.

The frequency distribution and significance testing indicate that slope would not be a useful variable for the purposes of predictive colonisation modelling – at least from within this archaeological framework.

Aspect

Aspect data were used along with slope to create drainage and subsequent watershed basin output (this chapter, 159-162). This was a difficult variable to examine. Because aspect provides the direction of slope of the landscape and is presented in 0 – 360 degrees from East, there are a total of 360 categories. In order to minimize the sample size problem (i.e. a small number of sites spread across a large number of categories), the data were reclassified into 10, 36-degree range, categories. The frequency distribution of sites across these 10 categories is shown in Figure 5.19. The only conclusions that can be drawn from the aspect data are that twice as many locations are found at more than 180 degrees of slope from East. However, the number of sites on either side of this division is quite evenly distributed. This can be attributed to the range classification. 36 degrees covers a large amount of space, which was necessary to resolve the problem of small sample size. However, this skews the results and does not allow for a sound representation of either the site data or the aspect data. Because aspect is also accounted for, along with slope, in the watershed basin output, I have chosen to eliminate aspect as an individual predictive indicator from the modelling process. My conclusions agree with Westcott and Kuiper (2000, 66) who chose to eliminate both slope and aspect from their own analyses.

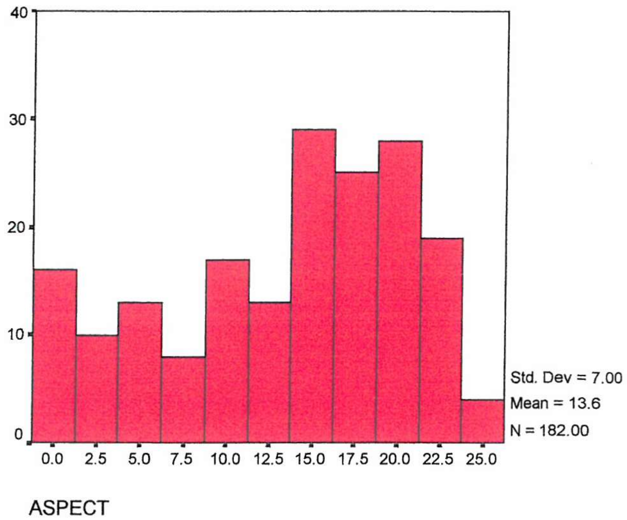


Figure 5.19: Frequency distributions for aspect data for all known site locations. Aspect data were reclassified so that every 36 degrees from East is represented by a single category beginning with 0 – 36 = 1.

Drainage

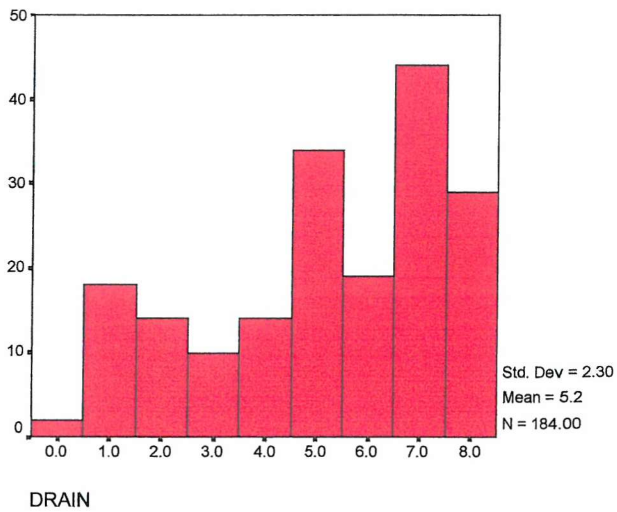


Figure 5.20: Frequency distributions for drainage data for all known site locations. Drainage data were reclassified so every 3 degrees of direction formed a single category (e.g. 1 – 3 = 1).

Drainage data (Figure 5.20) provides aspect for the direction, in degrees, that surface runoff will travel. It can be interpreted such that site locations within category 8, for example, are in closest proximity to drainage sources (i.e. rivers, lakes), while site locations in category 1 are furthest away. The frequency distribution suggests that the number of sites is highest where they are located along either side of drainage routes usually in close proximity to rivers, lakes or coastal zones, and show a tendency to decrease with distance from these drainage systems. This would suggest that drainage patterns do play some role as predictive indicators. However, the quality of these data as predictive indicators is questionable since they are based on both slope and aspect, which have been eliminated as good predictive variables. Since these drainage data were obtained through the creation of watershed basins that have already been accepted as input data for the modelling procedure, and in light of the above discussion, the drainage variable are eliminated from this preliminary model in favour of the watershed data.

Temperature

There is a wide degree of variance in the temperature data at any given site location that can be attributed to climate change between the 1000-year time slices. Considering this, the suggestion that temperature might have influenced site location is supported in the frequency distribution of site location data (Figure 5.21, Table 5.12). However, it was also necessary to further investigate the spatial relationship between surface temperature and site distribution. Because of the degree of variance between the temperature data through time at a single location, the method had to be altered to reduce potential error in the results while maintaining a large enough site location sample size. For this reason, the CCM1 model for 21k was used for comparison against only those sites from the 21000 cal BC – 25000 cal BC time slices. The frequency distribution suggests that while the site locations vary in temperature from -21°C to +12°C, almost 50% of the data are found in categories -9°C and -7°C. While it may not consistent with the testing of the previous variables, it does allow for satisfactory results to be achieved.

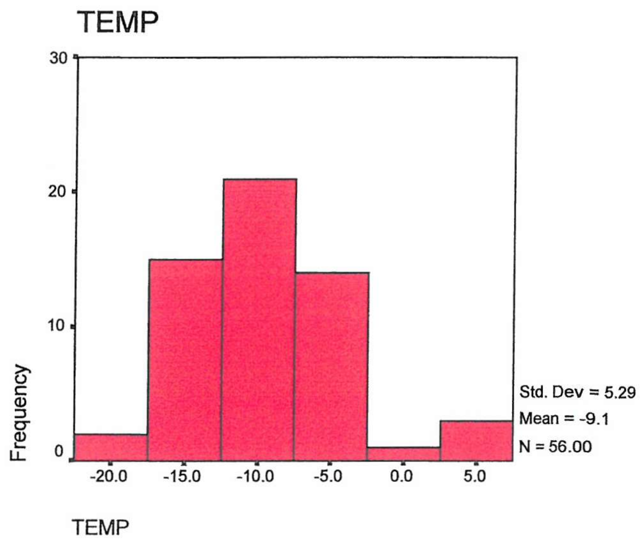


Figure 5.21: Frequency distribution of temperature for all known site locations.

TEMP

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	-19.0	2	3.6	3.6	3.6
	-16.0	3	5.4	5.4	8.9
	-14.0	6	10.7	10.7	19.6
	-13.0	6	10.7	10.7	30.4
	-12.0	2	3.6	3.6	33.9
	-10.0	2	3.6	3.6	37.5
	-9.0	16	28.6	28.6	66.1
	-8.0	1	1.8	1.8	67.9
	-7.0	10	17.9	17.9	85.7
	-3.0	4	7.1	7.1	92.9
	-1.0	1	1.8	1.8	94.6
	6.0	3	5.4	5.4	100.0
	Total	56	100.0	100.0	

Table 5.12: Frequency distribution of temperature for all known site locations.

Temperature	Observed	Area (%)	Expected	χ^2
-19	2	2.7	2.13	0.01
-16	3	4.21	3.32	0.03
-14	6	5.47	4.31	0.66
-13	6	5.47	4.31	0.66
-12	2	4	3.15	0.42
-10	2	6	4.73	1.58
-9	16	6	4.73	26.85
-8	1	6	4.73	2.94
-7	10	6	4.73	5.87
-3	4	18.08	14.27	7.39
-1	1	10	7.84	5.97
6	3	2.31	1.82	0.77
7 cats without sites	0	23.76	12.88	12.88
Total	56	100	56	**88.79**

Table 5.13: Chi-Squared Test results for temperature data at 21k, showing observed actual site locations (from 21000 cal BC – 25000 cal BC inclusive), the percent of the total area characterised by each value, the expected distribution and chi-squared results.

Significance testing was carried out on the temperature data (Table 5.13).

A significance level of 0.05 with 18 degrees of freedom was used to perform the 1-sample chi-squared test where

H_0 = there is not a significant difference in the distribution of sites across the categories.

H_1 = there is a significant difference in the distribution of sites across the categories.

$\chi^2_\alpha = 28.8693$

$\chi^2_{calc} = 88.79$

Since χ^2_{calc} (88.79) $\geq \chi^2_\alpha$ (28.8693) then H_0 is rejected. This indicates that there is a significant difference in the distribution of sites across the categories, which warrants further investigation. The significance test was performed on the data corresponding to the LGM. Frequencies and significance testing support the use of palaeo-temperature data as a predictive indicator of colonisation processes.

Summary

The primary concern in testing variables for the predictive model relates to the large scale of the spatial area in comparison to the small number of site locations on which the modelling procedure depends. The above analysis has led to the conclusion that aspect, drainage and slope must be eliminated as potential variables for use in the predictive modelling process. The environmental variables that will be used as predictive indicators are elevation, watershed basins, geology and temperature.

5.3 LOGISTIC REGRESSION

To perform the logistic regression procedure, the statistical package, SPSS was used (SPSS Inc., 1989-1999). This software consists of a complex set of analytical products and modules to aid user-specific research. The main advantages to SPSS are its ability to extract and explore data, and its predictive modelling capabilities.

Logistic regression is considered to be "one of the most powerful and flexible statistical techniques" for predictive modelling (Warren and Asch, 2000: 8). It is a statistical procedure useful in archaeological applications in which you want to predict the presence or absence of a site based on the values of a set of predictor variables. Logistic regression analysis is a flexible, probabilistic procedure that is based on one or more independent variables. These can be classified as descriptive variables since they tend to describe the dependent variable that is the subject of the modelling objective. This means that those variables chosen as input data must be selected for their potential role in influencing the outcome of the model. In this case, the variables are chosen for their potential to influence the decision-making processes that directed the movement of Upper Palaeolithic hunter-gatherers. The independent variables are the environmental variables outlined in the previous section, and the dependent variable is the site or non-site location. The method determines the probability that each variable is present or absent at each site location (Warren 1990).

The logistic regression formula "defines an S-shaped probability curve of group membership along an axis" where the axis represents the "interaction of environmental variables that best discriminates site locations from nonsite locations" (Warren and Asch 2000, 8). Discriminatory variables take on any form, such as personality traits or technologically classified groups (e.g. Gravettian), but for the purposes of this model, environmental variables are used. Figure 5.22 shows the structure of the logistic regression model. It can be tested for accuracy by applying the model to a sample data set and then predicting site locations. The most appropriate procedure for this is to randomly select the latter data to be withheld from the initial modelling test data (training data). The model is tested against the random data set. Frequencies showing the number of predicted and not predicted samples will demonstrate the accuracy of the model (Warren and Asch 2000, 9; Westcott and Kuiper 2000, 70). To illustrate the method, the data for 18000 cal BC is used.

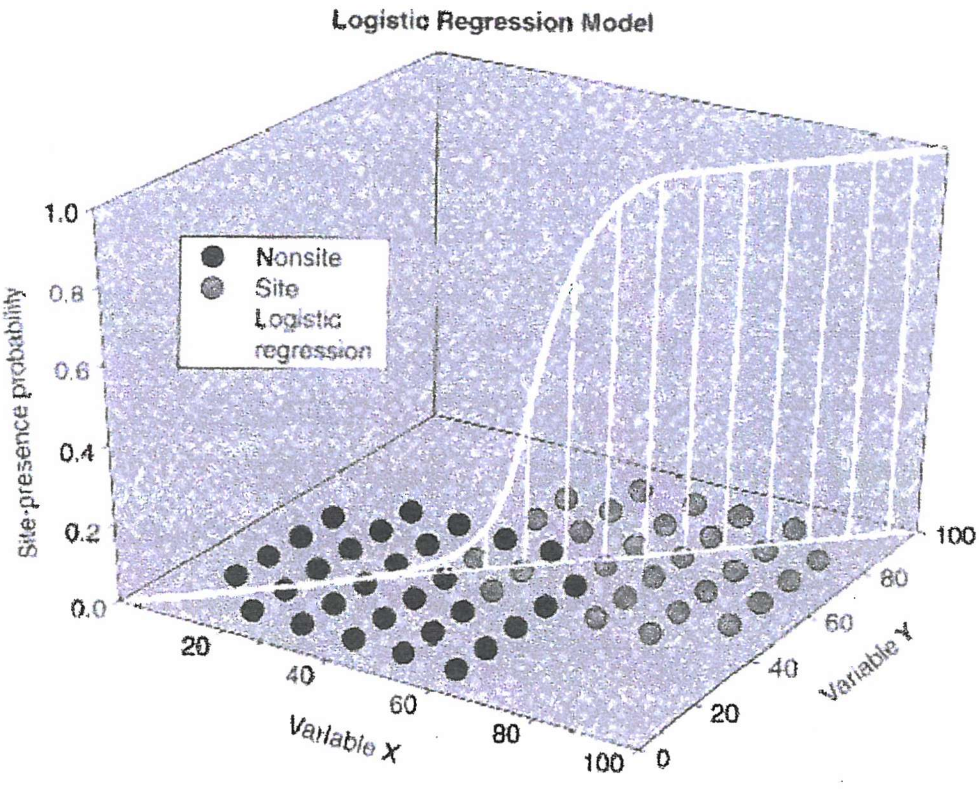


Figure 5.22: Sample Logistic Regression Model for two groups of objects across two independent variables. The line running across the centre is the axis that best discriminates between sites and non-sites. The S-shaped curve line shows an increase (from left to right) in the probability that sites are present (after Warren and Asch 2000, 9).

5.3.1 Testing the Method

To test the method, site and non-site data for 18000 cal BC are randomly sampled. This sample data set is used to test the logistic regression model. The remaining data for 18000 cal BC are used to confirm the results of the sample test. Using the block entry method (a procedure for variable selection in which all variables in a block are entered in a single step), a logistic regression model was generated with a significance level of 0.05 and removal factor of 0.10. In other words, a 95% confidence level was required. The procedure was performed step-by-step, removing one sample with each step. A cut-off factor of 0.5 was implemented. Table 5.14 shows the output.

The results of the regression model suggest that elevation was not as significant an indicator as were watershed basins, geology and temperature (Table 5.14, column Sig.). Note that only 50% of non-sites were predicted compared to 75% of known sites. This is most likely due to the small sample size.

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	ELEV	.709	.627	1.279	1	.258	2.033
	BASIN	-.079	.115	.477	1	.490	.924
	GEOLOGY	-.301	.609	.245	1	.621	.740
	TEMP	.080	.161	.246	1	.620	1.083
	Constant	.481	2.797	.030	1	.864	1.617

a. Variable(s) entered on step 1: ELEV, BASIN, GEOLOGY, TEMP.

Classification Table[a]

	Observed		Predicted SITE 1	Predicted SITE 0	Predicted Percentage Correct
Step 1	SITE	1	6	2	75.0
		0	4	4	50.0
	Overall Percentage				62.5

a. The cut value is .500

Table 5.14: Logistic regression model for 18000 cal BC experimental data set. B = estimated regression coefficient, S.E. = standard error, Wald = square of the ratio of the coefficient to its standard error, df = degrees of freedom, Sig = significance level for Wald (description after Hosfield 1999, 58).

Categorical Variables Codings

		Frequency	Parameter coding (1)	(2)	(3)	(4)	(5)	(6)	(7)
BASIN	.0	3	1.000	.000	.000	.000	.000	.000	.000
	4.0	3	.000	1.000	.000	.000	.000	.000	.000
	6.0	2	.000	.000	1.000	.000	.000	.000	.000
	14.0	2	.000	.000	.000	1.000	.000	.000	.000
	16.0	1	.000	.000	.000	.000	1.000	.000	.000
	20.0	1	.000	.000	.000	.000	.000	1.000	.000
	22.0	2	.000	.000	.000	.000	.000	.000	1.000
	26.0	2	.000	.000	.000	.000	.000	.000	.000
GEOLOGY	0	2	1.000	.000	.000	.000			
	1	3	.000	1.000	.000	.000			
	2	8	.000	.000	1.000	.000			
	3	1	.000	.000	.000	1.000			
	5	2	.000	.000	.000	.000			

Table 5.15: Variable coding for watershed basins and geology.

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	ELEV	4.739	76.653	.004	1	.951	114.317
	BASIN			.010	7	1.000	
	BASIN(1)	15.871	508.058	.001	1	.975	7810787
	BASIN(2)	-1.768	387.888	.000	1	.996	.171
	BASIN(3)	3.930	366.856	.000	1	.991	50.915
	BASIN(4)	33.242	431.487	.006	1	.939	2.7E+14
	BASIN(5)	38.842	824.305	.002	1	.962	7.4E+16
	BASIN(6)	31.391	558.339	.003	1	.955	4.3E+13
	BASIN(7)	-6.011	433.090	.000	1	.989	.002
	GEOLOGY			.001	1	.970	
	GEOLOGY(2)	-17.011	449.028	.001	1	.970	.000
	TEMP	-2.329	37.555	.004	1	.951	.097
	Constant	-44.966	545.083	.007	1	.934	.000

a. Variable(s) entered on step 1: ELEV, BASIN, GEOLOGY, TEMP.

Classification Table[a]

	Observed		Predicted SITE 1	SITE 0	Percentage Correct
Step 1	SITE	1	7	1	87.5
		0	1	7	87.5
	Overall Percentage				87.5

a. The cut value is .500

Table 5.16: Logistic regression model resulting from the categorical classification of watershed basins and geology.

The same method was conducted to show the categorical data for both watershed basins and geology (Table 5.16). Table 5.15 shows the variable coding for these two categories.

The logistic regression model shows that Geology 2 (Cenozoic-sedimentary) is the most significant category of this variable. Watershed basins are more uniformly distributed in this model than in the first. When the same procedure is performed such that, *either* the watershed basins *or* geology are categorised, the results show a larger percentage of non-sites predicted than actual sites. This would suggest a problem in the method that can be commonly attributed to incorrect classification of the data type. In all cases where basins and geology were categorised in this manner, the distribution of sites was more evenly spread over the landscape. This is because the model was required to perform several more calculations on a limited data set. The model weights the data in a different order thus increasing the chance, or probability, that each site will occur only once in a given combination.

This may also be a result of other methodological complications. First, the statistical package recognises non-scalar data as categories in the first place, but unless specified in the above fashion, will not output distinguishing factors (refer to Table 5.15). Second, there are a limited number of site locations across a large, spatially diverse landscape and this may influence the results. When the regression model was run on the re-categorised data shown in Table 5.16, the result was a map with single values of 0 (no data) and 1 (data) suggesting that the distribution of sites across the spatial area was uniform, even though the input variables were the same.

The next step of the modelling procedure involves producing a mathematical equation that can be used to input the logistic regression results back into the GIS. The output results in a raster cost surface map illustrating the predictive likelihood of locating sites in the given landscape. The mathematical equation is developed using the estimated regression coefficient (Table 5.16, column B) multiplied by the predictive indicator variable data in the form:

train18=100*(1/(1+exp(-(0.481+(0.709*reclass18)+(-0.079*b18)+
(-0.301*geology)+(0.080*t21)))))

where train18 = cost surface, reclass18 = elevation, b18 = watershed basin and t21 = palaeo-temperature. The resulting map for this output is shown in Figure 5.23. The cost surface is represented by categories on a scale of 0 – 1 statistically, and 0 - 100 on the raster map - the lower the value, the higher the probability of site location. The data are then reclassified on a scale of 0 to 5 to allow for better analysis and visualisation of site location potential such that it will also accommodate the small sample size at 1000-year intervals. The result of this can be seen in Figure 5.24 where the testing sample, randomly selected and removed from the 18000 cal BC data set (and consisting of sites and non-sites) is plotted along-side the training sample (consisting of sites and non-sites) and actual site locations, across the cost surface.

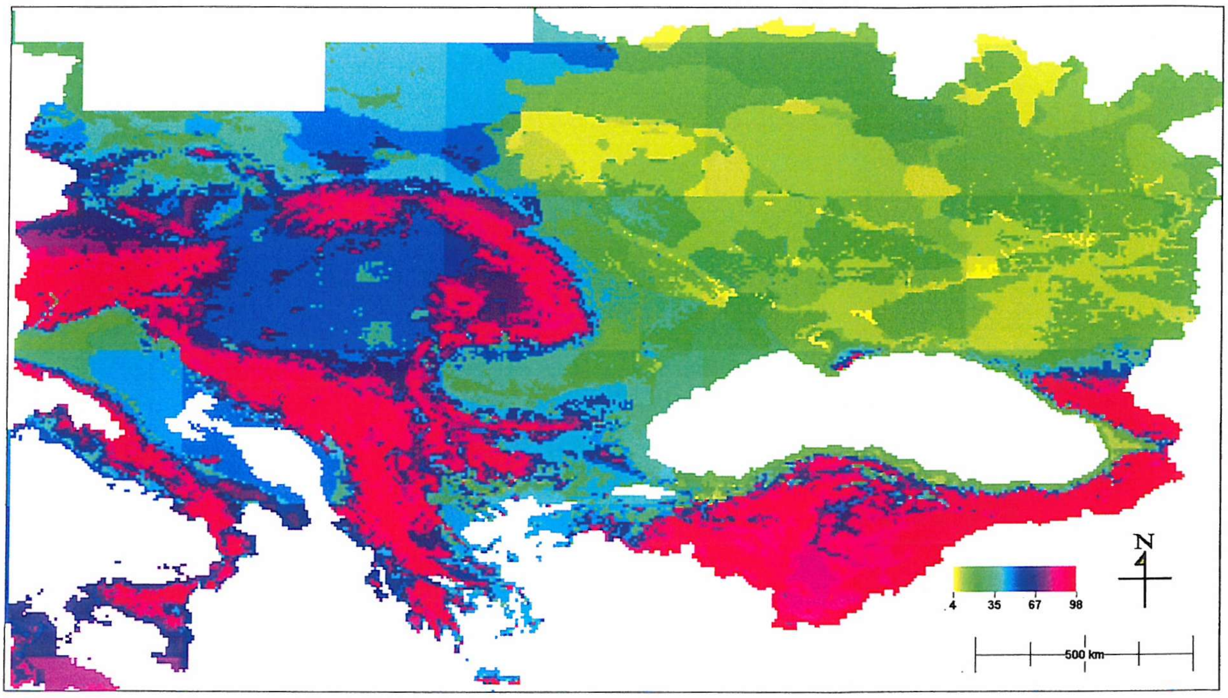
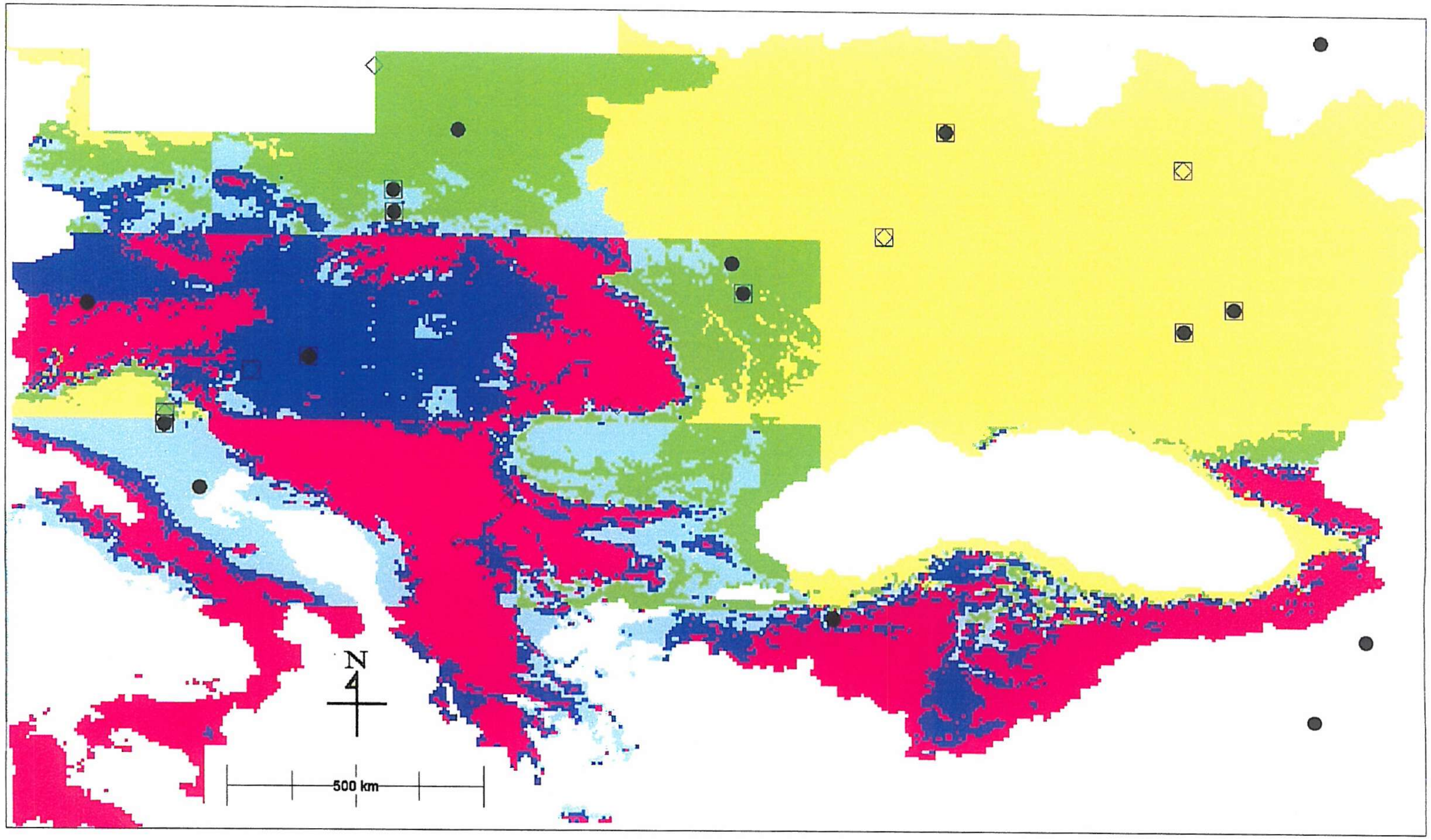


Figure 5.23: Cost surface for the experimental 18000 cal BC site and non-site locations. The lower the value (yellow), the higher the probability for site location.

Figure 5.24: 18000 cal BC sample site locations.
Test sample = Diamond; Training sample = Solid Dot; Actual sites = Square.
Data are plotted against the re-classed cost surface for 18000 cal BC.
0 = no data, 1(yellow) = 1-20 or very high probability, 2(green) = 21-40 or high probability,
3(light blue) = 41-60 or average, 4(blue) = 61-80 or low probability, 5(red) = 81-100 or very low probability.



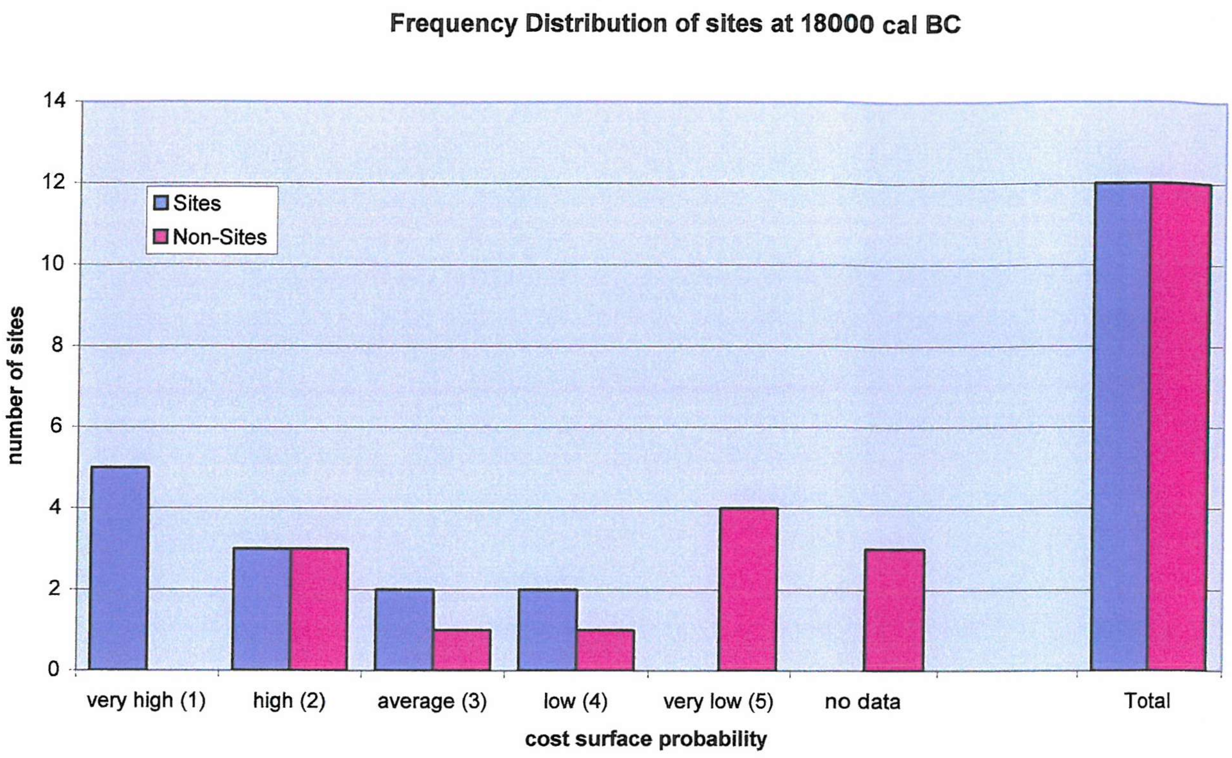
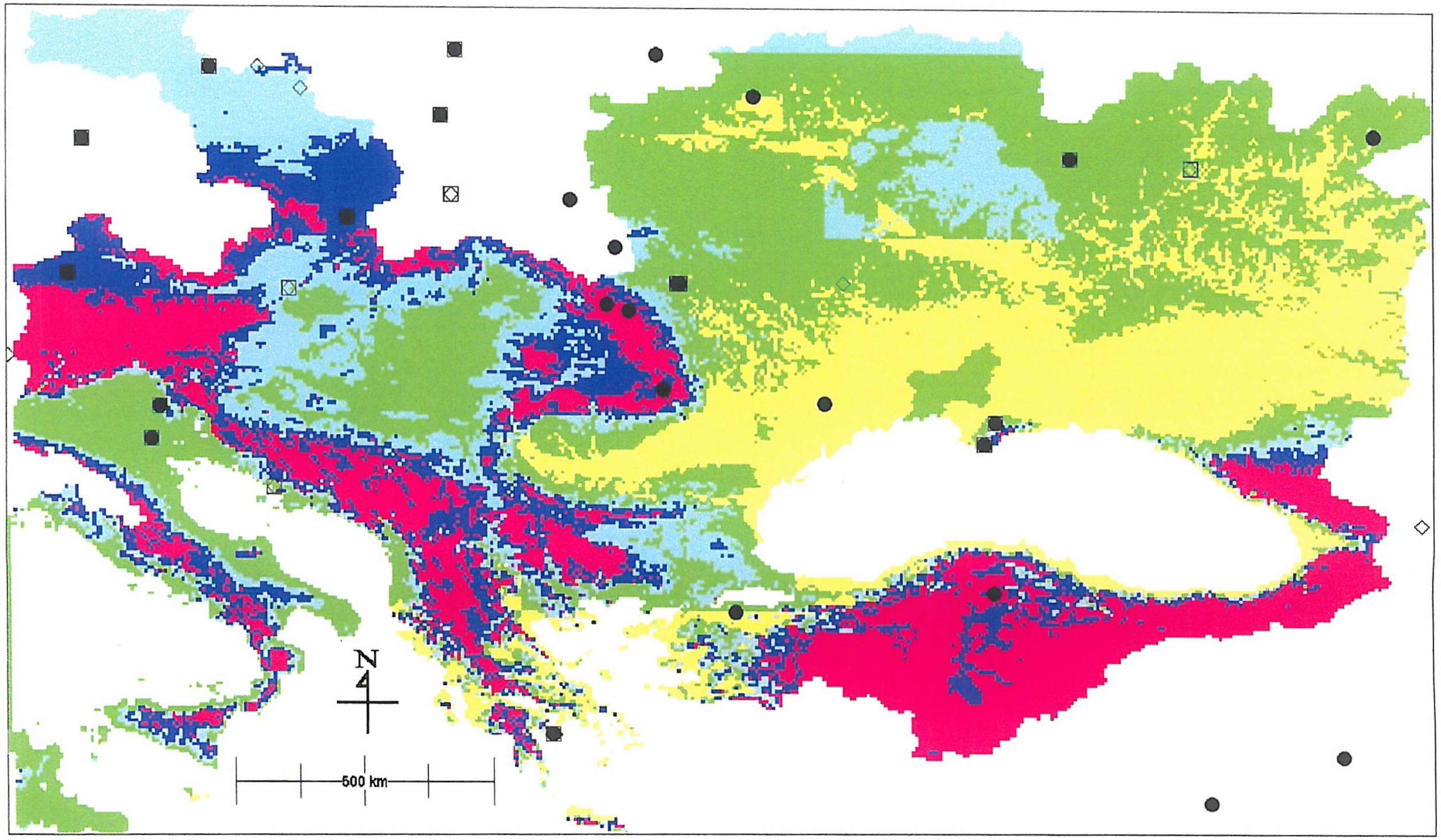


Figure 5.25: Frequency distributions of sites and non-sites across the cost surface. The lower the *x*-axis value, the higher the probability for site location.

The frequency of occurrence of site and non-site locations over the cost surface is shown in Figure 5.25. The results indicate that approximately 50% of the randomly selected non-sites correlated well to the predictive cost surface. Both actual sites and randomly produced non-sites are found together in the middle range of categories. At either ends of the spectrum, no non-sites are located in very high probability areas, and no actual sites are located in very low probability areas. I would suggest that these are satisfactory results that will allow patterns in the data to be observed in the final output of the predictive model.

Figure 5.26: 11000 cal BC sample site locations.
Test sample = Diamond; Training sample = Solid Dot; Actual sites = Square.
Data are plotted against the re-classed cost surface. 0 = no data, 1(yellow) = 1-20 or very high probability, 2(green) = 21-40 or high probability, 3(light blue) = 41-60 or average, 4(blue) = 61-80 or low probability, 5(red) = 81-100 or very low probability.



As a check the method was then applied to the temporal interval of 11000 cal BC. This time slice consists of a total of 36 site and non-site locations. Figure 5.26 shows the testing sample, randomly selected and removed from the 11000 cal BC data set (and consisting of sites and non-sites) plotted along-side the training sample (consisting of sites and non-sites) and actual site locations, across .the reclassified cost surface for 11000 cal BC. Figure 5.27 shows the frequency distribution of sites and non-sites for 11000 cal BC. Again, the results show that the mid-range probabilities are comparable between site and non-site data.

Despite two test site/non-site locations and several original "training" locations falling within the no-data category resulting from the watershed basin reconstructions, the predictive modelling process shows promise in this example. Elevation, geology and watershed basin play a more significant role during this warmest time in the study period, while palaeo-temperature appears to be a less important consideration. This is not surprising since the warmer temperatures would have been less of a barrier to population dispersal. As shown in the previous example, colder temperatures would have affected the types and abundance of resources, thus exerting greater influence on site location.

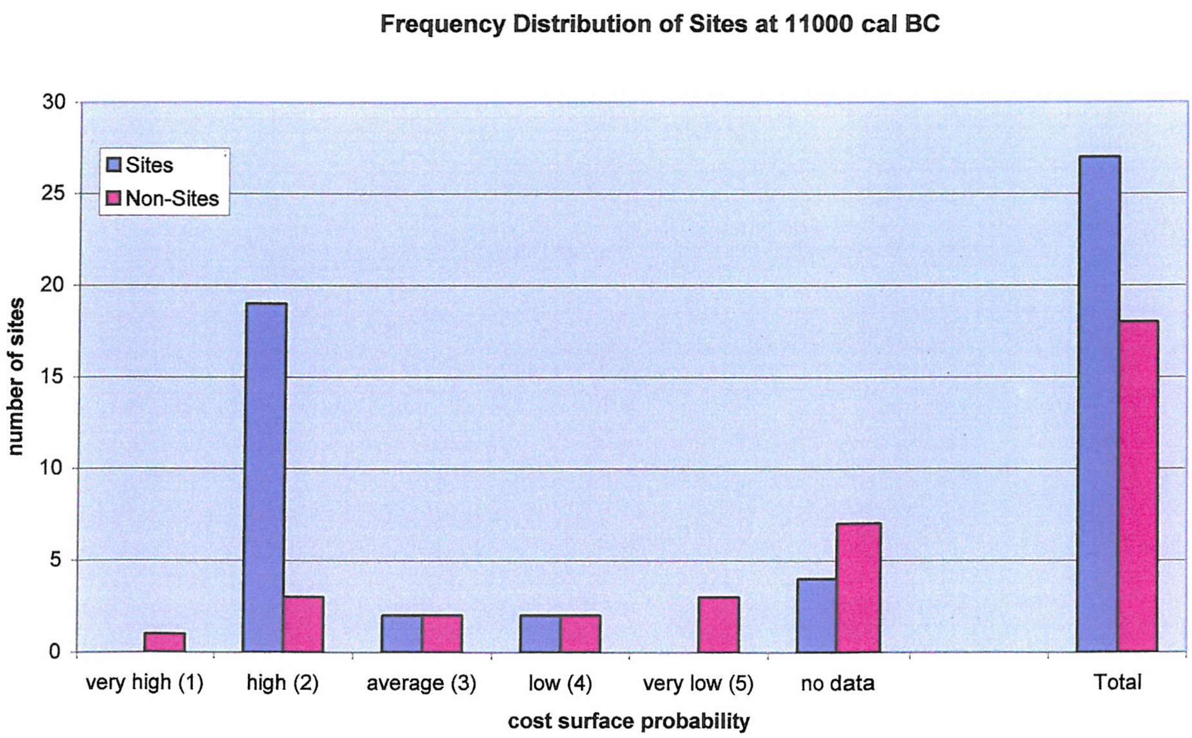


Figure 5.27: Frequency distribution of site and non-site data for 11000 cal BC.

5.4 A SPATIAL – TEMPORAL PREDICTIVE MODEL

The spatial-temporal model consists of 15 time slices, each representing a sub-model that predicts the probability for locating archaeological sites for the given 1000-year interval. The sub-models are then used to develop and interpret a combined spatial-temporal model that will explore the predicted colonisation processes for the Upper Palaeolithic of Central Europe.

5.4.1 The Sub-Model Output – Time Slices

Each time slice is unique in that the chronological, spatial and environmental characteristics change with each. In this section, these sub-models are interpreted.

Each of the sub-models (time slices) are displayed as raster maps and show the location of actual sites, the location of the randomly predicted sites (generated over a constant surface) as well as site and non-site locations for the *next* temporal interval. The data are output on a scale of 1 – 100 such that the lower the value, the higher the probability of site location. Each sub-model displays a legend that begins with the lowest value represented on the map. Therefore, on the reclassification scale shown in the previous section, values of 1 – 20 indicate very high probability, 21 – 40 suggest high probability, 41 – 60 are average, 61 – 80 indicate low predictability and 81 –100 suggest very low probability for predicting sites. The maps are shown in Figures 5.28 – 5.41, pages 196-202.

The logistic regression output for the sub-models yielded correct overall predictions as low as 55% for 12000 cal BC and as high as 80% for 16000 cal BC. The average percentage of correct predictions was approximately 67%. This is reflected in each of the maps. The temporal intervals with the lowest predictive percentages are those showing a larger sample of *actual* site locations in the lower half of the probability scale than in the higher. One alternative speculation to explain this might be that environmental variables weighed more heavily in the predictive process at certain times (e.g. 16000 cal BC = Oldest Dryas).

Site and non-site locations for each time slice, and site and non-site data representing 1000 years younger, were plotted to show the temporal predictive value of the model. In the case of each sub-model, these latter data are clearly associated with regions of higher probability for prediction (see Figures 5.28 – 5.41, 196-202).

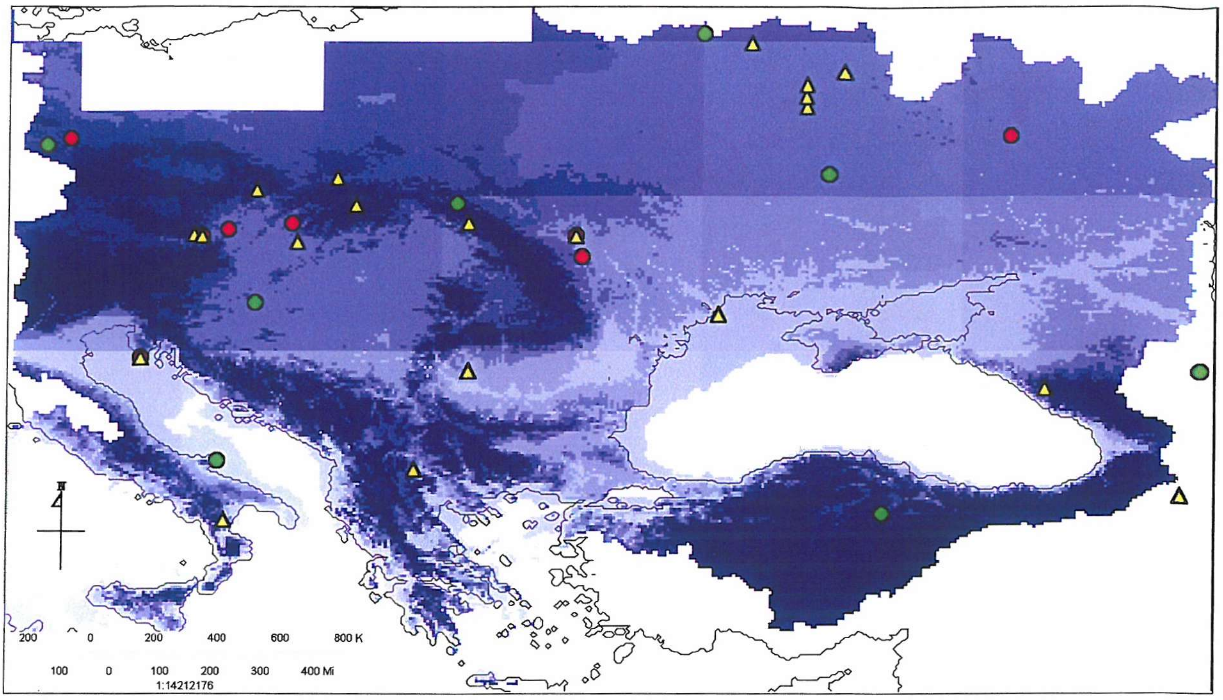


Figure 5.28: 25000 cal BC. Red = site; Green = non-site; Yellow = site and non-site for 24000 cal BC. Lighter blue values = higher probability for site location. Darker blue values = lower probability for site location.

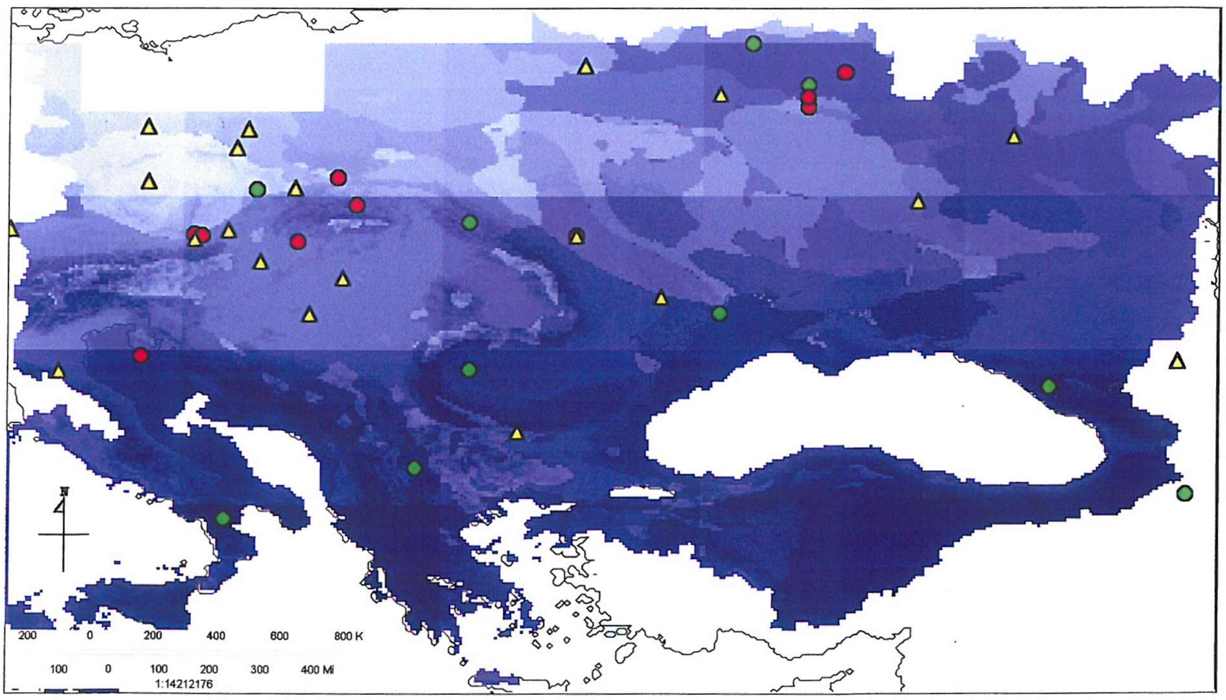


Figure 5.29: 24000 cal BC. Red = site; Green = non-site; Yellow = site and non-site for 23000 cal BC. Lighter blue value = higher probability for site location. Darker blue value = lower probability for site location.

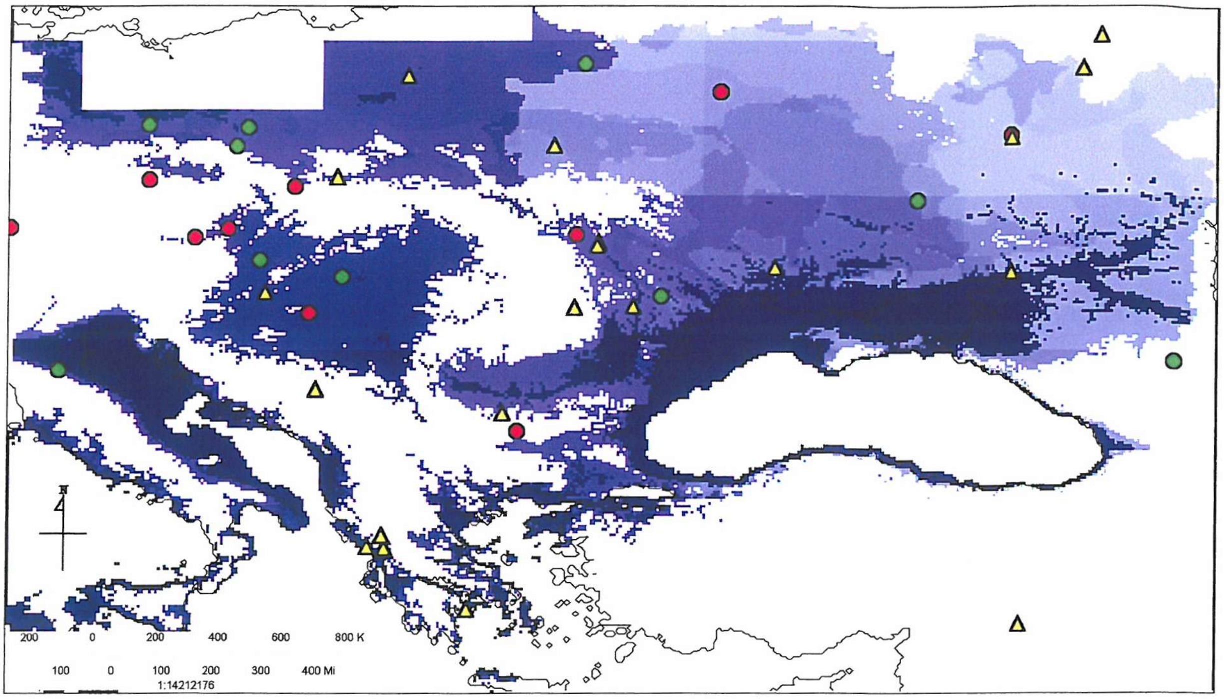


Figure 5.30: 23000 cal BC. Red = site; Green =non-site; Yellow = site and non-site for 22000 cal BC. Lighter blue value = higher probability for site location. Darker blue value = lower probability for site location.

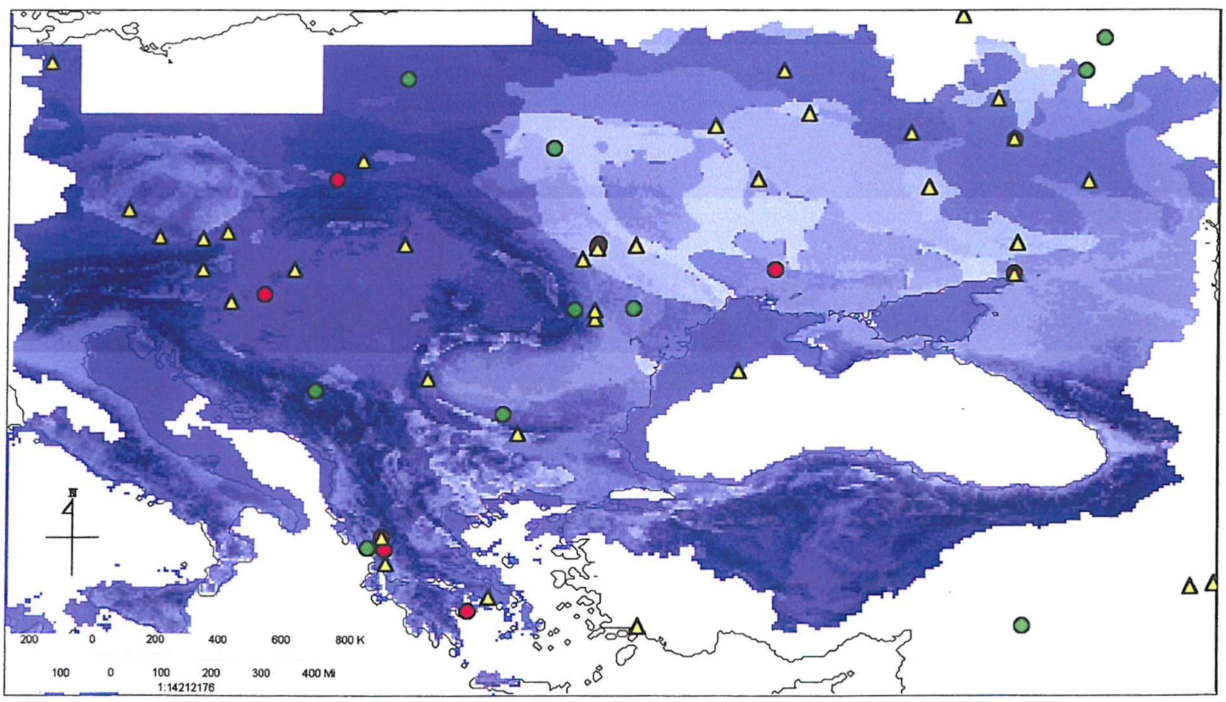


Figure 5.31: 22000 cal BC. Red = site; Green =non-site; Yellow = site and non-site for 21000 cal BC. Lighter blue value = higher probability for site location. Darker blue value = lower probability for site location.

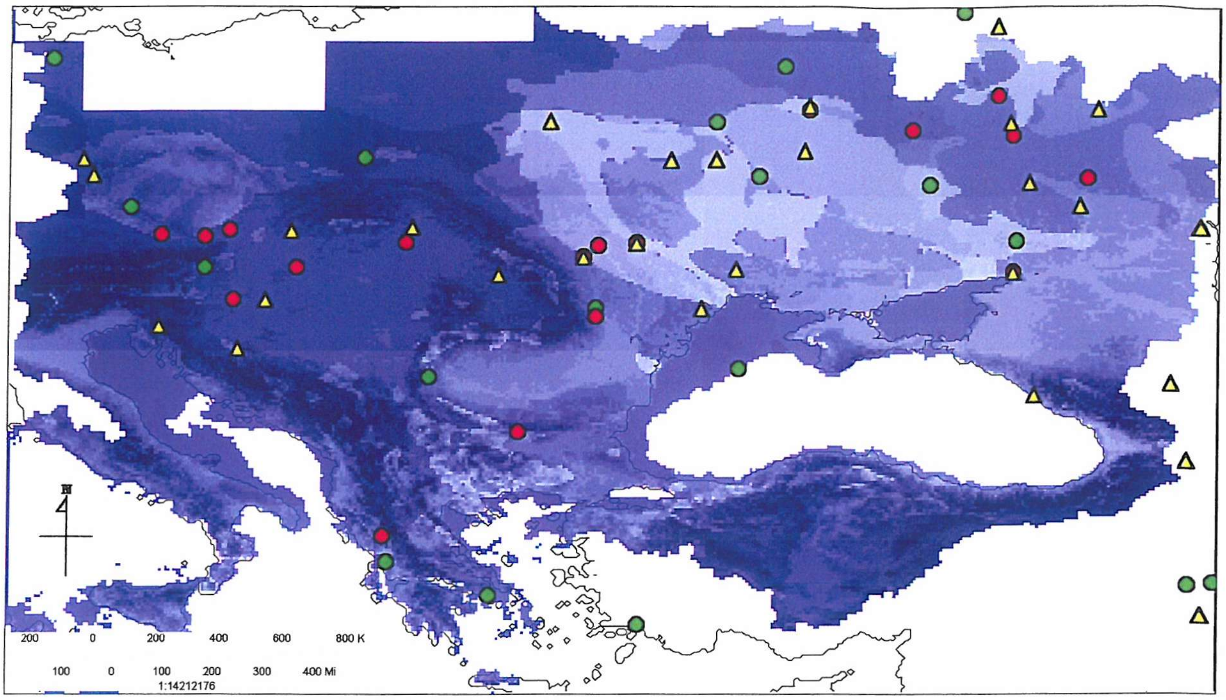


Figure 5.32: 21000 cal BC. Red = site; Green =non-site; Yellow = site and non-site for 20000 cal BC. Lighter blue value = higher probability for site location. Darker blue value = lower probability for site location.

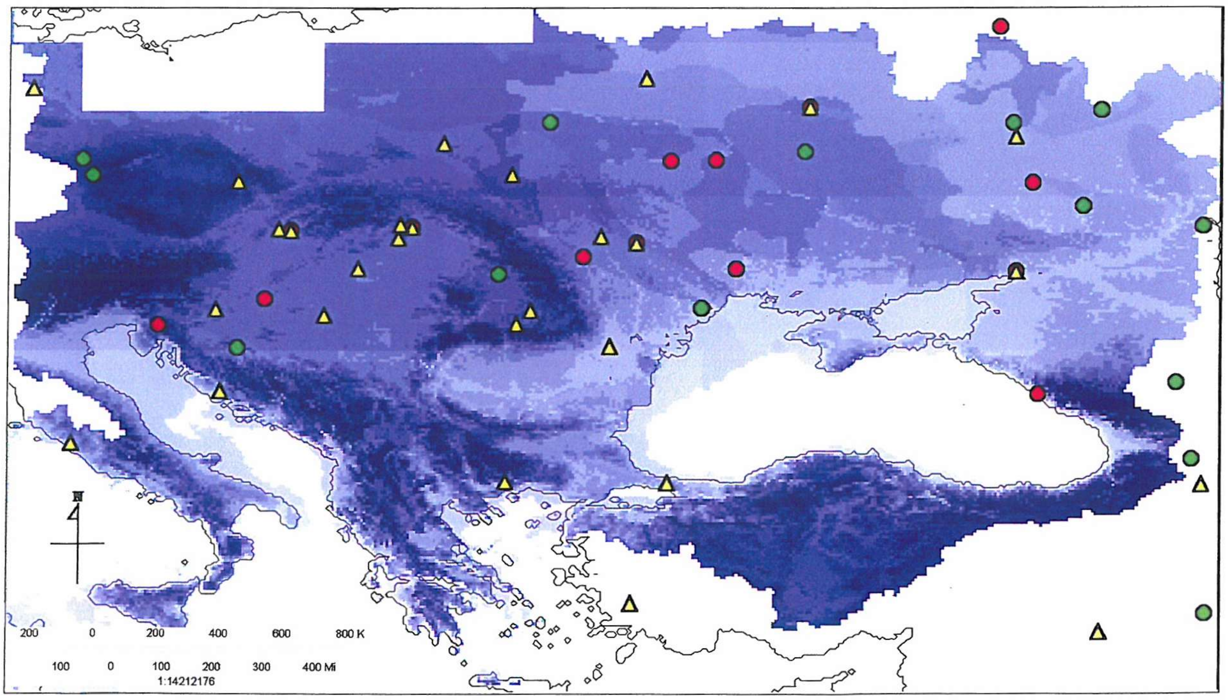


Figure 5.33: 20000 cal BC. Red = site; Green =non-site; Yellow = site and non-site for 19000 cal BC. Lighter blue value = higher probability for site location. Darker blue value = lower probability for site location.

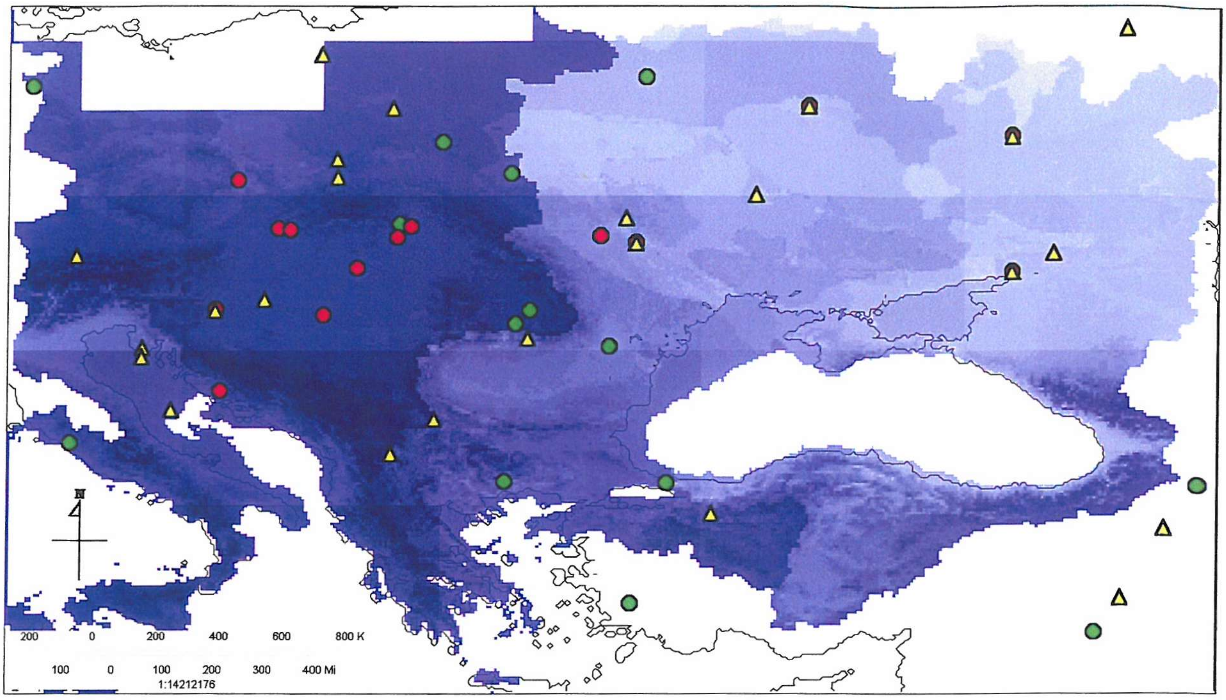


Figure 5.34: 19000 cal BC. Red = site; Green =non-site; Yellow = site and non-site for 18000 cal BC. Lighter blue value = higher probability for site location. Darker blue value = lower probability for site location.

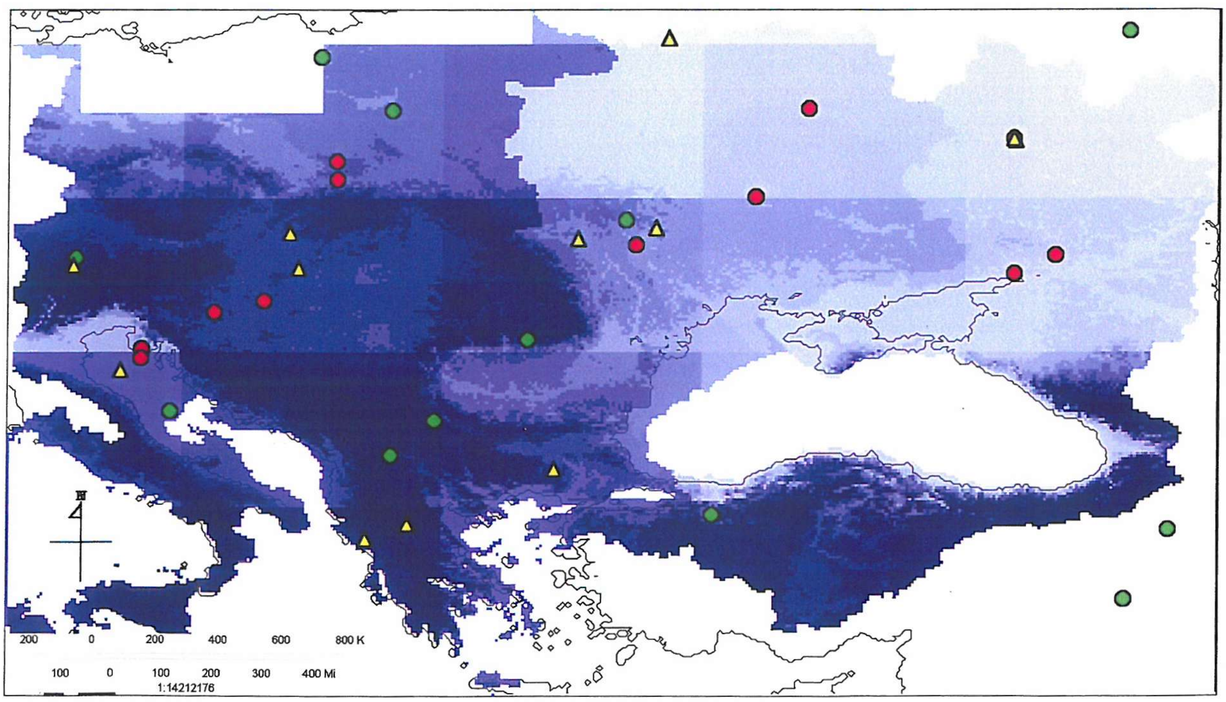


Figure 5.35: 18000 cal BC. Red = site; Green =non-site; Yellow = site and non-site for 17000 cal BC. Lighter blue value = higher probability for site location. Darker blue value = lower probability for site location.

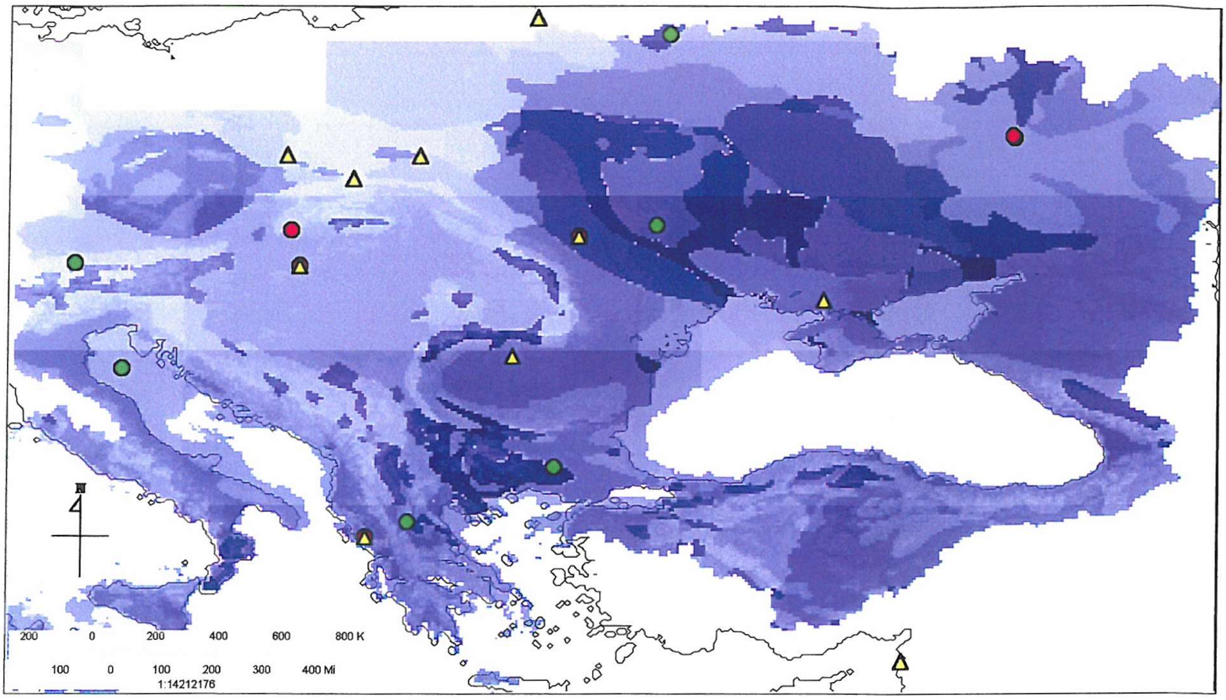


Figure 5.36: 17000 cal BC. Red = site; Green =non-site; Yellow = site and non-site for 16000 cal BC. Lighter blue value = higher probability for site location. Darker blue value = lower probability for site location.

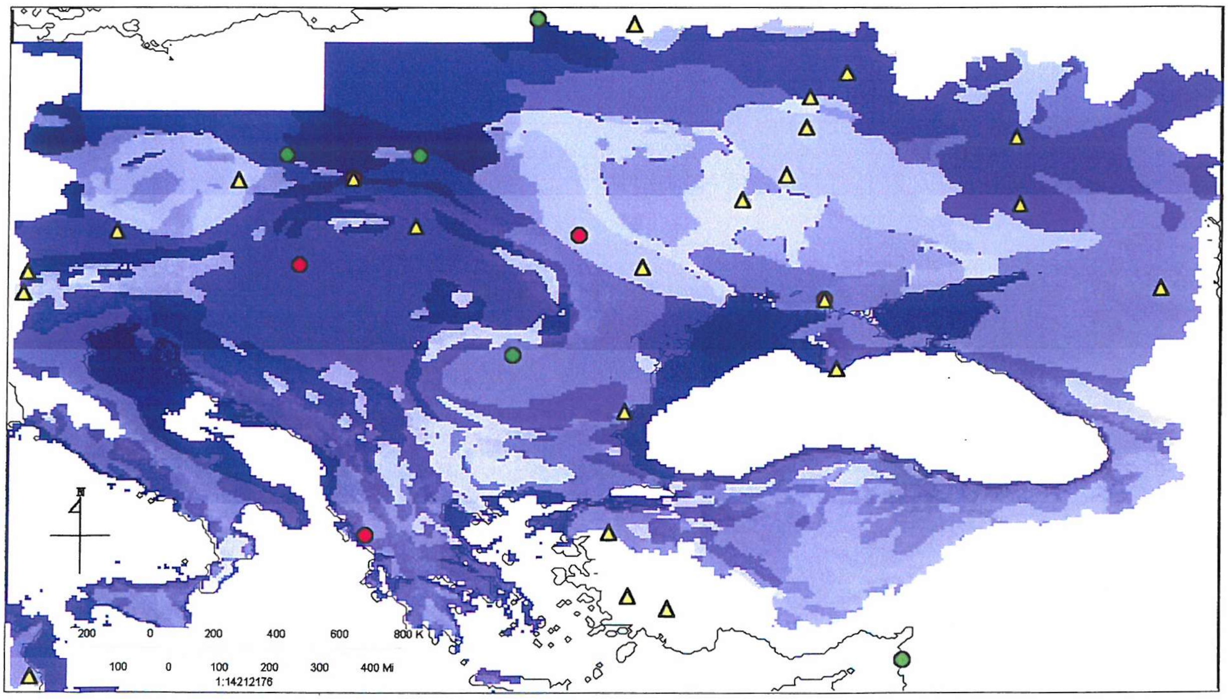


Figure 5.37: 16000 cal BC. Red = site; Green =non-site; Yellow = site and non-site for 15000 cal BC. Lighter blue value = higher probability for site location. Darker blue value = lower probability for site location.

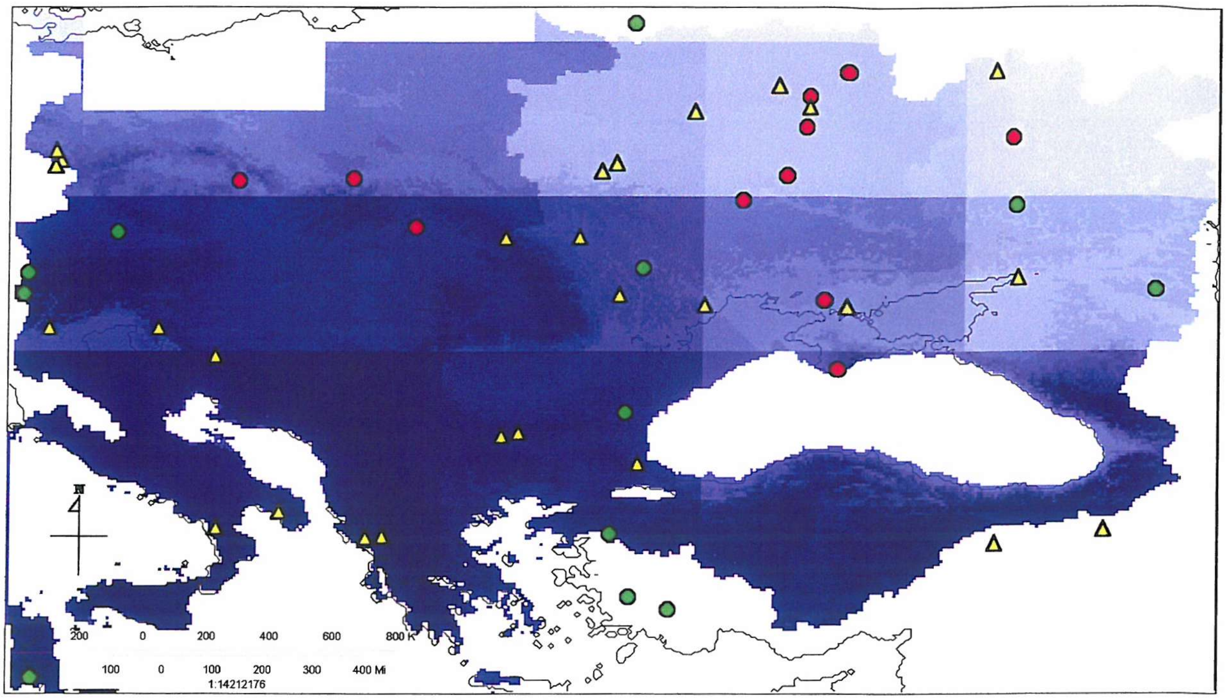


Figure 5.38: 15000 cal BC. Red = site; Green =non-site; Yellow = site and non-site for 14000 cal BC. Lighter blue value = higher probability for site location. Darker blue value = lower probability for site location.

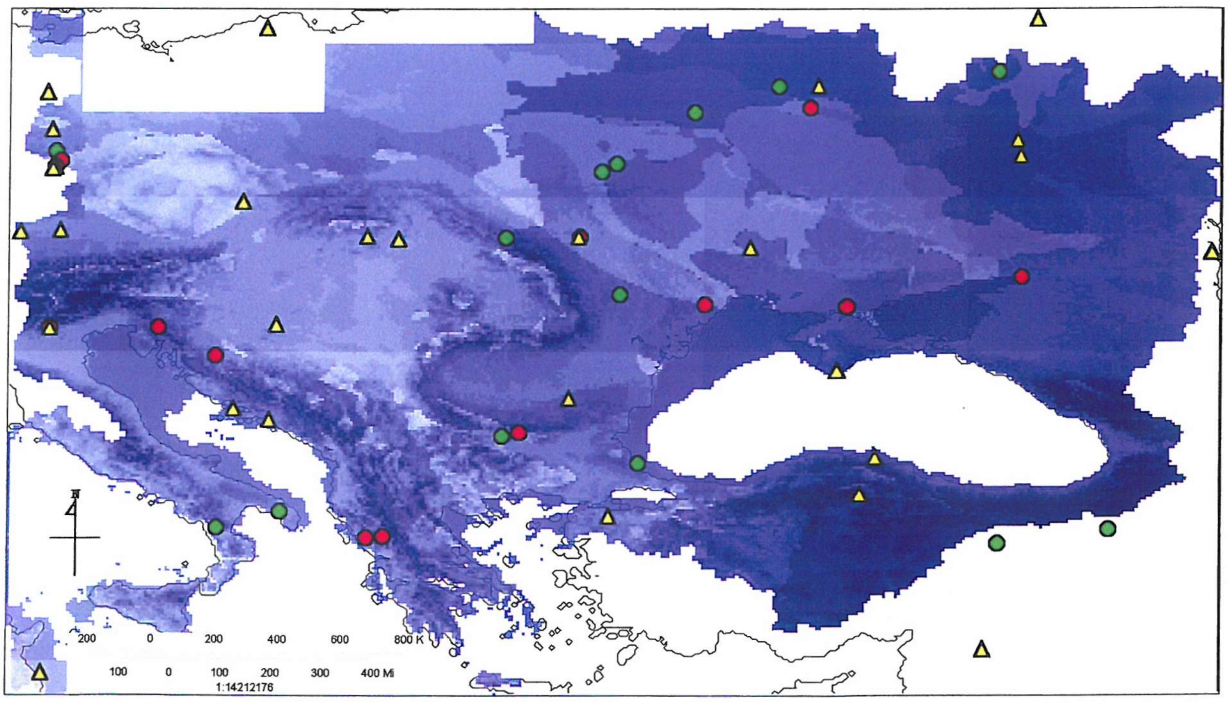


Figure 5.39: 14000 cal BC. Red = site; Green =non-site; Yellow = site and non-site for 13000 cal BC. Lighter blue value = higher probability for site location. Darker blue value = lower probability for site location.

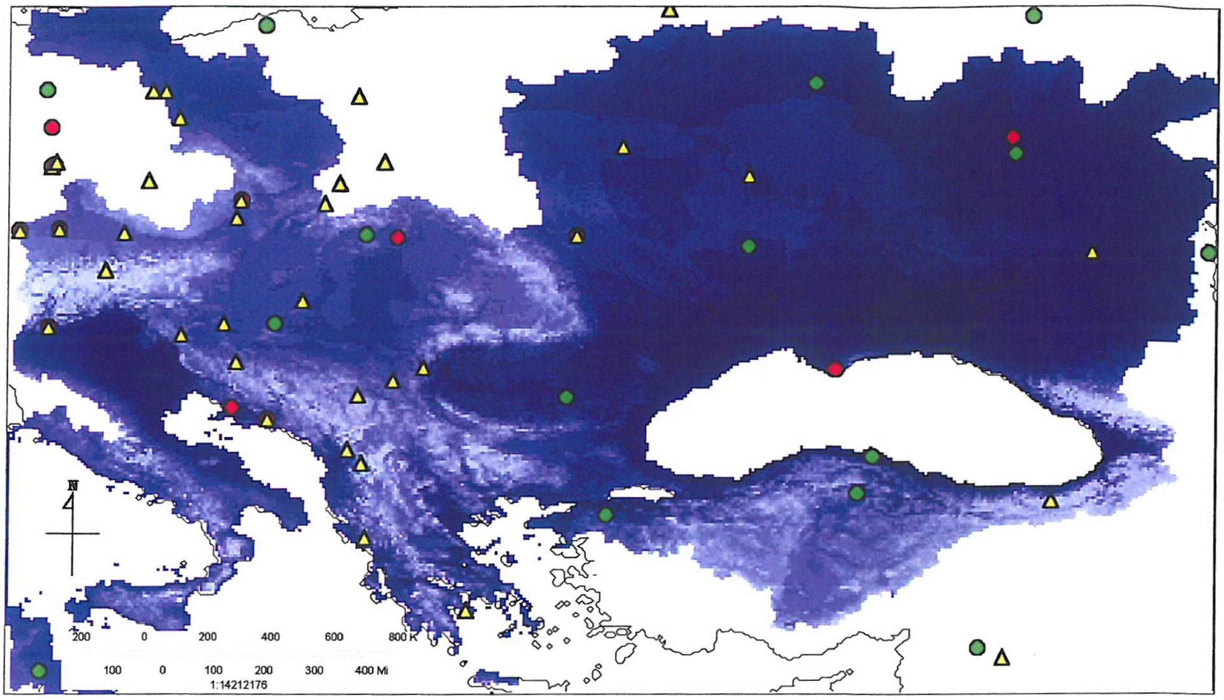


Figure 5.40: 13000 cal BC. Red = site; Green =non-site; Yellow = site and non-site for 12000 cal BC. Lighter blue value = higher probability for site location. Darker blue value = lower probability for site location.

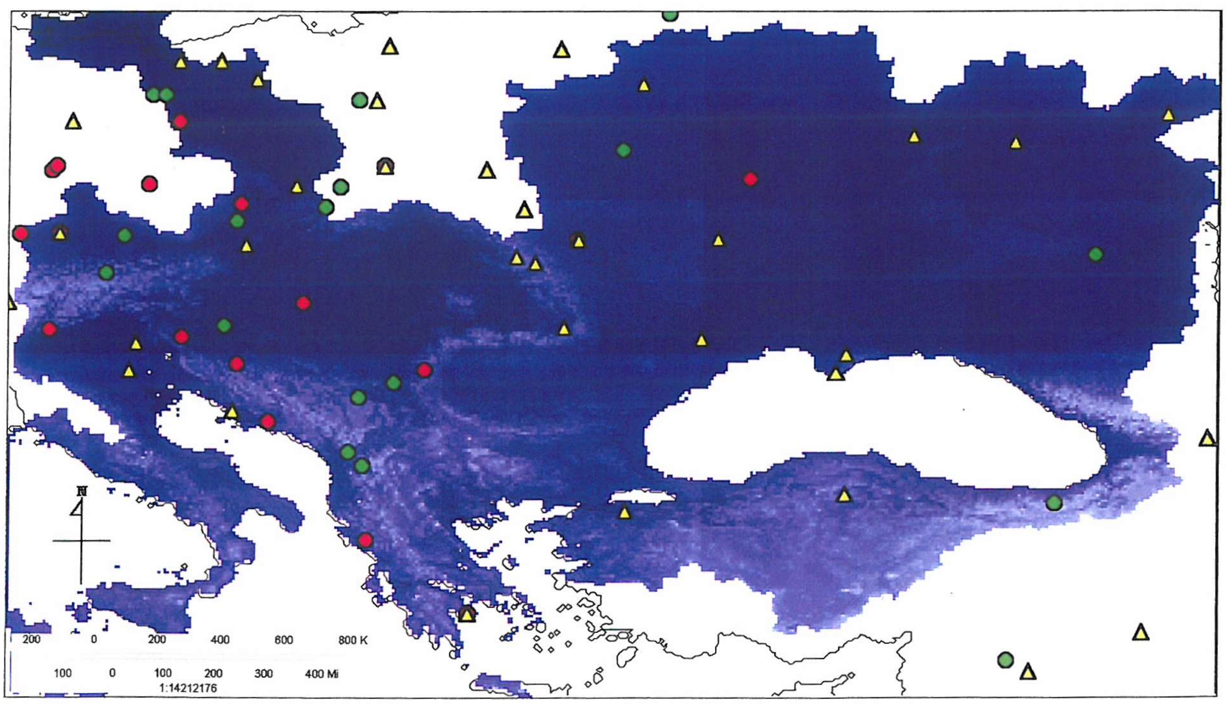


Figure 5.41: 12000 cal BC. Red = site; Green =non-site; Yellow = site and non-site for 11000 cal BC. Lighter blue value = higher probability for site location. Darker blue value = lower probability for site location.

5.4.2 The Primary Model

An examination of the predictive 1000-year sub-models to reveal colonisation patterns has therefore yielded interesting results. In this section a spatial-temporal model for archaeological visibility is presented. The results are synthesised to produce a general model of late Upper Palaeolithic colonisation processes in Central Europe. This synthesis is presented in Chapter Six.

To illustrate the predictive model, each of the predictive sub-model maps were reclassified into five categories: 1 = very high probability; 2 = high probability; 3 = medium; 4 = low probability; 5 = very low probability. Additionally, maps were produced to show the predictive output at the mid-point between each 1000-year time slice to better illuminate the spatial patterning through time. For example, if category 1 represents the highest probability of locating sites, and this in turn represents potential dispersal, or colonisation patterns, then the potential rates and directions of movement are more visible and more easily interpreted. The mid-point maps are simply derived by determining the average between two adjacent time slice maps. All of these maps are shown in Appendix F.

The predictive output suggests that during the coldest periods of the late Upper Palaeolithic (i.e. at the cold maximum and the Oldest Dryas) the highest probability locations are distributed as discreet locales in the landscape. This can be seen in the time slices 22500 – 22000 cal BC, representing the height of the LGM but is especially visible at 16500 – 16000 cal BC during the coldest part of the Oldest Dryas.

A second discernable observation is related to the influence of temperature on the results. During periods of rapid climate change such as the onset of the cold maximum shown on the 23000 cal BC sub-model, and the rapid climate warming following the Oldest Dryas as shown on the 15000 cal BC sub-model, the blocked temperature data is much more defined. This is particularly visible because of the coarse resolution of the original data. A comparison of the GISP2 $\delta^{18}O$ measurements and the North Atlantic surface temperature data (core CH73-139c) (Jöris and Weninger, 1999) shows correlation between spatial patterning and rapid temperature change (Figure 5.42).

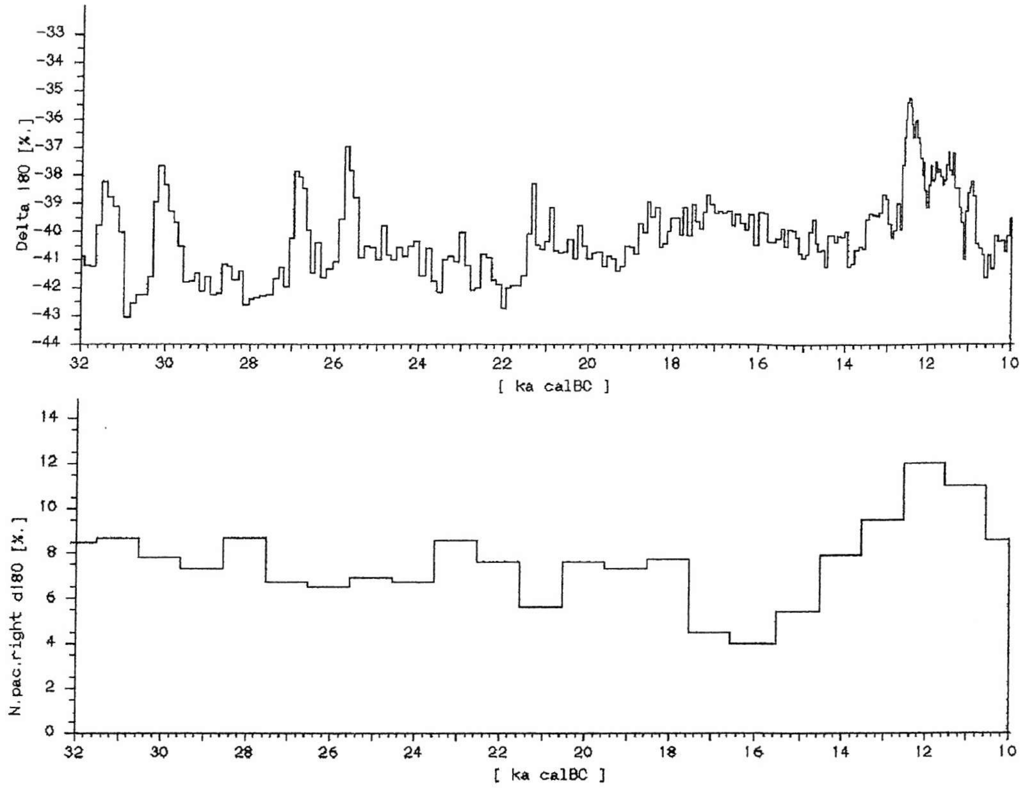


Figure 5.42: GISP2 $\delta^{18}O$ measurements and the North Atlantic surface temperature data (core CH73-139c) obtained via CALPAL (Jöris and Weninger, 1999).

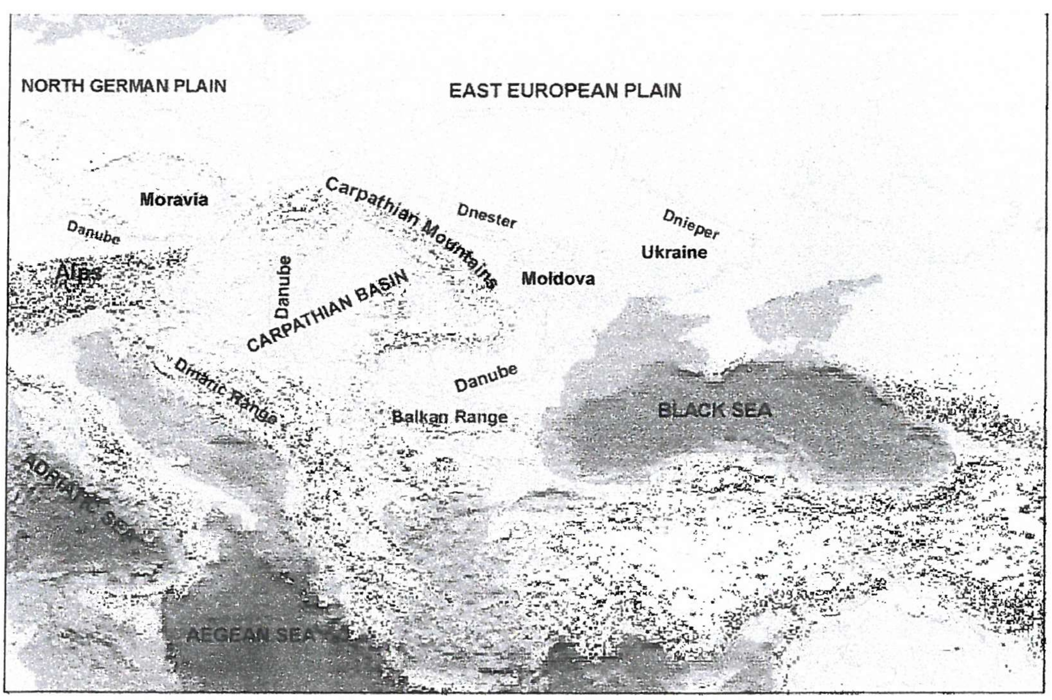
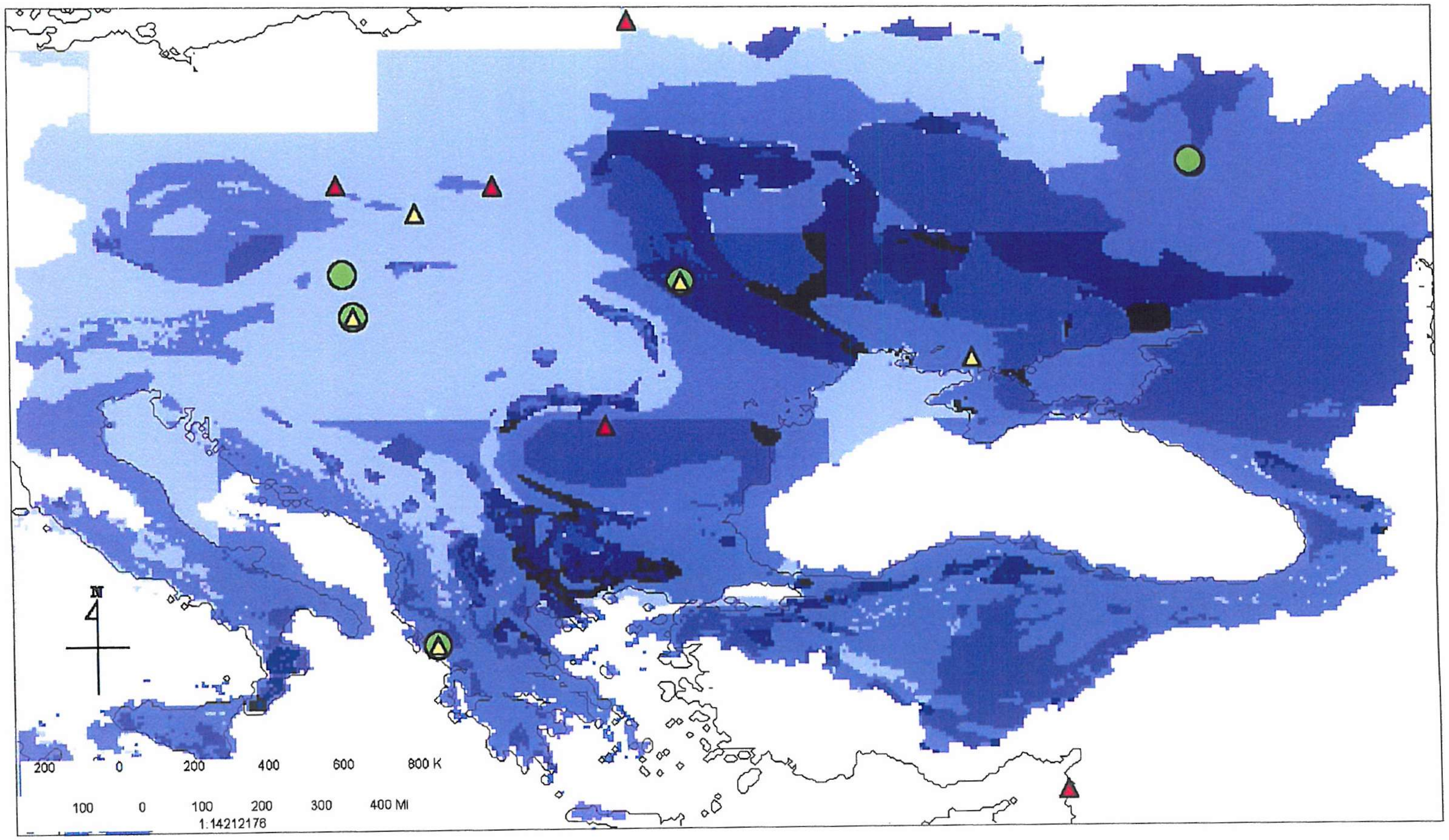


Figure 5.43: Major locations in the study area.

The model for 17000 cal BC predicts a higher likelihood for site location in the Carpathian region. This is supported when the site / non-site locations are plotted against the data. The 16000 cal BC data however, clearly shows concentrated pockets of high probability in Moravia and Bulgaria (to the north and South of the Carpathian Basin), along the eastern inside margins of the Carpathian Mountains, and the Ukraine (p. 200, Figure 5.37; Figure 4.43). The latter is consistent with current views about refugia (Jochim 1987; Housley et al. 1997), but the former presents a possible case of potential refugia in Moravia as opposed to the Carpathian Basin itself, as has been hypothesized in this paper. Possible reasons that may account for this are the bias in the radiocarbon database (e.g. more data may be available due to extensive excavation), and the large accumulation of post-glacial deposition in the Carpathian Basin that might affect archaeological visibility (see Chapter Six, Figure 6.19). Further application of more appropriate predictive indicators (perhaps the inclusion of soils data) may yield different results. However, it remains likely that Moravia represents a place conducive to continuity rather than abandonment.

A third important consideration is illustrated in Figure 5.44. It shows the predictive output for the onset of the Oldest Dryas (c.17000 cal BC). Actual site locations for 17000 cal BC are plotted against sites and non-sites for 16000 cal BC. Of ten site and non-site locations, 5 are located in 'very high probability' areas, 2 are located in 'high probability' areas, two are located in less probable areas and 1 is categorised as 'no data'. Four of five actual sites for 16000 cal BC are located in high or very high probability areas. This suggests that each temporal sub-model predicts more accurately where sites should be located 1000 years later than it predicts contemporary locations. This was unexpected, but informative - implying the true predictive nature of the model. As the purpose was to produce a model that is useful for not only predicting locations in space, but in time as well, the model is successful in this regard. This is made possible by the methodology, which first reconstructed the space backwards in time, and then used forward predictive modelling.

Figure 5.44: Reclassified predictive sub-model for 17000 cal BC.
Green = actual sites at 17000 cal BC; Yellow = actual sites for 16000 cal BC
Red = non-sites for 16000 cal BC.
Light Blue (category 1) = very high probability of site location
Dark Blue (category 5) = very low probability of site location.



Summary

The predictive model suggests that prior to the LGM Cold Maximum most of the region was occupied including peripheral, or marginal, areas. By 22000 cal BC, at the height of the LGM, the Ukraine is shown to have a high probability of site location, while peripheral regions became less attractive. Following the LGM, when the model suggests localised concentrations of high probability areas, the predictive model suggests that the entire eastern portion of the study area was open to recolonisation (p. 198, Figures 5.32 – 5.33).

With the onset of the Oldest Dryas, at 17000 cal BC, the Carpathian Basin and the surrounding regions to the north and west, and Moldova are predicted to show a rapid increase of potential site locations (Figure 5.43). As previously stated however, the 16000 cal BC data suggests specific pockets of occupation. This is consistent with the view of refugia held by Jochim (1987, 322), discussed in Chapter One (section 1.2.2). It also suggests that the significant decrease in surface temperature was an influencing factor in population movement during the Oldest Dryas.

During the rapid climate warming following the Oldest Dryas, the model supports rapid population expansion across Central Europe - first into the north and east, then west, south and northwest. Temperature is less significant during this period, while any environmental influence would have been exerted by physical data such as elevation and geology. The significance of this influence is reflected in such choices as habitation preferences. This is consistent with the results of the work in Chapter Three, which showed a transition in preferred occupation sites that occurred during the Oldest Dryas from open-air sites to rockshelters.

In Chapter Six, the predictive output presented here and the results from the analysis of previous chapters are synthesised to produce a general model of the late Upper Palaeolithic recolonisation of Central Europe that meets the objectives for this research outlined in Chapter One.

CHAPTER SIX

INTERPRETING COLONISATION IN CENTRAL EUROPE

This research has made it possible to propose explanations for the colonisation processes of late Upper Palaeolithic hunter-gatherers in Central and Eastern Europe. The following considerations have been put forth:

1) During the Oldest Dryas there is a preferential transition from open-air sites to rockshelters that cannot entirely be attributed to climate conditions.
2) Two models interpreting colonisation processes have been proposed which differentiate between open-air sites and rockshelters, the LGM and post Oldest Dryas, and more speculatively, between coastal and inland adaptations. In the first instance, these are, respectively, a three-phase long-term process and a two-phase rapid process.
3) Potential areas of refuge are identified. The timing of abandonment and/or continuity is determined.
4) Potential routes and directions of population movement are proposed.
5) There is substantial evidence to suggest the coexistence of completely separate hunter-gatherer adaptations in the late Upper Palaeolithic.
6) Radiocarbon data and environmental data can be applied as predictive indicators of archaeological visibility for the purposes of modelling the processes of colonisation.

The above interpretations have been suggested at various stages in the analytical process. In this chapter, the results of this process are synthesised in order to present a model for the late Upper Palaeolithic colonisation of Central Europe. The chronological and spatial interpretations presented in Chapter Three and Chapter Four are explored as they relate to,or may be revealed and interpreted from within, the predictive model presented in Chapter Five. The above considerations are re-addressed as the questions put forth in the goals and objectives outlined in Chapter One of this research are resolved. The objectives of this research are as follows:

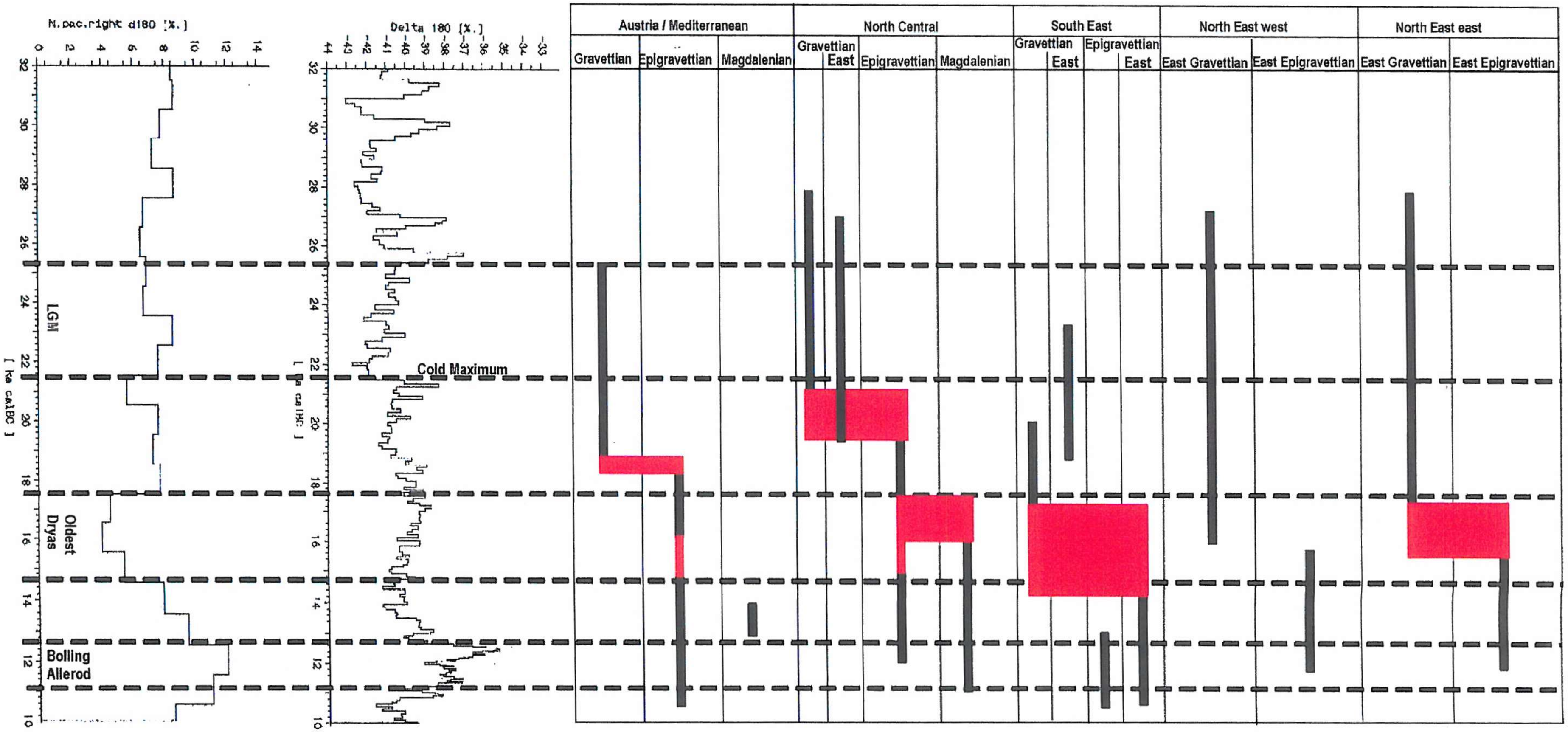
1) To establish the timing and location of colonisation and/or abandonment of human populations in Central Europe for the period approximately 25000 – 11000 years ago;
2) To determine the rate(s) and direction(s) of population spread;
3) To determine the role that the Carpathian Basin may have played as potential refugium for hunter-gatherers during the cold phases of the late glacial;
4) To place the colonisation of Central Europe and the Carpathian Basin within the context of greater Europe.

6.1 LATE UPPER PALAEOLITHIC SETTLEMENT IN CENTRAL EUROPE

The first objective of the research was to establish the timing and location of colonising populations in Central Europe. Though (due to the 'large scale – small database' problem discussed throughout this thesis) the coarse resolution of the model does not allow for more localised conclusions, the timing and location of colonisation remains visible to the degree that interpretations can be made with confidence at the broader scale.

The second objective was to determine the rates and directions of dispersal. While again the rates of colonisation cannot be determined at the localised level, or for shorter periods of time, this too can be shown through large-scale analysis. In this section, the results are discussed to resolve these two primary objectives. Figure 6.1 offers a summary of the distribution of dated site locations by broad technocomplex categories and regional divisions. The data are plotted against empirical climate data obtained via the CALPAL radiocarbon calibration program (Jöris and Weninger 1999). Figure 6.1 will be referred to throughout this chapter.

Figure 6.1(page 188): cal BC dates are plotted by technocomplex and region - against the North Atlantic temperature data, core CH73-139c and GISP2 $\delta^{18}O$ data (Jöris and Weninger 1999). Red blocks mark periods of abandonment inferred by the radiocarbon data.


N.pac.right d18O [‰]
Delta 18O [‰]
[ka calBC]
LGM
Cold Maximum
Oldest Dryas
Bolling Allerod
Austria / Mediterranean
Gravettian
Epigravettian
Magdalenian
North Central
Gravettian East
Epigravettian
Magdalenian
South East
Gravettian East
Epigravettian East
North East west
East Gravettian
East Epigravettian
North East east
East Gravettian
East Epigravettian

6.1.1 Prior to the onset of the LGM

The earliest occupations in the database are at the Aurignacian rockshelter sites of Oblazowa Cave in Poland and Šandalja II in Croatia, and at the open-air site of Mezin in the Ukraine and the Kostenki locale in Russia. As these data fall outside the temporal framework of this research, they are used in this section only to serve as confirmation that humans occupied most regions in the early Upper Palaeolithic (Soffer 1987, 346). There will be no analysis in this section about colonisation prior to the study period, or outside the geographic boundaries of the study area. This exploration will take place in the concluding remarks. The recolonisation of Central and Eastern Europe then, begins according to the data collected for this research, at approximately 28000 cal BC, which coincides with the decline of the Maisiéres-Tursac interstadial identified in the Summit ice core (this thesis, Figure 1.4, p.16; Djindjian et al. 1999, 44).

The period before the LGM is represented, almost solely, by a steady increase in open-air sites (Figure 6.2). These are distributed in visibly distinct locales in the study area: Moravia (North Central region), the Dnester River, Ukraine/Moldova (North East west region) and at the Kostenki locale on the Don River in Russia (North East east region). These are illustrated in Figure 6.3. In particular, the Kostenki locale is represented by data from three site locations prior to the LGM. All three locales, as will be illustrated in this chapter, are likely locations for continuous occupation throughout the late Upper Palaeolithic.

Distances between sites are limited, within each of these locales and their peripheries, to less than 200 kilometres (Figure 6.3). The greater distances separating the three locales suggest that for this 3000-year period, 28000 cal BC – 25000 cal BC, contact between them was likely very limited or non-existent. This conclusion is drawn on the basis that all three locales are occupied prior to the start of the study period. Assumptions about how they were first colonised and potential early relationships cannot be drawn from within this research framework.

The importance of the distance relationships between sites within a locale is consistent with Hahn (1987, 255-257) who examined the differences between Aurignacian and Gravettian raw material networks in Germany (Figure 6.4). Hahn notes that more than 95% of lithics found at two Aurignacian locales in central Germany, were obtained locally (in the Lone and Ach valleys) within a range of 60km. Likewise, the Gravettian raw material network was similar but at a larger scale.

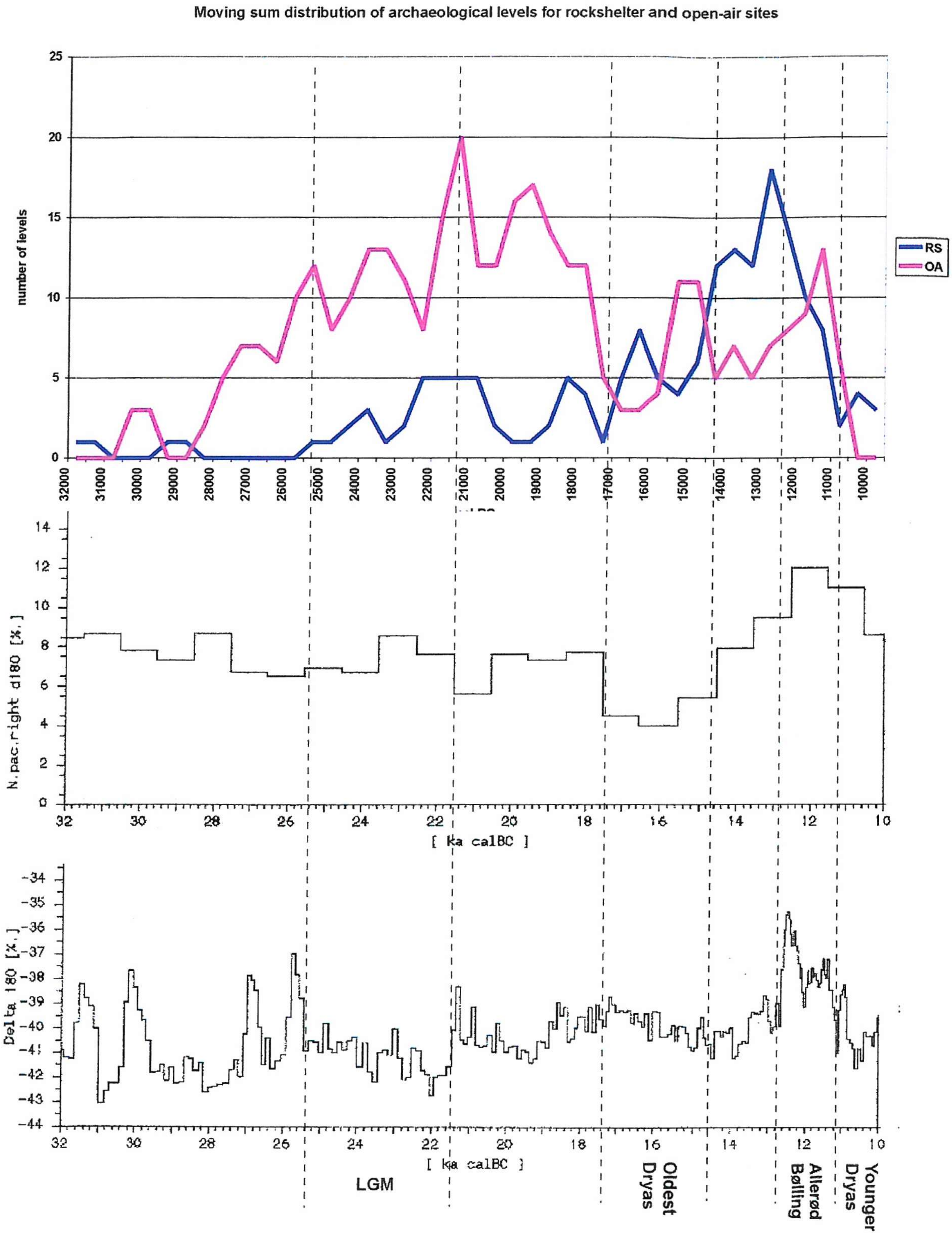
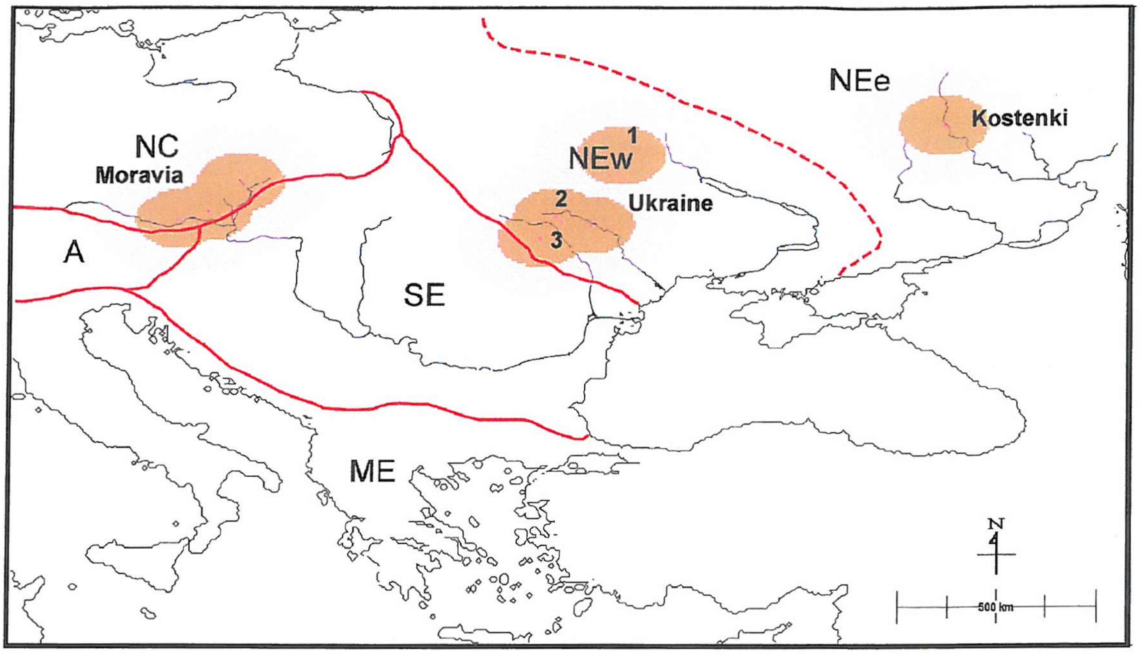


Figure 6.2 : the moving sum distribution of archaeological levels for rockshelter (RS) and open-air site (OA). Middle - North Atlantic temperature data, core CH73-139c; Lower – GISP2 $\delta^{18}O$ data. Data plots are from CALPAL (Jöris and Weninger 1999).

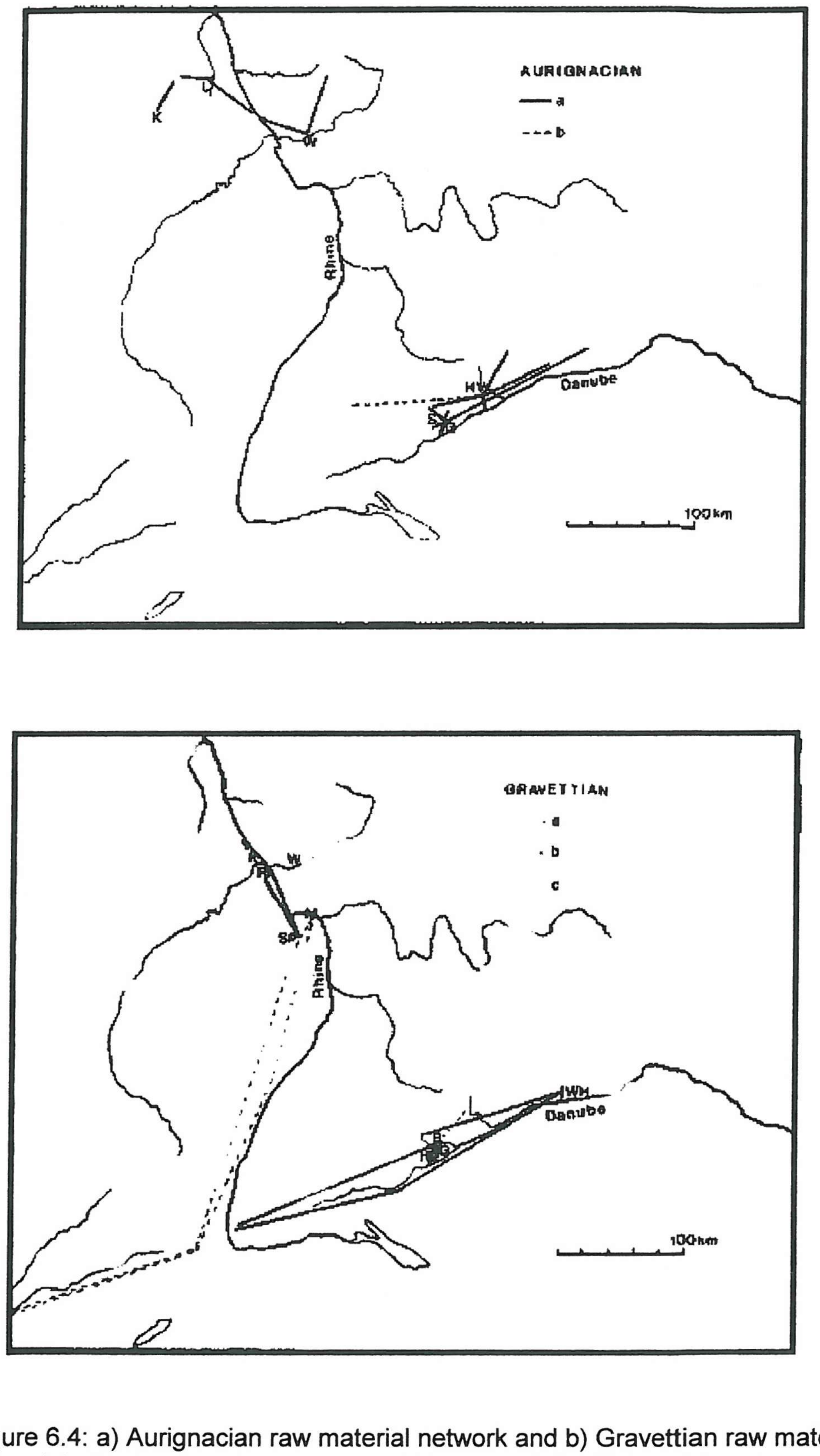
Figure 6.3: location of sites dating 28000 cal BC to 26000 cal BC showing 100km and 200km contours. Regions adapted from Gamble (1999, 66).
1=Korolevo; 2=Koulytchivka; 3=Korpatch.



Gamble (1999, 314-315) also notes that the maximum distance of lithic transfer in the regions of early Upper Palaeolithic Central Europe was 200km in his examination of changes in raw material transfer distances in space and time prior to 21000 years ago.

Hahn (1987, 256-257) suggests that the Gravettian had higher mobility, with improved exchange systems, although, he cautions that what may appear to be "far reaching contacts" may simply be different adaptations. He also notes that where the Aurignacian procurement network traverses river systems, the Gravettian network is linear and follows along river systems, thus allowing for increased travel distance.

The data presented here are considered early Gravettian / East Gravettian. While Hahn's views about raw material strategies cannot be explored in detail here due to the constraints of this research, the observable data would support this localisation of settlement. The potential for long distance exchange and high mobility is supported in



a)

b)

Figure 6.4: a) Aurignacian raw material network and b) Gravettian raw material network in the Lone and Ach valleys of Germany (after Hahn 1987, Figure 1).

the Ukraine locale where Korolevo 1, level 1a is contemporary with Koulytchivka, Ia and Korpatch, layer IV (Figure 6.3) and at Kostenki. Soffer (1999, 160) notes "as in Moravia, their lithic inventories show the habitual use of exotic superior raw material originating at distances of 150 to 300 km from the sites".

In previous chapters of this thesis, Moravia (Chapter Five, 184) and the Ukraine (Chapter Four, 124) have also been considered possible refugia during the coldest maximum and the Oldest Dryas.

Though there is continuity in these locales leading up to the onset of the LGM as shown here, continuity and/or abandonment of a region, does not warrant classification as refugia. This aspect will therefore be explored further in section 6.2 of this chapter.

6.1.2 The Last Glacial Maximum

Spatial and Temporal Patterns

With the onset of the LGM occupation of the three primary locales, Moravia, Moldova/Ukraine and Kostenki, is continued. This period (c. 25000 cal BC – 23000 cal BC) however shows two main changes of interest. First is the reintroduction of data supporting the first habitation of rockshelter sites since the Aurignacian - a lapse of about 5000 years according to the available radiocarbon data. This also marks the beginning of late Upper Palaeolithic occupation in the Mediterranean region. The site is Šandalja II, Croatia (Mediterranean region), dating to about 25400 cal BC. By 24400 not only is Šandalja II settled, but the Aurignacian site of Oblazowa Cave is again in use. Temnata Cave, Bulgaria (South East region) is dated to c. 23500 cal BC and is the final rockshelter site represented in the database for this time period.

Figure 6.5 illustrates the spatial and temporal distribution of site locations for 25000 – 23000 cal BC. Beginning with 25000 cal BC, the data shows continued occupation of the Moravia, Ukraine/Moldova and Kostenki locales as well as the initial occupation of the Šandalja II rockshelter.

By 24000 cal BC there is a new settlement locale on the Central Russian Plain in the NE east region, approximately 400km northwest of Kostenki. This locale shares similar features to Moravia and the Ukraine/Moldova locales in terms of raw material procurement distances. The main difference here is that the occupation of this area is short lived (i.e. no continuity). In fact, there is a maximum duration of occupation of

500 years – the difference between the dates for Pieny I at 24587 cal BC and the two contemporary sites of Khotylevo 2 and Soutchkino 2 at 24048 cal BC and 24040 cal BC respectively. The Kostenki locale appears to be abandoned for this temporal interval although this is attributed to the separation of the radiocarbon data into 1000-year intervals for the analysis. This led to Kostenki 4, with a date of 23970 cal BC to be plotted at the 23000 cal BC interval. Thus it is safe to say that logistical error gives the illusion of abandonment in spatial analysis where none is likely to have occurred in this case.

By 23000 cal BC, the data suggests reduced occupation of the Pieny locale (Figure 6.5). A single site, Berdyzh, remains and may be considered part of the remaining settlement system, as it falls within the 200km maximum procurement distance (Gamble, 1999, 315) discussed earlier in this chapter. At the same time, occupation of the Kostenki locale re-emerges in the data at Kostenki sites 1, 14 and 8.

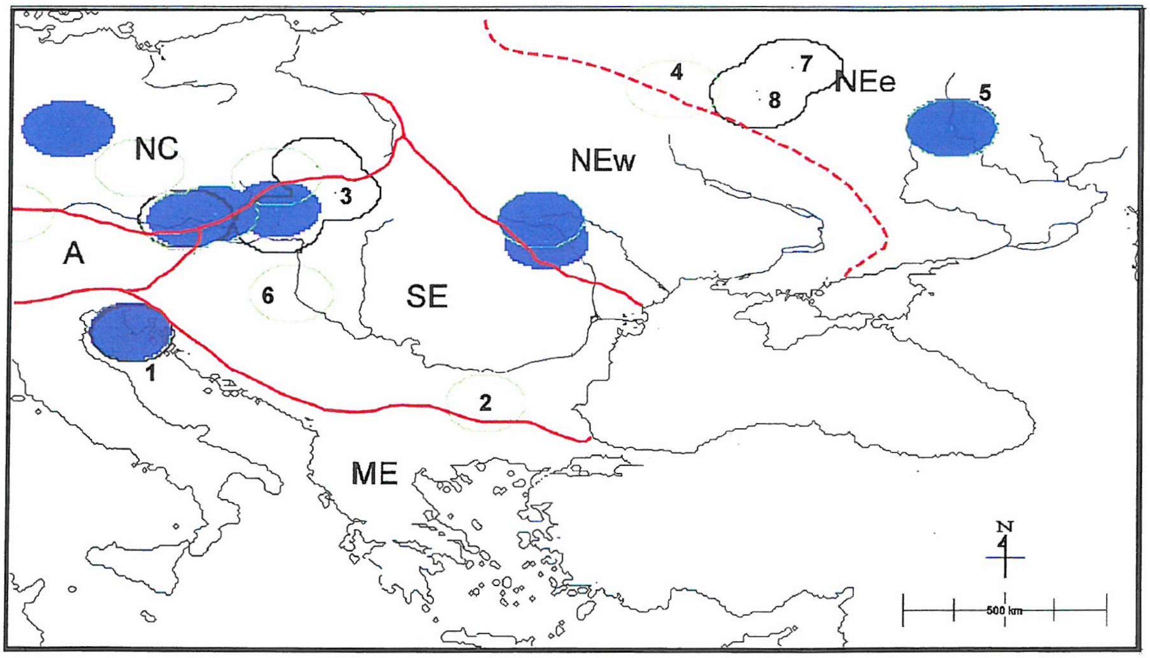
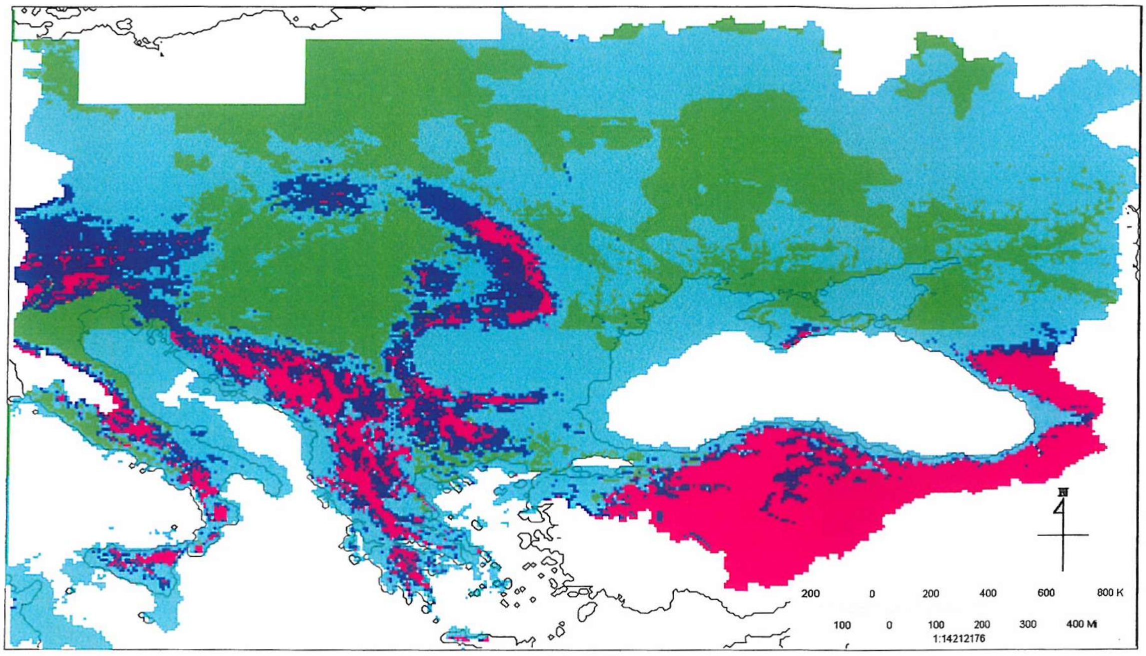


Figure 6.5: 100km buffer zones for sites at 25000 cal BC (solid blue), 24000 cal BC (black) and 23000 cal BC (green). 1= Šandalja II; 2= Temnata Cave; 3= Oblazowa Cave; 4=Pieny 1; 5=Kostenki; 6= Dunaszekcsô; 7= Khotylevo 2; 8=Soutchkino 2. Regions adapted from Gamble (1999, 66).

a)



b)

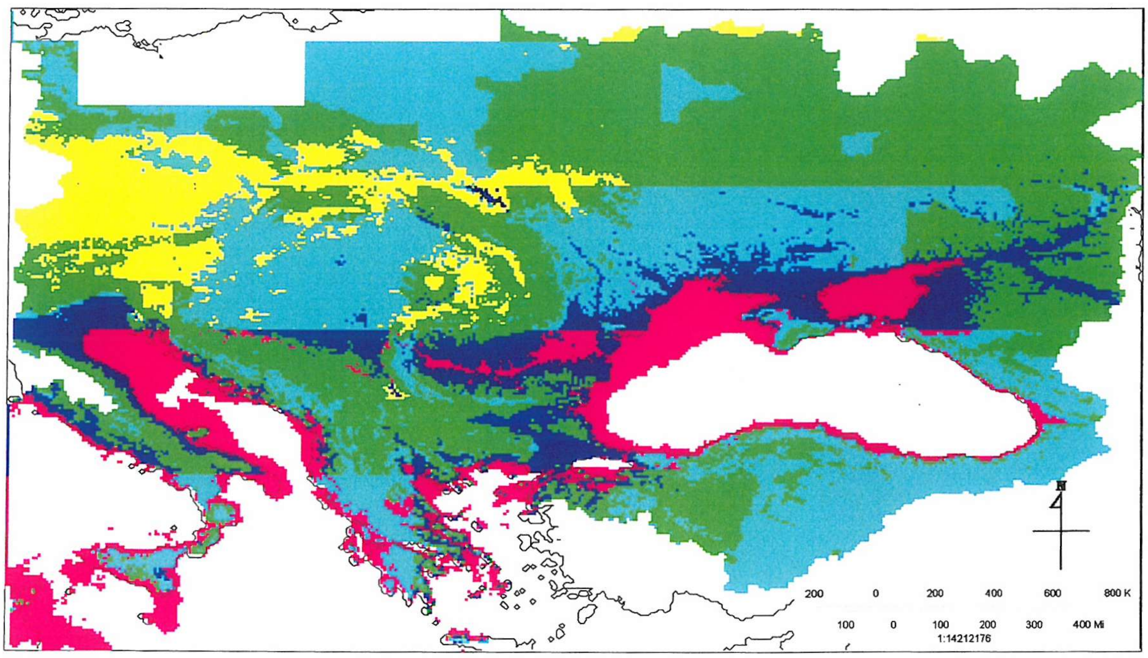


Figure 6.6: Predictive cost surface for the transition period from a) 25000 cal BC to 24000 cal BC and b) 24000 cal BC to 23000 cal BC. Yellow (class 1) = very high probability for site location, Green (2) = high probability, Light Blue (3) = average (medium) probability, Dark Blue (4) = low probability and Red (5) = very low probability for site location.

In the NE west region, the Ukraine/Moldova locale remains occupied through 23000 cal BC with little evidence to suggest movement away from this area.

In Moravia, there is still continuity of occupation at 24000 cal BC, but we begin to see dispersal in a westerly direction to Krakow, Poland, just north of the Carpathian Mountains and into the Carpathian Basin. The distribution of 24000 cal BC sites suggests that there is a larger scale system in this region indicative of increased mobility and extended contact. Soffer (1999, 159) attributes the shift in the core archaeological record to climate deterioration at the advent of the LGM. By 23000 cal BC Moravian populations are again concentrated at the gate of Moravia and the Carpathian Basin, however a new pattern is visible. Sites falling in this temporal interval are strategically located along the River Danube, stretching from Aggsbach, Austria (23695 cal BC) to Dunaszekcsô, Hungary (23045 cal BC) at the centre of the Carpathian Basin, to Temnata Cave (23525 cal BC) in the south Danube watershed (see Figure 6.5).

Two points of interest here are first that there is support for linear settlement as suggested by Hahn (1987, 255-257) for the Gravettian; and second that the chronology of the dates along the Danube are approximately at 200 year intervals, with younger sites located in the southeast. The sites are approximately 350km apart along the river. Temnata Cave is the chronological exception. This can be attributed to two things: the differentiation between rockshelters and open-air occupation site subsistence strategies, and second that Temnata Cave is a site that was occupied prior to the LGM. The site shows distinct stratigraphy (Kozlowski 1992) that supports not only continued re-use of the site, but also reflects hunter-gatherer choices about habitation. This is a period dominated by open-air site occupation.

A comparison of the data to the predictive output in Figure 6.6 suggests that the potential for occupation of the study area during this time frame is high, indicating that the LGM conditions may not have influenced colonisation patterns in Central Europe as strongly as has previously been believed. The distribution of the high potential data also supports the apparent change from the more localized settlement patterns of the earliest Gravettian to the more mobile Gravettians (Hahn 1987, 257). These differences are reflected in the spatial patterning of the predictive model.

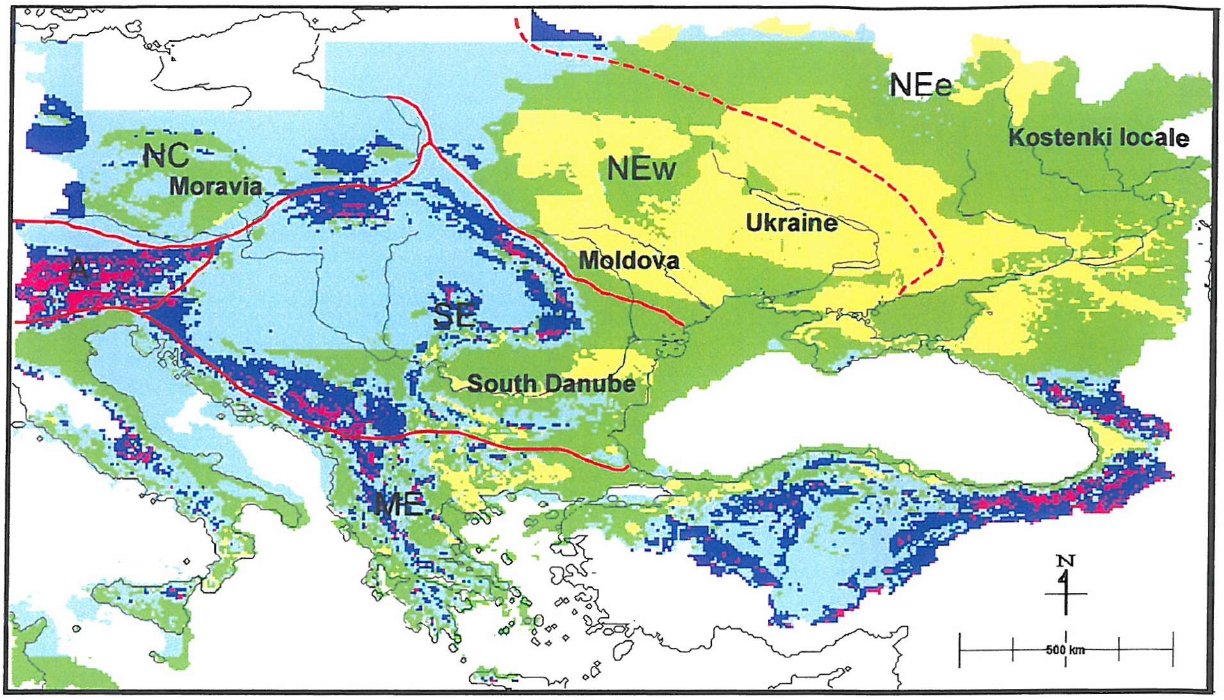
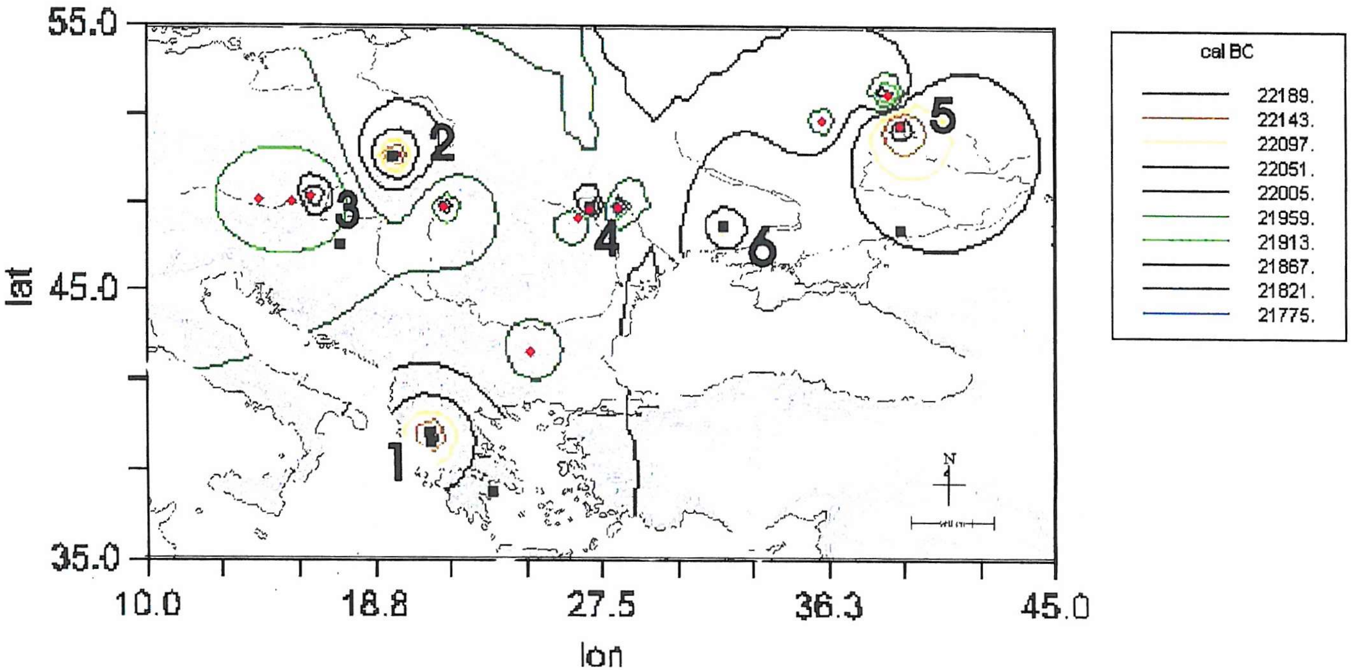


Figure 6.7: Predictive cost surface for the Cold Maximum of the LGM (22000 cal BC). Yellow (1) = highest probability for site location; Yellow (class 1) = very high probability for site location, Green (2) = high probability, Light Blue (3) = average (medium) probability, Dark Blue (4) = low probability and Red (5) = very low probability for site location.

The Cold Maximum of the LGM occurs between 22000 cal BC – 21500 cal BC. Figure 6.1 shows that at this time the North Central region is abandoned for about 3000 years immediately *following* the LGM (Soffer 1999, 159). However my research does not support a case for abandonment of *during* the LGM (Figure 6.7). On the contrary, there appears to be more distance between distinct locales, and an increase in rockshelter habitation, particularly in the Mediterranean region. This is supported by a comparison of the predictive model (Figure 6.7) to data dispersal (Figure 6.8). The plots for 22000 cal BC shown in Figure 6.8 suggest that the study area was sparsely populated with widespread distribution, and increased concentrations in the well-established locales of Kostenki and Ukraine/Moldova through 21500 cal BC. In the Mediterranean, the cold maximum coincides with the emergence of the oceanic rockshelter habitations in Greece (e.g. Klithi). Although there are no sites attributed to the LGM Cold Maximum (c. 22000 cal BC) in the South Danube area, this too shows a very high potential for occupation (Figure 6.7).

Figure 6.8: Surface interpolation of data for 22500 cal BC to 21500 cal BC.
1=Klithi rockshelter environs.; 2=Kraków Spadzista; 3=Moravia; 4=Ukraine/Moldova; 5=Kostenki-Borshehevo; 6=Sagaidak 1. Black=22000 cal BC; Red=21500 cal BC. The contours represent the range of data in the given time span. The red and black markers represent site location, which may or may not consist of more than one dated cultural level.



I would suggest that at the Cold Maximum, hunter-gatherer mobility was reduced, along with a lower concentration of sites within distinct locales. There is evidence to suggest that some movement occurred into the Carpathian Basin (e.g. Tokaj and Balatonszabadi, Hungary). Given the brief hiatus following the cold maximum in the North Central region, this may represent an attempt to avoid climate conditions to the northwest, but this is not conclusive.

Colonisation in the Late Glacial Maximum

This research has shown that the radiocarbon evidence for the LGM in Central Europe does not support the view that Upper Palaeolithic colonising populations reacted dramatically to the influence of the Scandinavian and Alpine Ice Sheets and associated climate conditions – the cause and effect scenario. Rather, I would suggest that Upper Palaeolithic hunter-gatherers in Central and Eastern Europe would have applied adaptive strategies based more on socio-economic behaviours. For example, Dolukhanov (1999, 9-10) remarks that there was an increase in the density of Kostenki sites during the course of the LGM. Despite the location of sites in areas of intensive permafrost, he suggests that diverse hunting strategies existed. Population "movement" to the south is reflected in this diversity (Dolukhanov 1999, 10; Soffer 1999, 160). In Moravia, the shift in the core cultural location at the onset of the LGM may well have been influenced by climate conditions; however, the spatial and temporal patterning of radiocarbon evidence, as shown in the previous section, also draws support for the processes of colonisation as described by Housley et al. (1997). In the Ukraine, there is continuity throughout the LGM. Patterns of dispersal are less clear. Soffer (1999, 160) suggests "evidence from the different parts of the Russian Plain shows the arrival of people from elsewhere, and the use of the region as a refugium — reflected, most clearly, in the archaeological records of the Dniester and of the Don". Figures 6.7 and 6.8 reflect these considerations.

Colonisation in Central and Eastern Europe is clearly defined by the relationship of Upper Palaeolithic groups to the three archaeological locales of Moravia, Ukraine/Moldova, and Kostenki. Each of these locales is characterised by large, well-stratified and abundant archaeological sites. The dispersal of populations emanates from these locales based on subsistence and social strategies.

6.1.3 After the LGM (ca. 21000 cal BC – 17500 cal BC)

The period between the cold maximum of the LGM and the Oldest Dryas is generally identified by the degradation of the Scandinavian and Alpine Ice Sheets, and climate warming. The short rapid climate amelioration at 21000 cal BC immediately following the LGM saw the beginning of a new wave of population dispersal in Central and Eastern Europe. In the North East east region especially, there is a significant increase in the number of sites on the Central Russian Plain. It is also shown that, in each of the three primary locales, the peripheral borders have expanded in terms of both number of sites and the distance covered.

The transition from 21000 cal BC to 20000 cal BC illustrates clearly the latitudinal interpretations about Upper Palaeolithic hunter-gatherers supported by Soffer (1999) and Dolukhanov (1999) for the North East regions. Upper Palaeolithic populations are now located in a linear fashion along the major water routes of both the Don and the Desna Rivers, in a north-south direction. Figure 6.9 shows that this region is indicative of a very high probability for site location at this time. Figure 6.10 shows the distributions of sites spatially and temporally across the study area and should be referred to in this section.

The first notable consideration in the western parts of the study area is the disappearance of Gravettian populations in Moravia following the LGM, c. 22000 cal BC (this chapter, Figure 6.1; Soffer 1999, 159). This is reflected in the predictive model for 20000 cal BC (Figure 6.9). Sites locations in the Carpathian Basin remain in use, with no radiocarbon evidence to support the occupation of new locations until the transition to 19000 cal BC.

By 19000 cal BC there is also a new trend visible in the data. There is a significant increase in the number of site locations in the Carpathian Basin, while in the North East, the number of site locations is reduced to the primary locales that have shown continuity throughout the study period, and at the now established Avdeevo locale.

19000 cal BC also marks the beginning of the recolonisation of Moravia and the North Central region (Soffer 1999, 159) of the Epigravettian technocomplex. This recolonisation is limited until about 14000 cal BC and the expansion of the Magdalenian technocomplex (Soffer 1999, 159; Street and Terberger 1999, 259).

By 18000 cal BC, there is little change except in the region of the Carpathian Basin. There are distinctly fewer sites and those that remain are located along the eastern slopes of the Dinaric Alps. There are also the first signs of comparatively more intense occupation of rockshelter sites in the North Central Region (Descrowa Cave, Poland) and in the Mediterranean region where Šandalja II, Velika Pećina and Druška peć in Croatia are now in use.

In the North East, there is intensified settlement at Cosautsi in the Ukraine, and again we see continued occupation in the Ukraine/Moldova and Kostenki locales. This constriction can be attributed to the onset of the Oldest Dryas.

A comparison of the moving sum distributions in the NEw and NEe Regions for the period between the LGM and the Oldest Dryas (Figure 6.11) shows some support for the long term three-phase, open-air site colonisation pattern proposed earlier. Also, when the moving sum distributions shown in Figure 6.11 are compared against the maps illustrated in Figure 6.10, there is observable evidence to support *either* an expansion-contraction phenomena *or* a movement to refugia phenomena – both influenced by the onset of the Oldest Dryas. The former may well indicate a difference in social behaviour reflected in settlement structure that is not necessarily associated with population movement, while the latter would indicate adaptive behaviour influenced to some degree by climate change and the onset of the Oldest Dryas.

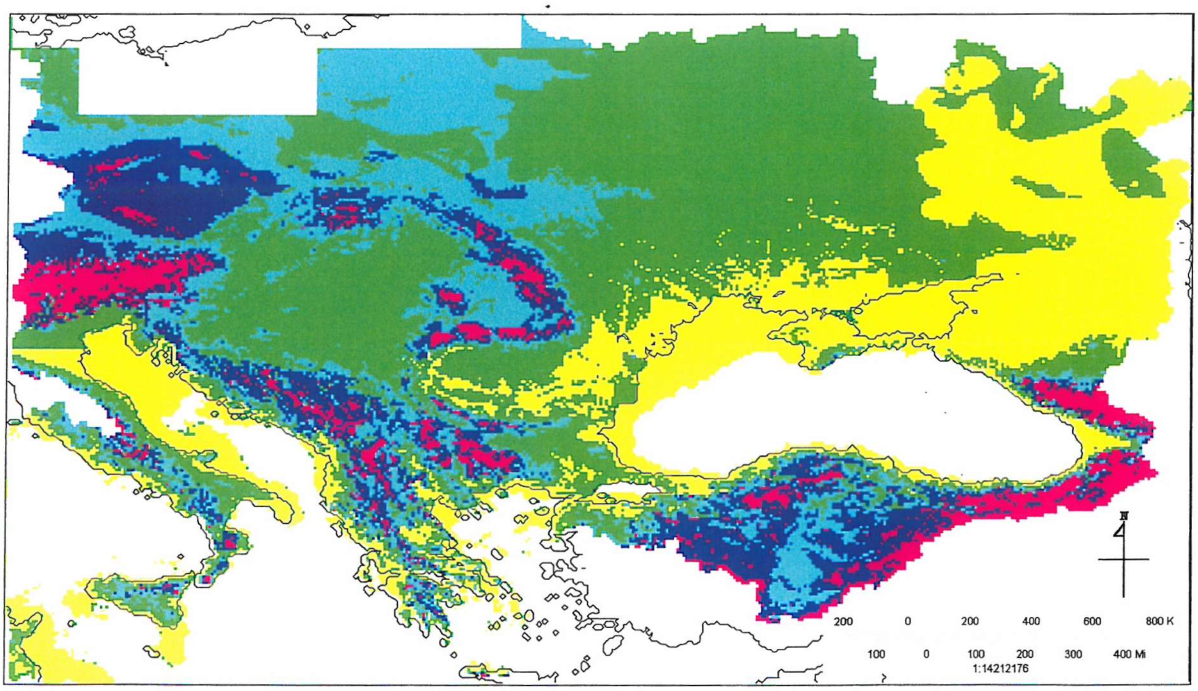
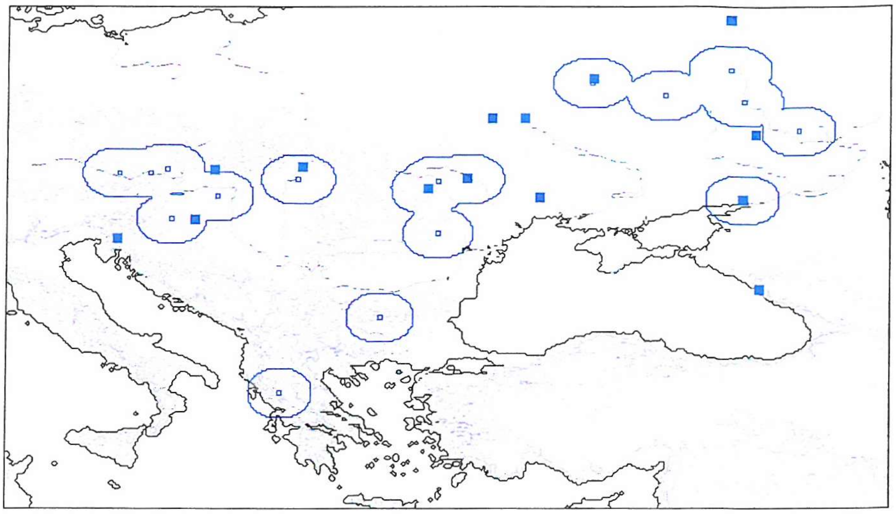
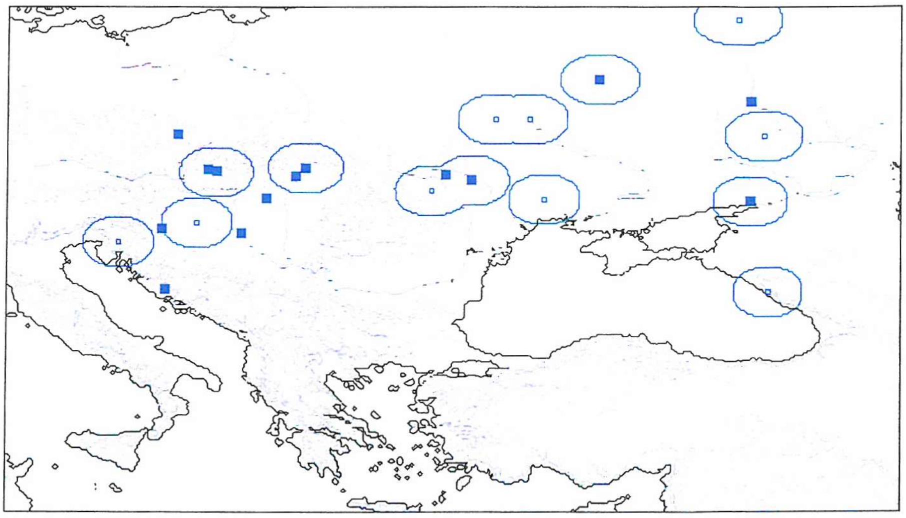


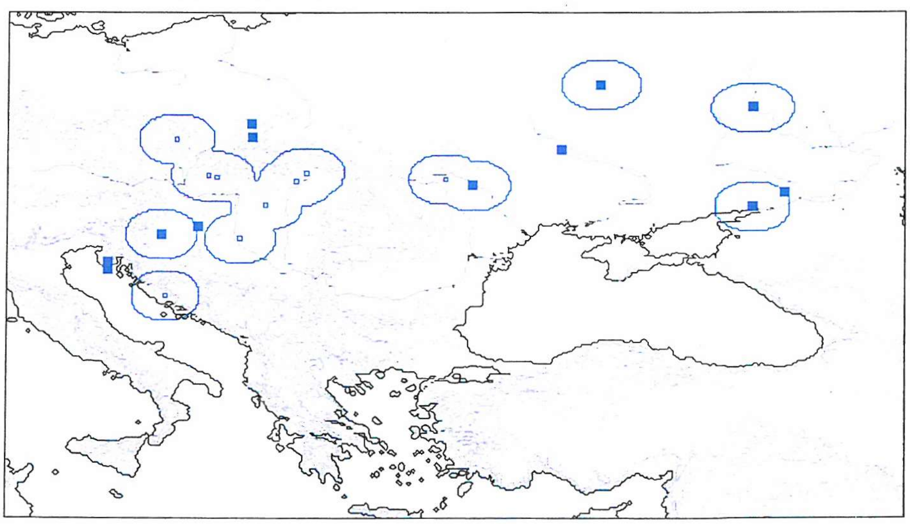
Figure 6.9: Predictive cost surface for 20000 cal BC. Yellow (class 1) = very high probability for site location, Green (2) = high probability, Light Blue (3) = average (medium) probability, Dark Blue (4) = low probability and Red (5) = very low probability for site location.



21000 cal BC – 20000 cal BC



20000 cal BC – 19000 cal BC



19000 cal BC – 18000 cal BC

Figure 6.10: Distributions of site locations in the post Glacial Maximum. Squares=younger sites. Buffers represent the earlier sites at 100km radius.

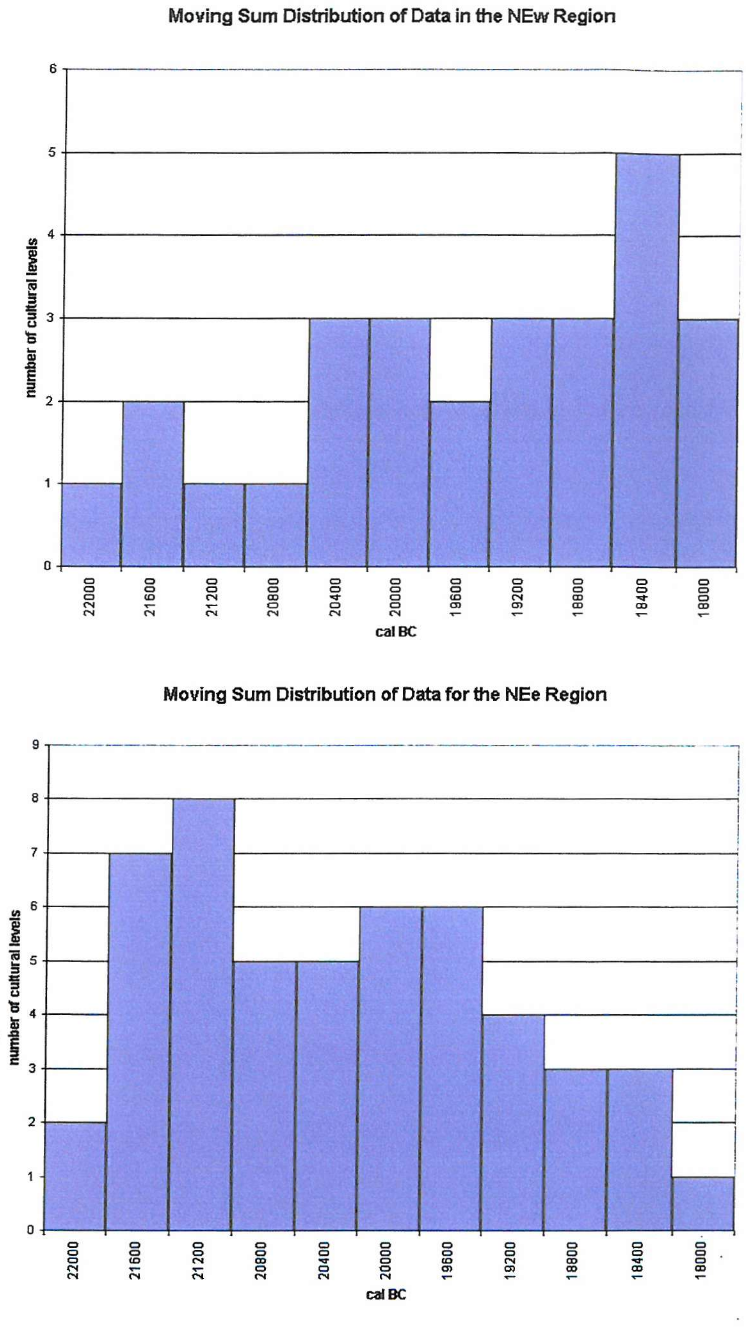


Figure 6.11: Comparison of the moving sum distributions of calibrated radiocarbon data for the North East west and North East east regions of the study area at 400 year intervals.

6.1.4 Oldest Dryas

The importance of the Oldest Dryas to the resolution of the recolonisation processes in Central Europe is twofold.

First, I have concluded in this thesis that the Oldest Dryas, and not the LGM, represents the almost total abandonment and the virtual disappearance of Upper Palaeolithic populations in Central and Eastern Europe (refer to Figure 6.1). The evidence for this was presented in Chapter Three, which showed that the rapid decline in population normally associated with the Last Glacial Maximum occurs in Central Europe at approximately 17000 cal BC (Figure 6.12). The Oldest Dryas climate was cold and dry with no discernible amelioration (Djindjian et al. 1999, 46). This is in

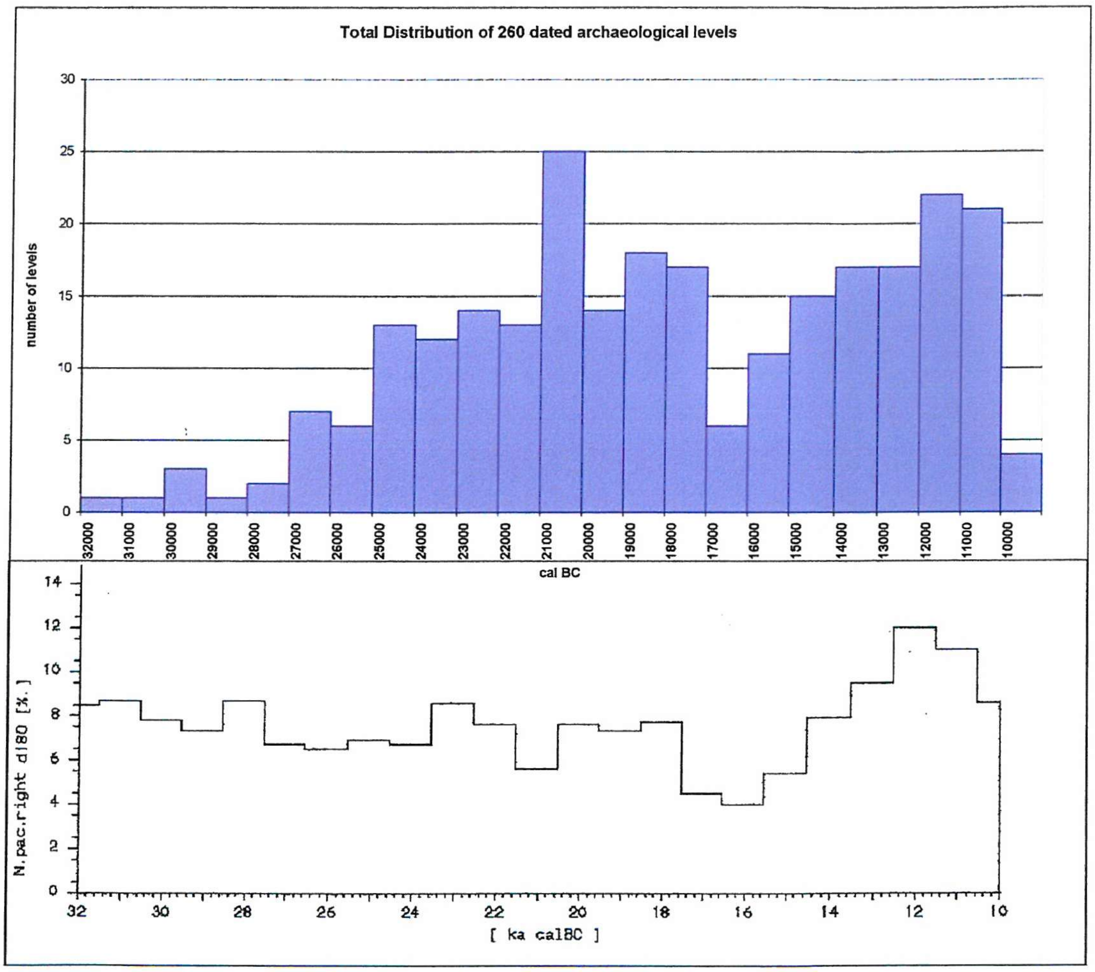


Figure 6.12: Distribution of 260 archaeological levels plotted against North Atlantic surface temperature data, core CH73-139c. (Jöris and Weninger 1999).

contrast to the LGM, where recent reconstructions have shown that although the climate may not have been favourable, it was not as harsh as previously predicted (Willis et al. 2000). In fact, Willis et al. (2000, 209) used charcoal and molluscan evidence to support the claim made by others (e.g. Tzedakis 1993) that macro-environmental conditions "of sufficient warmth and humidity" would have played an important refugial role for flora and fauna during the full glacial. The spatial and temporal dispersal of the calibrated radiocarbon data suggests that at the LGM, populations did not decrease in numbers, but rather intensified while choosing to remain closely associated within localised regions.

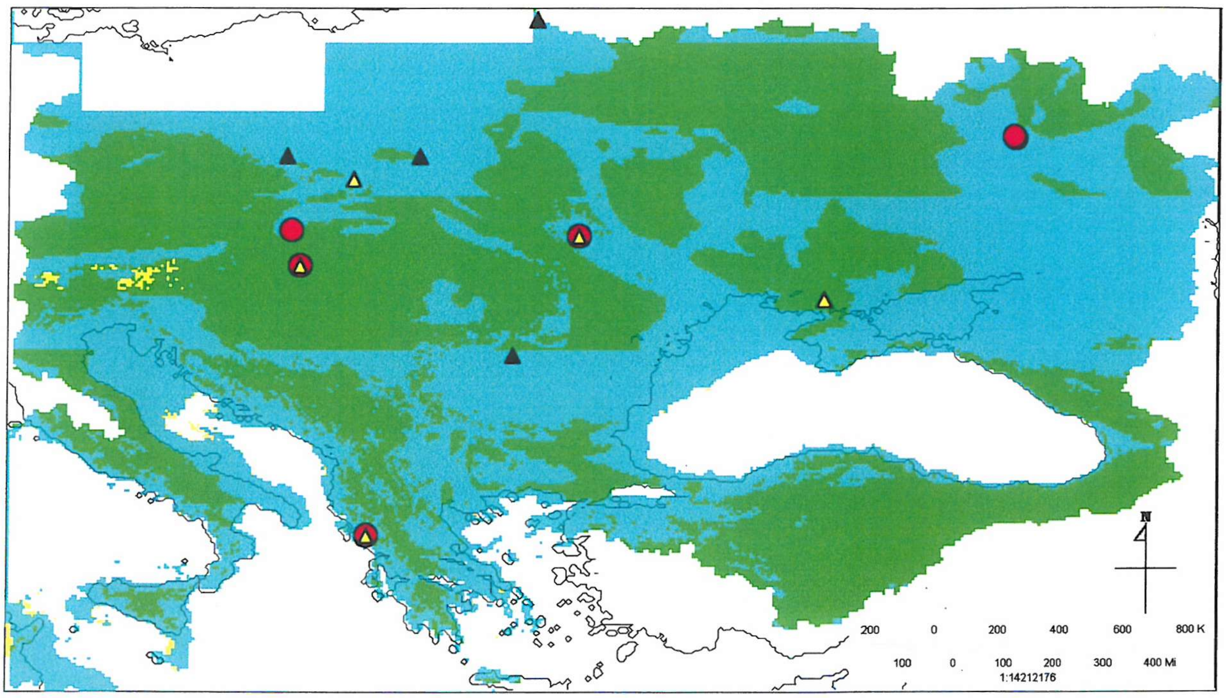


Figure 6.13: Distribution of Oldest Dryas sites overlaid on the predictive cost surface for 16500 cal BC. Red = 17000 cal BC (actual sites); Black = non-sites for16000 cal BC; Yellow = sites for 16000 cal BC;Green = high probability for site location.

This does not support a case for LGM refugia, but certainly does emphasise that the climate conditions of the Oldest Dryas played a much more significant role in the colonisation processes of Central and Eastern Europe.

Second, during the Oldest Dryas there is a noticeable *decrease* in the number of site locations and the abundance of calibrated radiocarbon evidence. The spatial and temporal dispersal of this data supports both the existence of refugia during this time, and regional adaptation to climate (Figure 6.12). Figure 6.13 highlights pocketed potential areas for occupation. It is during this period that the evidence suggests a transition from the open-air settlement that dominated the landscape until 17000 cal BC to rockshelters (Figure 6.14). Rockshelters provided dry shelters during glaciations and cold phases, while open-air sites allowed for control over larger landscapes. Transition between these two types of sites would have meant a change in hunter-gatherer regional behaviours. Svoboda et al. (1996, 203) suggested that hunting strategies and mobility patterns in particular would have differed. Open-air adaptations would have involved travel over further distances in a circulating pattern, whereas rockshelter adaptations meant travel over shorter distances in a radiating pattern centred on the cave.

While the harsh conditions of the Oldest Dryas may have influenced the initial decisions to adapt the latter strategy, the evidence for a stronger social influence occurs when hunter-gatherers maintain rockshelter habitation as the dominant choice *after* the Oldest Dryas.

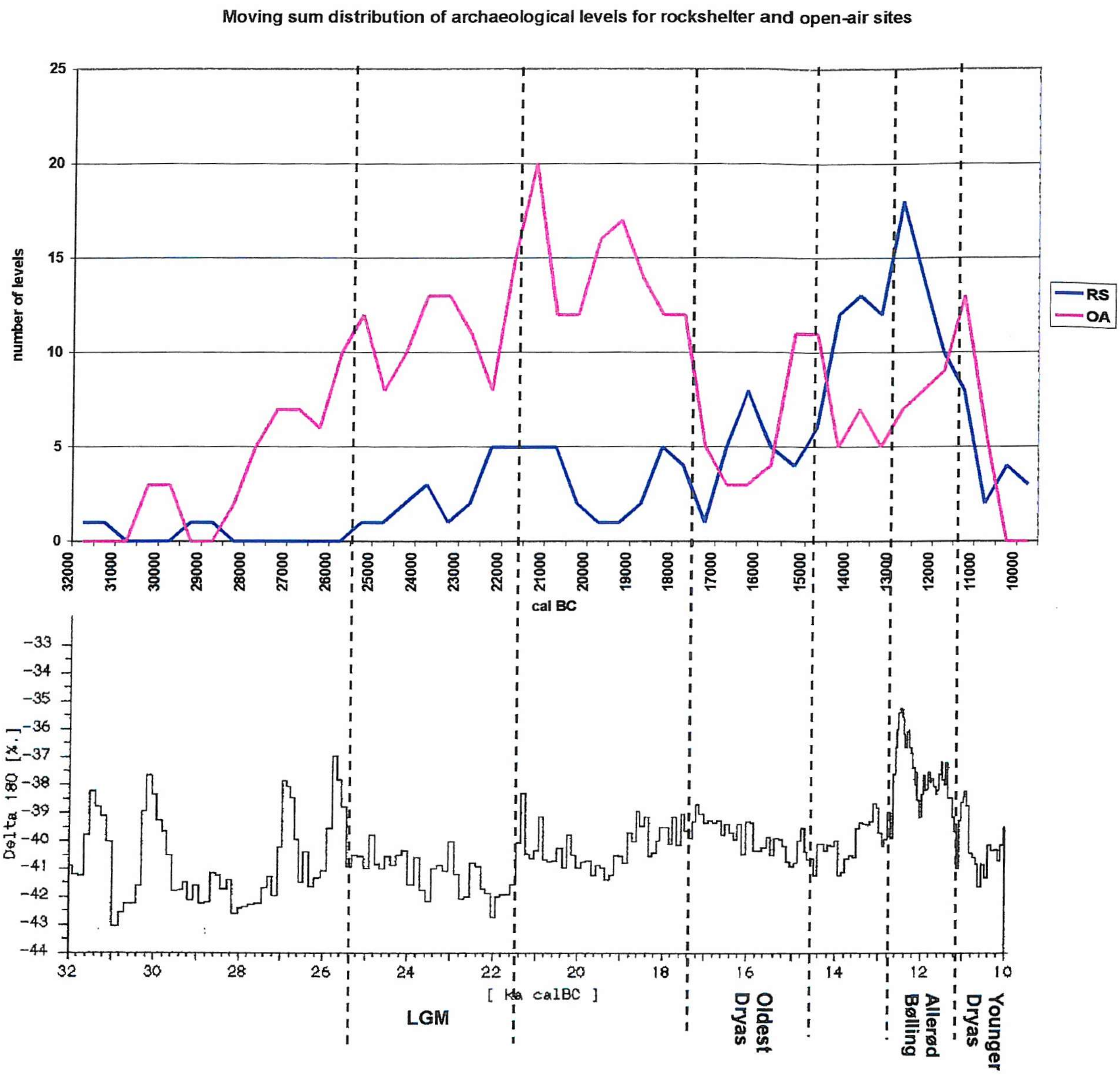


Figure 6.14: the moving sum distribution of archaeological levels for rockshelter (RS) and open-air site (OA) against the GISP2 $\delta^{18}O$ data (after Jörös and Weninger, 1999).

6.1.5 After the Oldest Dryas

The period following the Oldest Dryas marks a recolonisation phase in Central and Eastern Europe. At 15000 cal BC there is a brief reversal in the radiocarbon evidence for the types of sites that are occupied. There is a rapid increase in the occupation of open-air sites, while rockshelter occupation declines. This is short- lived since by 14000 cal BC there is again a rapid increase in the number of rockshelters, to the extent that this occupation type remains dominant at least until the onset of the Holocene.

The recolonisation of Central and Eastern Europe begins with a linear wave of advance back into the North East region from the Dnester River region at 15000 cal BC. This is an open-air adaptation movement (Figure 6.15). There is also an abandonment of rockshelter sites in the South East and Mediterranean regions, however, Skalisty Rockshelter in the Ukraine north of the Black Sea, and Maszycka Cave, Poland remain in use. By 14000 cal BC there is a significant increase in the number of rockshelters, including recolonisation in the Klithi environs in Greece and in Croatia.

A second wave-like trend in the data can be seen in the transition from 15000 cal BC to 14000 cal BC, when the distribution suggests a dual wave of advance out of the north-northeast. This might also be interpreted as a latitudinal distribution to the south and in a westerly direction, back into North Central Europe (Figure 6.16). In the eastern half of the study area (east-northeast of the Carpathian Mountains), sites are of the open-air occupation type.

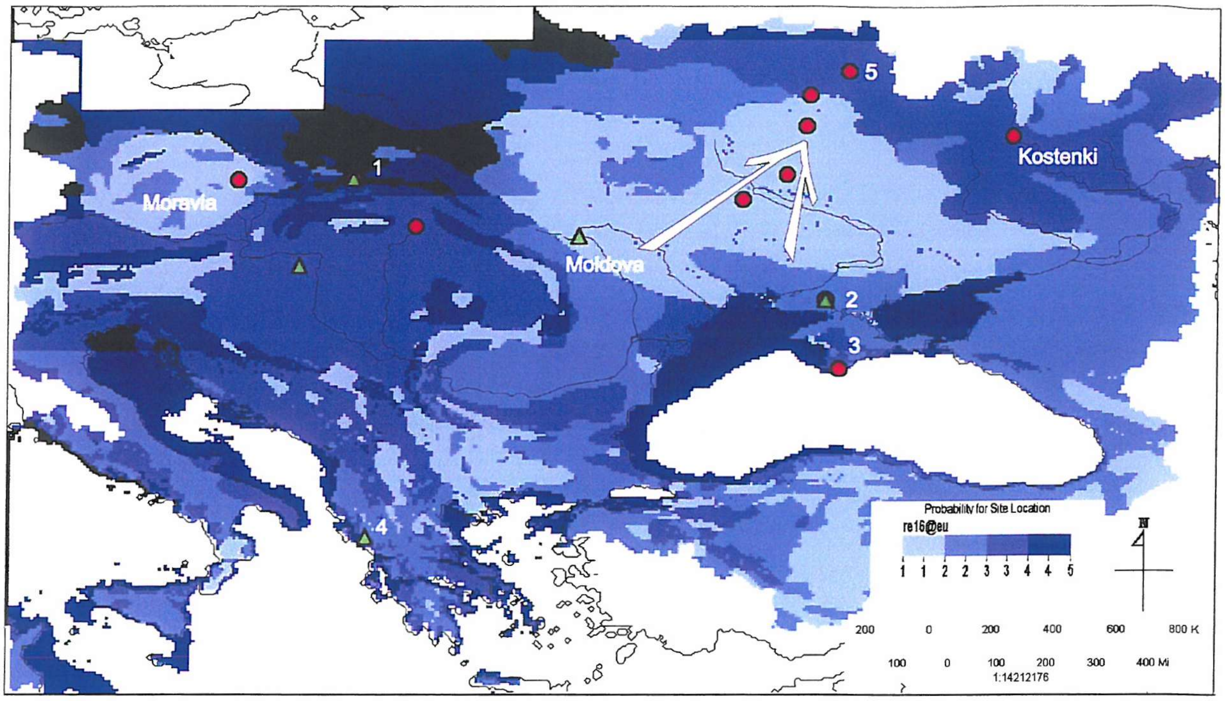


Figure 6.15: Predictive cost surface for 16000 cal BC showing a linear advance into the North East Region. Category 1 = very high probability for site location. Green = sites at 16000 cal BC; Red = sites at 15000 cal BC. 1=Maszychka Cave, 2=Eliseevichi 3=Skalisty, 4=Klithi 5=Khotylevo 2.

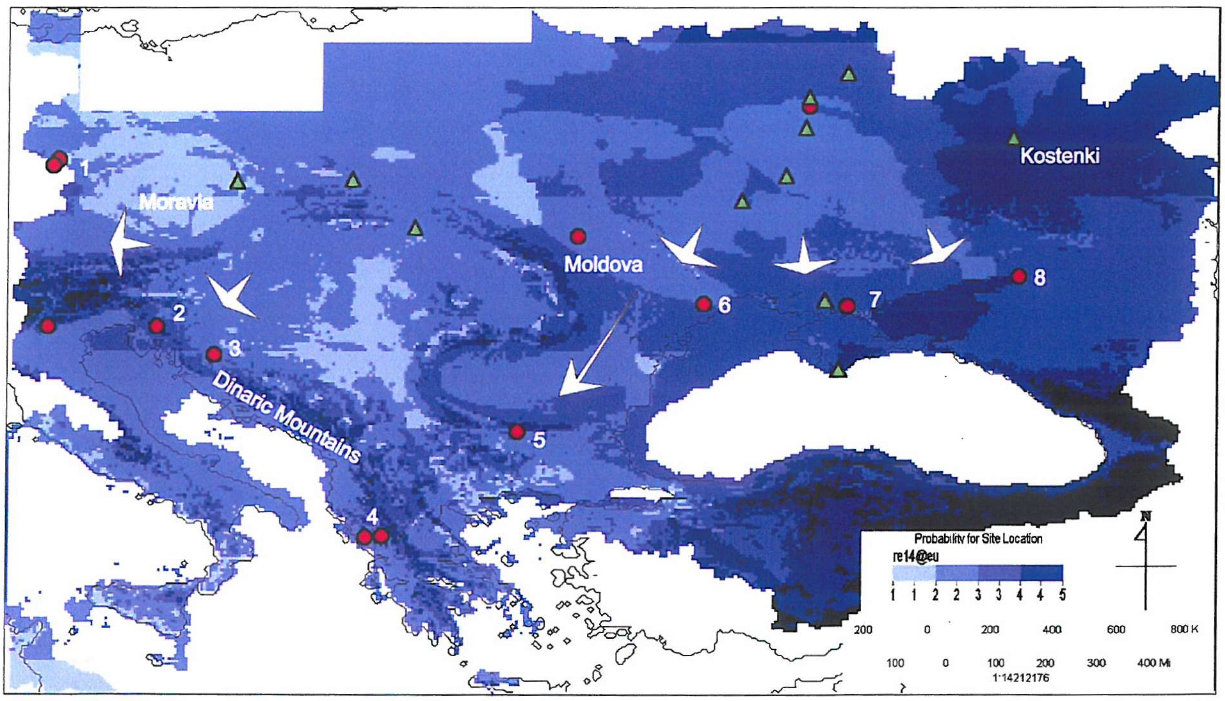


Figure 6.16: Predictive cost surface for 14000 cal BC showing wave of advance to the south and west. Category 1 = very high probability for site location. Green = sites at 15000 cal BC; Red = sites at 14000 cal BC. 1=Kniegrotte, 2=Županov Spodmol, 3=Mališina Stijena, 4=Klithi, 5=Temnata Cave, 6=Semonovka 1, 7=Souponevo, 8=Kamennaya Balka II.

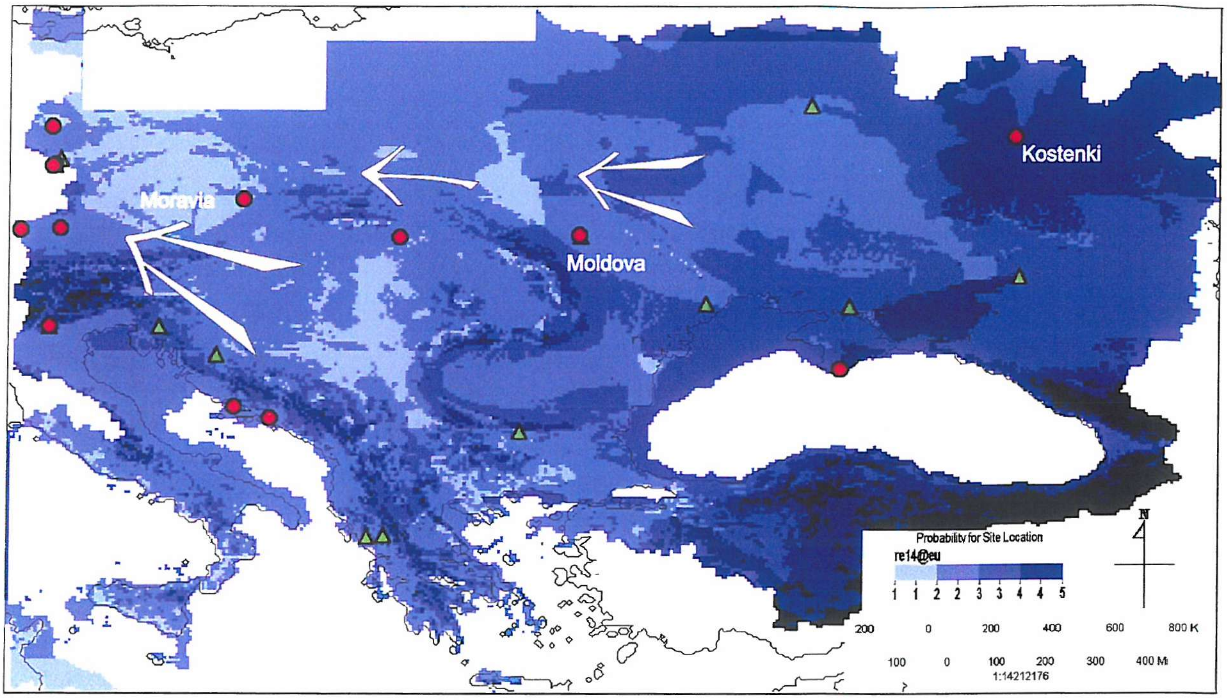


Figure 6.17: Predictive cost surface for 14000 cal BC showing rapid advance back into the northwest. Category 1 = very high probability for site location. Green = sites at 14000 cal BC; Red = sites at 13000 cal BC.

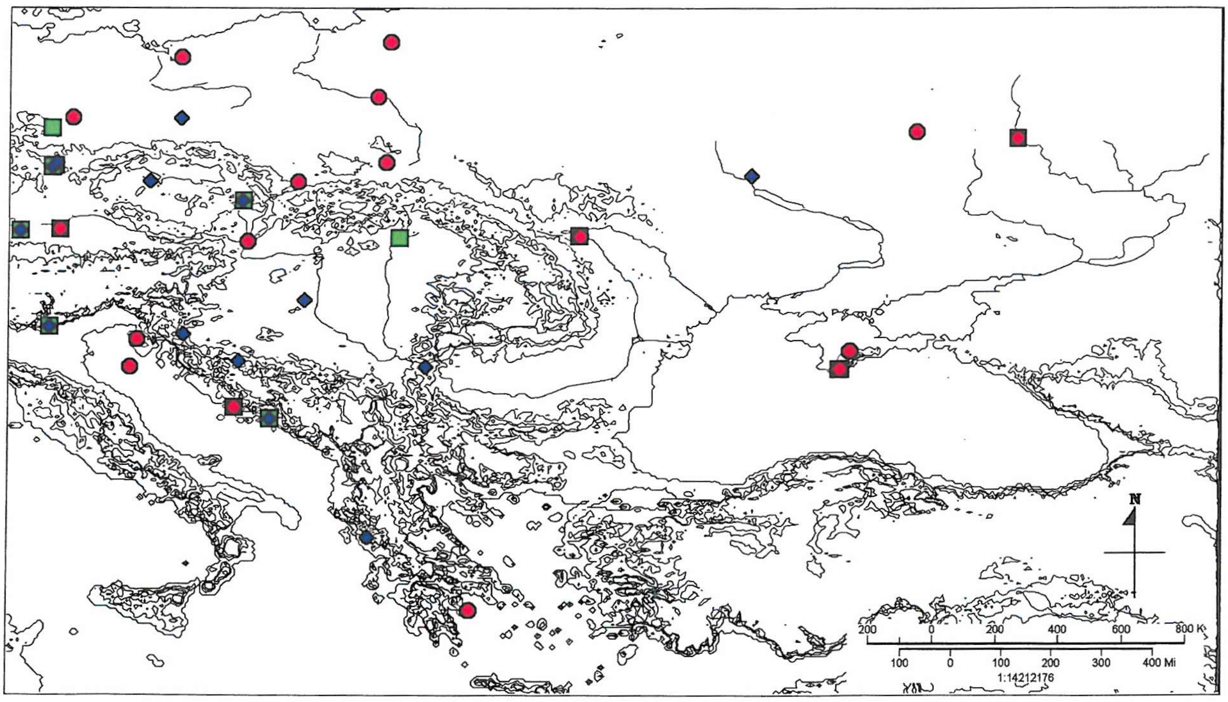


Figure 6.18: The recolonisation of North Central Europe between 13000 cal BC and 11000 cal BC. Blue=13000 cal BC; Red=12000 cal BC; Green=11000 cal BC

The 14000 cal BC - 13000 cal BC transition marks the beginning of rapid recolonisation of the Magdalenian technocomplex back into Northwest Central Europe (Figure 6.17).

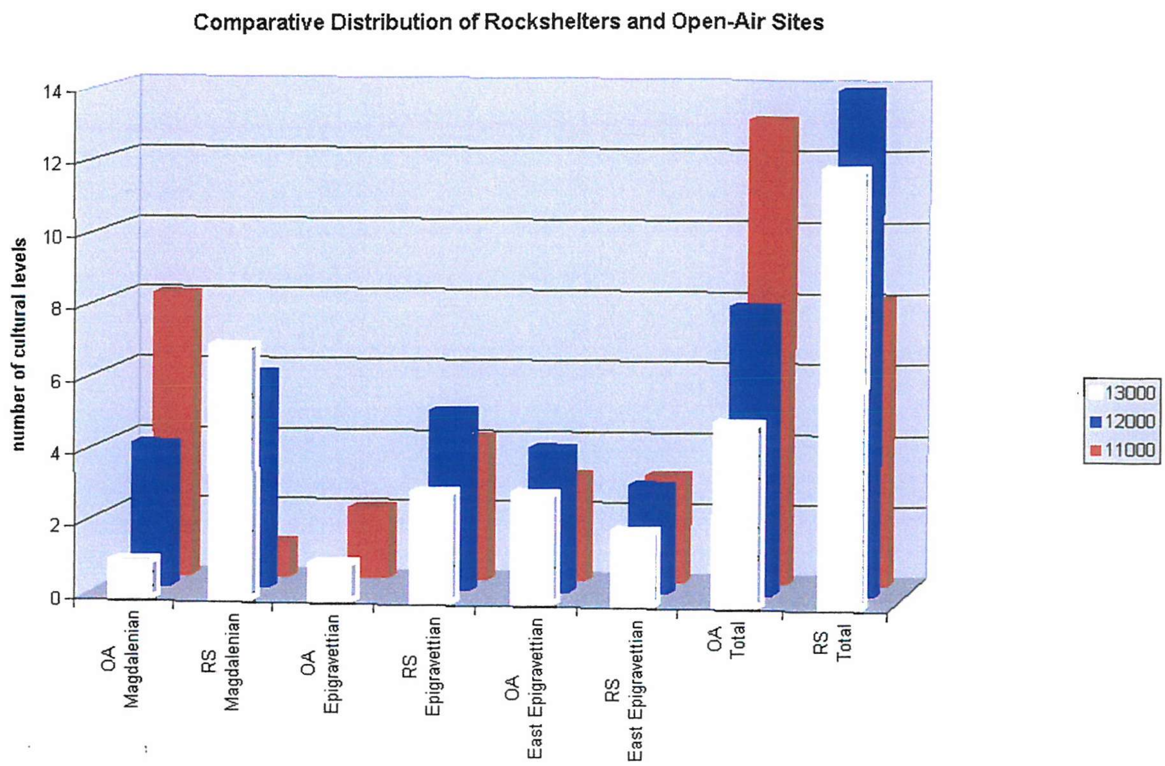
The data for 12000 cal BC suggests that another increase in population took place (Figure 6.18). I would suggest that period not only represents the advent of Magdalenian intensity, but more complex social and economic structures as well. A final consideration that can be mentioned here is that of distinguishing between Magdalenian and Epigravettian/East Epigravettian technocomplexes, and their relationships relevant to rockshelters and open-air sites (Figure 6.19). This distribution and the temporal data support the theory reviewed in this thesis that Magdalenian rockshelter cultures and East Epigravettian open-air cultures coexisted (Chapter Three, 88). It has been shown (Svoboda et al. 1996, 145) that these technocomplexes differ significantly in both technological productivity (toolkits) and social manifestations (e.g. art). Rockshelters also feature more prominently during this period and it may be suggested that there is a potentially significant difference between observable patterns of colonisation between rockshelters and open-air sites.

By 11000 cal BC, populations had permanently settled North Central Europe after the glacial retreat and the fluctuation between the chosen occupations of rockshelters and open-air sites appears to have stabilised into a relatively even distribution. There is a notable wave of population movement into the Baltic Sea region to the north that coincides with Anundsen's view that the recolonisation of Scandinavia following the retreat of the Scandinavian Ice Sheet from the Southwest took place during the Younger Dryas glacial re-advance (Figure 6.18; Anundsen 1996, 207-217). This may account for the interesting transition from rockshelters to open-air sites indicated by the Magdalenian data from 13000 cal BC to 11000 cal BC (Figure 6.19).

The sparseness of data in the North East compared to the intense occupation in the North West is most likely indicative of the difference in settlement strategies (i.e. open-air inhabitants were highly mobile), and not necessarily related to a diminished population.

The predictive cost surfaces presented in Figures 6.15 – 6.17 correlate well with the explanations provided in this section for recolonisation patterns following the Oldest Dryas.

Figure 6.19: Comparative Distribution of moving sum totals (500 year intervals and 1000 year range) of rockshelters and open-air sites by technocomplex for the period leading to the onset of the Holocene.



6.2 THE CARPATHIAN BASIN AS REFUGIA?

While colonisation accounts for species movement into new ecological niches and the use of those niches (Gamble 1993, 1995), it also allows for the examination of refugia as explanation. Soffer (1999, 159-160) and Dolukhanov (1999, 9-10) cite evidence to support the idea of refugia in the Dniester River locale (Ukraine/Moldova) and the Don River locale (Kostenki) in North East Europe.

In the course of this research, I have alluded to the Carpathian Basin as a possible refuge area. I have also suggested that the predictive model output supported a Moravian refuge area rather than the Carpathian Basin. This thought was due to the similarities between the Moravian locale and those defined as refugia by Soffer (1999, 159). I will argue in this section that the case for refugia as defined by Jochim (1987, 320) cannot necessarily be applied to the Don River locale, or Moravia, in a convincing manner, yet the evidence put forth by Dolukhanov (1999, 9-10) warrants acknowledgement. Instead, I will suggest that the same evidence can be used in support of the Carpathian Basin.

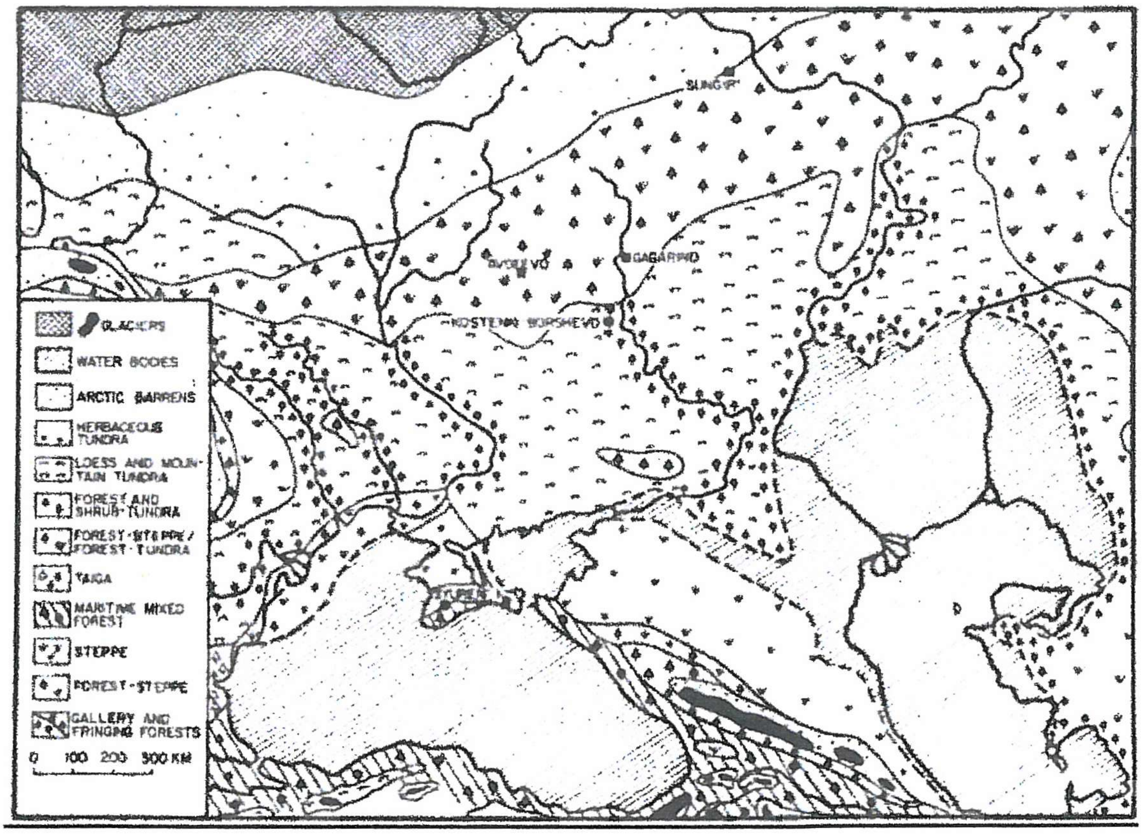


Figure 6.20: Vegetation zones in the North East region (after Klein 1969, map 1).

In his analysis of the settlement of Upper Palaeolithic populations on the East European Plain, namely the Kostenki and peripheral regions, Dolukhanov (1999, 9-10) comments on "the clear clustering of Upper Palaeolithic sites in the areas of an intensive loess accumulation". Figure 6.20 is a map showing vegetation zones in the North East region. Loess locales are illustrated. Figure 6.21 shows the loess stratigraphy in Central Europe (Kozlowski 1986, figure 1). The profile for Hungary, in the Carpathian Basin, shows a significant amount of loess accumulation. This most certainly will have influenced archaeological visibility in the region.

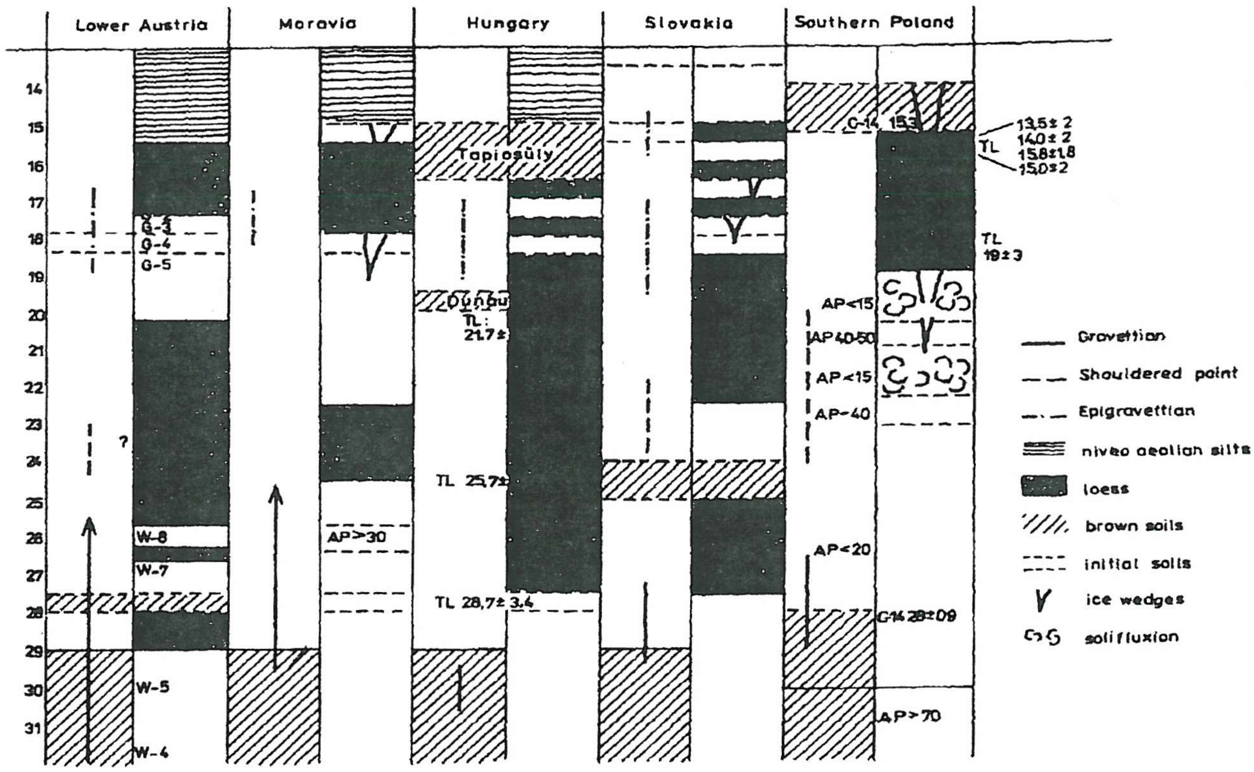


Figure 6.21: Loess depositional sequences in Central Europe (after Kozlowski 1996, figure 1).

Willis, Rudner and Sümegi (2000) challenged the long-held view that full-glacial conditions in Central and Eastern Europe were extremely cold and arid, dominated by steppe or tundra, and inhospitable to colonising human populations. They obtained radiocarbon dates on charcoal samples from 31 sites in Hungary and modelled the results in conjunction with molluscan and pollen analyses. Mollusc data were used to construct a palaeo-temperature curve that suggested a mean July palaeo-temperature of between 16 and 18°C. The results were calibrated in cal BP against the GISP2 ice core and data from the Nordic Sea. Willis et al. (2000, 203-213) found that during full glacial conditions in the Carpathian Basin, micro-environmental "oases" of arboreal forests were present that are comparatively similar to the modern boreal forest. They suggest that the evidence convincingly shows that these areas "provided an important cold-stage refugium for the European flora and fauna".

The issue of refugium during the late Upper Palaeolithic has also been tackled through mtDNA studies by Stefan et al. (2001, 27-33) and the evidence provided adds support for the potential role of the Carpathian Basin as refugia during the coldest phases of the late Upper Palaeolithic.

Stefan et al. (2001, 27-33) identified the geographical region of the Carpathians as a break point in the gene geography of eastern Central Europe. They did this by measuring affinities between populations in terms of haplogroup frequencies to provide a finer definition of one of the possible sharp genetic changes observed in Western *vs* Eastern Europe. "Through a combination of Y-chromosomal binary and microsatellite markers, Malaspina et al. [1998] have shown peculiar geographic distributions of certain lineages across Europe, suggesting that Central Europe might be the area where some of these lineages undergo the sharpest changes in frequencies" (Stefan et al. 2001, 27). In this work, the authors examined the frequencies of Y-chromosomal haplogroups from regions of Romania and in the Republic of Moldova.

Their analysis suggests that the Carpathians coincide with a genetic boundary within eastern Central Europe, where the area east of the Carpathians is characterised by much higher frequencies than those west of the Carpathian Mountains. "We suggest that the association between the mountain ridge and this genetic discontinuity is not a mere coincidence, since the Carpathians are also representative of an ecological boundary" (Stefan et al. 2001, 27-33). They suggest that the main Y-chromosomal correlate of the above distribution reaches frequencies greater than 20% north of the study area and in Germany, and that another haplogroup arose in Asia and subsequently spread to Europe. "Thus, the Y-specific population-structuring here described may testify in favour of the poor overlap between the peopling of steppe and plain *vs* mountain environments, the latter being in closer continuity with the rest of Western Europe". The authors caution however that the frequency of this marker in Hungary has been attributed to a marginal effect of Neolithic migrations in Eastern Europe and a later migration of peoples in the Hungarian Plain. This latter event may have influenced the results.

When re-examined in light of this evidence, the results obtained using radiocarbon data are strong. I have shown in Chapter Four that the Carpathian Basin may very well have played a more significant role in population dispersal, particularly during the LGM and Oldest Dryas.

Figure 6.13 (p. 227) and Figure 6.22 show the site locations of radiocarbon data during the Oldest Dryas and the coldest part of the LGM respectively, as plotted against the predictive model outcome for each associated time period. The predictive model results are in agreement with the kriging interpolation results obtained in Chapter Four. These results show the dispersal patterns of the radiocarbon data to be routed through the Carpathian Basin, particularly during the LGM, suggesting that late Upper Palaeolithic populations would have utilised the Basin more than previous research suggests (Figures 6.23 and 6.24). 29% of the total number of cultural levels represented in the working database fall within the South East regional borders. Of these 22% are within the temporal limits of the Cold Maximum of the LGM, and the Oldest Dryas (given an approximation of a 23000 cal BC to 21500 cal BC in the first case and 17500 cal BC to 15500 cal BC in the second). The majority of these are spatially distributed in, or along the periphery of, the Carpathian Basin. Given the large spatial and chronological scale of the research framework, this ratio is sufficiently high to support the suggestion that the Carpathian Basin could have acted as refugia during the coldest periods of the late Upper Palaeolithic.

Figure 6.22: Site locations for 21500 cal BC 23000 cal BC plotted against the predictive cost surface for 22000 cal BC. Yellow = sites at 23000 cal BC; Green = sites at 22000 cal BC; Red = sites at 21500 cal BC.

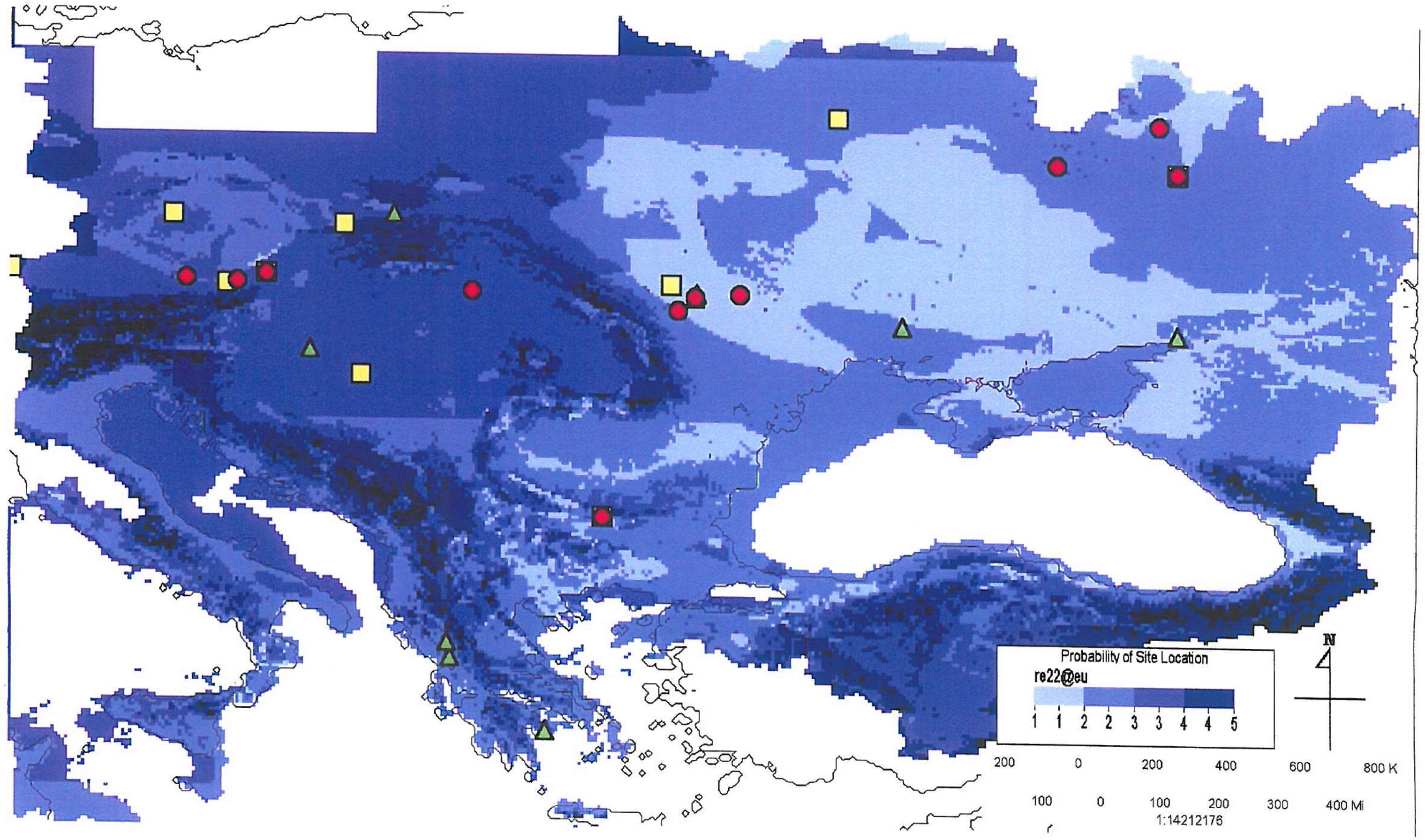


Figure 6.23: Interpolation results for dated archaeological levels of rockshelters.
1) Oblazowa Cave, 2) Brinzeni I, 3) Skalistiy, 4) Akhshtyr Cave, 5) Klithi

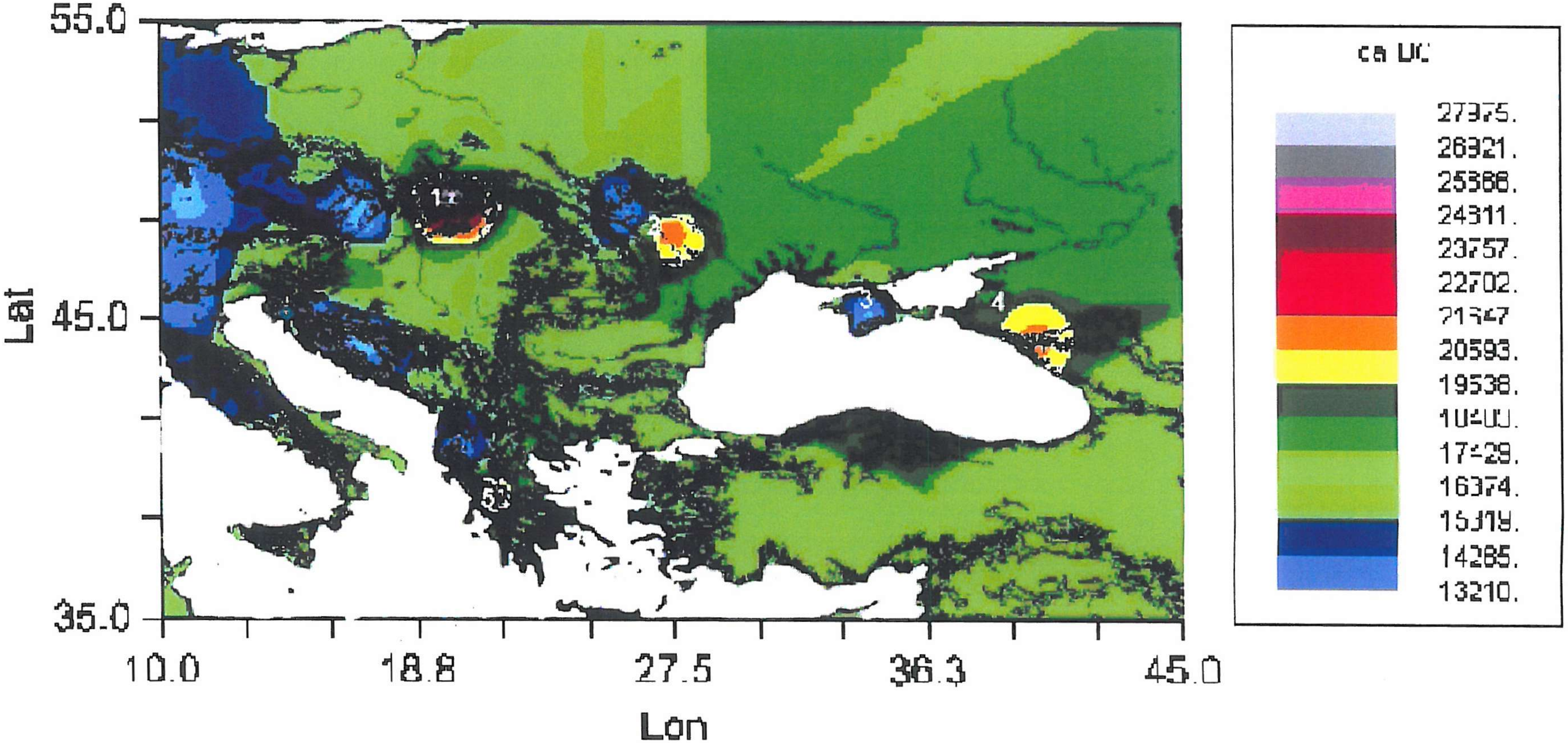
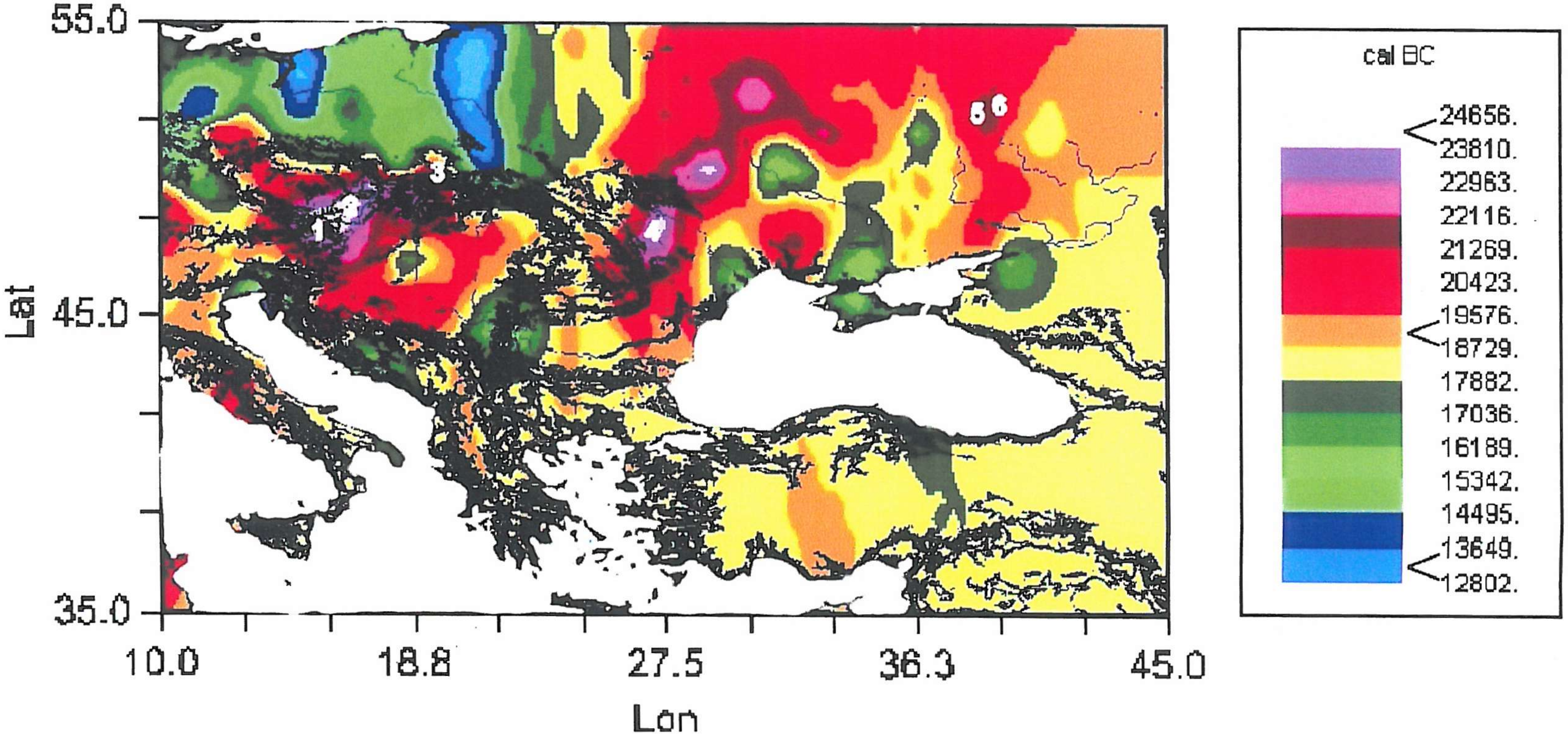


Figure 6.24: Interpolation results for dated archaeological levels of open-air sites.
1) Willendorf II, 2) Dolni Vestonice, 3) Spadzista, 4) Moldova V, 5)Gargarino 6) Kostenki



I would suggest that, if the assumption is taken that areas of refuge were utilized during the LGM and the Oldest Dryas, then, these refuge zones include the Dnester River locale (Ukraine/Moldova) and the Don River locale (Kostenki) in North East Europe (Soffer 1999, 159-160; Dolukhanov 1999, 9-10), and the Carpathian Basin. The difference lies in how these regions were used. In North East Europe, occupation appears to be continuous at the local level throughout the late Upper Palaeolithic, with spatial dispersal radiating out, even as these areas were occupied. This differs from the Carpathian Basin in that the radiocarbon evidence suggests higher mobility, with a more pronounced incursion and exodus of population (to less localised locales within the Basin) at the onset of the LGM and Oldest Dryas, and the warming trends thereafter.

These conclusions however are drawn on the visible relationship between the Carpathian Basin, Moravia, and Moldova. As I pointed out in Chapter Four (p. 101), there is considerable data available for the Moravian Karst and Moldovan regions that have influenced the kriging interpolation to suggest a potential dispersal pattern from Moravia, into the Carpathian Basin and, potentially, out through the Tisza Valley to Moldova. The amount, and quality, of available data has, of course, always influenced research results. In this case, additional support for the Carpathian Basin as potential refugia comes from the results of the predictive model output (Figures 6.13 and 6.22).

6.3 RECOLONISATION IN CENTRAL EUROPE: A SUMMARY

I have shown in the course of this research that the radiocarbon evidence indicates that there appears to be significant changes in the colonisation processes of late Upper Palaeolithic populations that are strongly influenced by differences in socio-regional behaviours, and in a lesser way by harsh climate changes – the latter being more closely related to colder temperatures.

Colonisation in Central and Eastern Europe is clearly defined by the relationship of Upper Palaeolithic groups to the three archaeological locales of Moravia (e.g. Willendorf, Spadzista), the Dnester River area in the Ukraine/Moldova region (e.g. Molodova V, Cosausti), and the Don River area of the Central Russian Plain (e.g. the Kostenki sites). Each of these locales is characterised by large, well-stratified and abundant archaeological sites. Soffer (1987) has indeed shown a macro-relationship between these locales through an analysis of the distribution of Kostenki knives and Venus figurines. The dispersal of populations emanates from these locales based on subsistence and social strategies. "It seems likely to us that some of the large open-air sites could have represented a substantial focus of occupation, perhaps even residential bases..." (Bailey et al. 1997, 532).

Prior to the Oldest Dryas, the settlement and colonisation processes of open-air site dwellers clearly reflects this pattern. Distances between sites are limited, within each of these locales and their peripheries, to less than 200 kilometres, which is consistent with the results of lithic analyses as described by Hahn (1987, 255-257) and Gamble (1999, 314-315). Temporal distances between cultural levels are generally within 400 – 800 years of one another for each phase of population expansion. Given the scale of the research, this is broadly compatible with Housley et al. 1997). Colonisation takes place in a series of pulsations out from these primary locations. The evidence suggests that these expansions take place within the regional ecosystem of the primary settlement locale. At the coldest part of the LGM, though population numbers may have been reduced, there is no evidence of the disappearance of Upper Palaeolithic groups in Central Europe. These groups *either* retreated to the shelter of the primary settlements forcing population pressure, using them as refugia as Soffer (1999, 159-160) and Dolukhanov (1999, 9-10) have suggested for North East Europe, *or* dispersed into sheltered regions and abandoning others, reducing population pressure as the case for the Carpathian Basin might suggest.

At the large scale of this research, the moving sum distribution of data for the period prior to the LGM supports the three-phase process to colonisation of open-air sites proposed in this paper (Figure 6.25; Chapter Three, 87). Bang-Andersen (1996, 219-234) interprets this as consisting of a "pioneer and discovery" initial phase followed by an "immigration" phase and resulting in a settlement phase that can be defined as "complete annual exploitation" of the newly occupied territory.

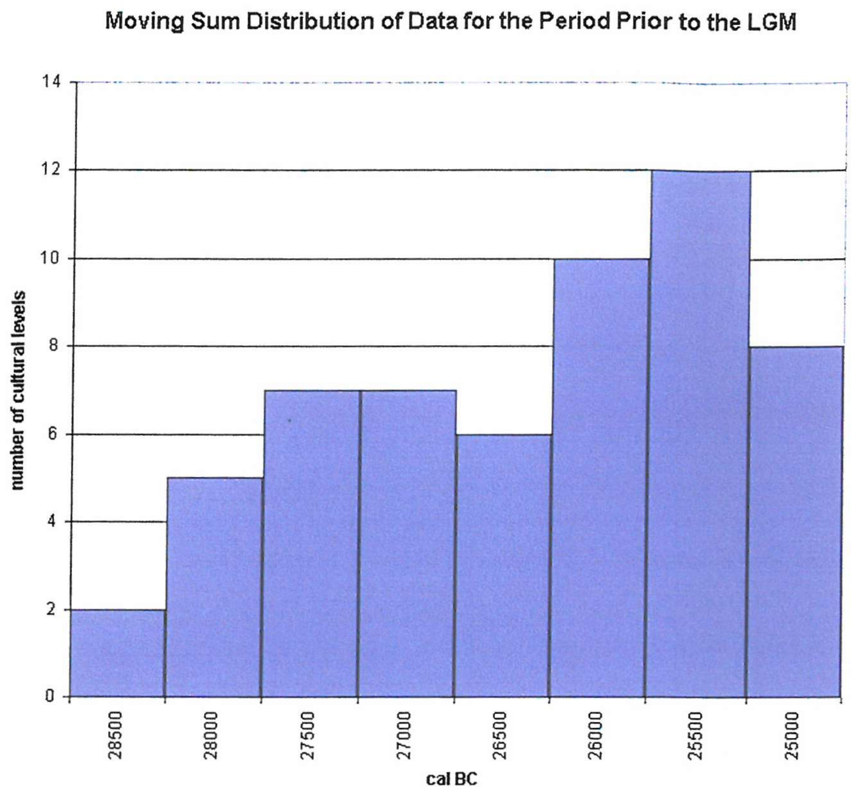


Figure 6.25: Moving sum distribution of open-air site cultural levels spanning the 3000 years prior to the Last Glacial Maximum.

Following the coldest periods of the LGM and Oldest Dryas, there appears to be a two-phase process of recolonisation, similar to that proposed by Housley et al. (1997) for Northwest Europe - the pioneer phase and the residential phase. In my research this pattern is visible with particular association to the dominance of, or increased adaptation to, rockshelter habitation. The moving sum distribution of rockshelter data for the period covering the LGM thru the Oldest Dryas supports the two-phase rapid colonisation process suggested for this type of occupation (Figure 6.26). In each case, this rapid process follows a period of almost complete abandonment of rockshelters. This type of colonisation process may be associated primarily with rockshelter occupation; however, there is an observable link with rapid climate warming, and spatial location and/or distribution. This two-phase approach out of

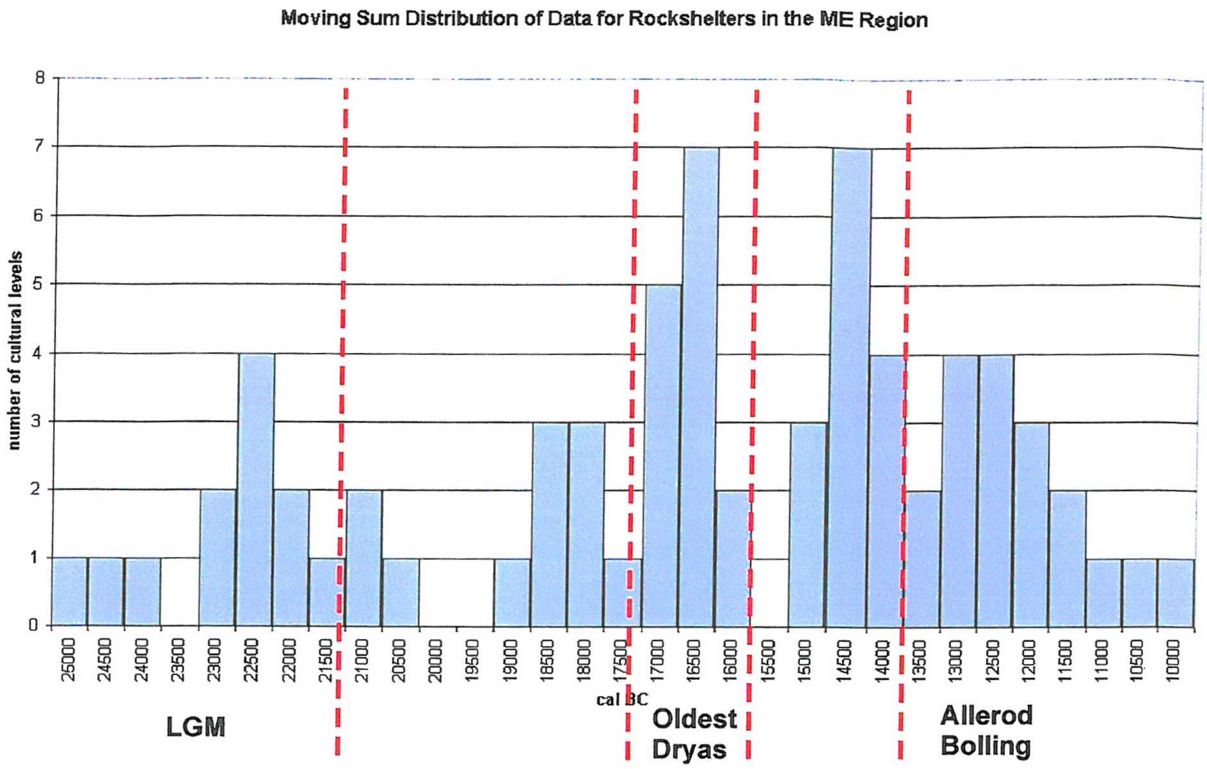


Figure 6.26: Moving sum distribution of rockshelter site data in the Mediterranean Region, 25000 cal BC – 12000 cal BC. The most prominent climate phases are marked according to GISP2 $\delta^{18}O$ measurements (after Jöris and Weninger, 1999).

refugia involves more site locations separated by further distances. Also, this approach is more appropriately applied to the western part of the study area where not only are rockshelters are more apt to be located, but there is a technological distinction from the rest of the study area, particularly after the Oldest Dryas. This distinction is between Magdalenian (dominated by rockshelters) and East Epigravettian (dominated by open-air sites) populations.

This latter point has led to the determination that very different social and ideological constructs governing such behavioural strategies as subsistence, mobility and social relationships, and resulting specialisation resulted in the successful repopulation of distinct groups (Chapter Three, 92). The fact that they coexist lends further credence to the conclusion that while climate may have influenced the adoption of one or the other form of occupation site, it could not have been the driving influence in colonisation processes, since rockshelters remained dominant through the onset of the Holocene, and open-air sites remained the choice of occupation during the LGM.

It is plausible then that the processes of colonisation changed in accordance with social behaviour and adaptation. There are two main recolonisation episodes in the late Upper Palaeolithic. LGM recolonisation was subtler than has previously been suggested, and is associated primarily with open-air sites. The only indication of abandonment appears in peripheral zones such as the northwestern region of the study area. Street and Terberger (1999, 259) have suggested that there is increasing evidence to support the view that regions peripheral to refugia may very well have been occupied sporadically or at lower intensity. That this is not reflected in this research can be attributed to a lack of available radiocarbon data, or a lack of archaeological sites. The recolonisation of Central Europe took place on a micro-regional level.

The Oldest Dryas can be considered *the* climate event that influenced the abandonment of large areas, drastic population reduction, and significant culture change previously credited to the LGM. There is an abandonment of open-air locations in favour of rockshelters. Recolonisation following this event was rapid and covered great distances in a shorter period of time. While rockshelters remained the dominant choice of occupation, open-air sites were almost as popular. In the west, Magdalenian populations rapidly expanded through the once glaciated parts of north central Europe, while in the east, East Epigravettian populations spanned the Central and East Russian Plains. Likewise, there is a definitive attraction to coastal occupation associated with rapid sea level rise. Recolonisation following the Oldest Dryas took place in a wave-like fashion on a macro-regional scale.

The south Mediterranean region (Greece) appears to be an anomaly in that the radiocarbon evidence for colonisation in this region shows no clear relationship to the rest of Central Europe. This is suggested in both the kriging interpolation results (Figure 6.21) and in the temporal and spatial distribution of data. Dates for this region are associated primarily with the LGM and the Oldest Dryas, with continued occupation following the latter. Bailey (1997, 673) provides one plausible explanation as a delayed arrival of the "Upper Palaeolithic package" to a region that is a relatively isolated geographic setting.

In Chapter Seven I will attempt to place the radiocarbon evidence for the recolonisation of Central Europe within the context of greater Europe. I will address the problems and concerns associated with the conclusions I have drawn in this research, and highlight the positive results.

CHAPTER SEVEN

CONCLUSIONS

In conducting this research I have examined, synthesized and quantified the radiocarbon evidence for late glacial human colonisation processes during the late Upper Palaeolithic in Central Europe. I have investigated the use of archaeological radiocarbon dates as a primary source for the investigation of these processes. Of particular interest are the human choices about occupation and movement during the cold phases of the European Last Glacial Maximum (LGM). Toward this end, a spatial and chronological model for the late Upper Palaeolithic colonisation of Central Europe was developed and evaluated against existing research.

The aim of this research has been to build on existing theoretical perspectives and methodological applications in order to provide new insights into Upper Palaeolithic archaeology, European hominid expansions and hunter-gatherer social behaviour. If this work has been only partially achieved this aim, it has been successful.

In this chapter I review the following:

- Assessment of thesis goals
- The wider comparative context of the research
- The process of Late Glacial recolonisation
- Methodological problems, and
- Future prospects

7.1 ASSESSMENT OF THESIS GOALS

My research has had two primary goals. The first was to explore ways to use archaeological radiocarbon data as indicators of colonisation processes. The objectives were outlined in Chapter One as follows:

1) To compile a database of all available archaeological radiocarbon dates for sites within the study area;
2) To develop a means of determining an acceptability threshold for these control data by invoking some form of quality assessment criteria.
3) The development of a working database comprised of single characterised dates representing individual culture layers.

The second goal was to investigate various approaches to modelling these control data both chronologically and spatially, to allow the following objectives of this research to be met:

1) To establish the timing and location of colonisation and/or abandonment of human populations in Central Europe for the period approximately 25000 – 11000 years ago;
2) To determine the rate(s) and direction(s) of population spread;
3) To determine the role that the Carpathian Basin may have played as potential refugium for hunter-gatherers during the cold phases of the late glacial;
4) To place the colonisation of Central Europe and the Carpathian Basin within the context of greater Europe.

While I believe that for the most part, the results of this research have been more than successful at meeting the defined objectives, the degrees of success have been variable. The methodological aspects of working with radiocarbon data for the purposes of spatial-temporal modelling remain in need of further research. Also, the rates and directions of population dispersal have not been refined enough to enable smaller-scale regional analysis. Much work remains to be done in this area.

Three additional queries were put forth for investigation. The first was aimed at the potential for site prediction in areas of poor archaeological visibility, through the application of a predictive model. This was not achieved to satisfactory results primarily due to the time constraints of this project, but the predictive model results suggest that future spatial modelling applications will indeed help to resolve this issue.

The second query was to assess the potential for predicting Palaeolithic hunter-gatherer decision-making processes with respect to movement. The predictive model produced in Chapter Five has shown that the determination of population spread may be derived through simple modelling of data (in this case radiocarbon dates and site location). The potential for predicting population movement into regions where data is limited was assessed using statistical and spatial modelling. I have suggested that the results of such analyses reflect the decision-making processes of the Palaeolithic peoples that directed this movement.

Finally, the work presented here examined the extent to which radiocarbon data can be used to interpret and model the behavioural factors involved in colonisation processes. My research follows the assumption that human colonisation processes are systematic (Housley et al. 1997, Gamble 1995), with purposeful hunter-gatherers acting on choices, as opposed to random dispersal too often assumed in spatial modelling attempts of this nature (e.g. Ammerman and Cavalli-Sforza, 1979). Gamble proposed that, at the continental scale, settlement behaviours could be observed as they relate to latitude, longitude and relief, since these factors "controlled continentality, growing season and hence the productivity of resources... irrespective of the prevailing climatic conditions, glacial or interglacial" (1999, 66). He suggested that variation in behaviours across regional divisions could be shown via density and frequency of occupation, and that social relations could be shown to be the dominant influence over settlement patterns. This too has been tested in this thesis with the result that we can now see in Central Europe, patterns in the data distribution, spatially and temporally, that reflect active choices made by hunter-gatherers.

Radiocarbon evidence has been used in this research in an attempt to determine the recolonisation processes that took place in the late Upper Palaeolithic of Central Europe. The results have provided new insight and raised new questions, as well as new problems. They have also highlighted old questions and concerns that still warrant satisfactory resolution. In this chapter, the results are addressed in relation to large-scale colonisation studies that will enable the recolonisation of Central Europe to be placed within the context of greater Europe.

The goal is to provide future researchers with a better foundation on which to establish a cohesive picture of the recolonisation of Europe in the late Upper Palaeolithic. Also in this chapter, questions, problems and concerns raised by this research are discussed. These include the application of radiocarbon data as predictive indicators (i.e. data quality and usefulness), and the value of predictive modelling techniques. Finally, directions for future research are outlined.

7.2 THIS RESEARCH IN THE CONTEXT OF GREATER EUROPE: A COMPARISON OF ARCHAEOLOGY AND GENETICS

This study has been limited by spatial and temporal boundaries to the extent that regions and chronologies outside of the study have been virtually ignored. Because of this, there exists the problem of perceiving the results with blurred vision. Placing these results within the context of the colonisation and recolonisation of the *whole* of Europe may therefore reveal major discrepancies that cannot be ignored. Indeed, correlation with other regional studies is useful, but since each of these studies is usually subject to similar constraints, I would suggest that the recolonisation of Central Europe can be better placed within the context of greater Europe by correlating the results of this research with studies of an even larger scale. Mitochondrial DNA research is therefore ideal for this purpose.

Richards et al. (2000) explored the geographic distribution of genetic variation markers, such as mtDNA, the "phylogeographic approach" is used to investigate population expansion and migration in "Tracing European Founder Lineages in the Near Eastern mtDNA Pool". They categorised mtDNAs into distinct clusters (haplogroups) to investigate, using founder analysis, (which "picks out founder sequence types in potential source populations and dates lineage clusters deriving from them in the settlement zone of interest"), recurrent gene flow between their supposed source and derived populations (2000, 1252). Torroni et al. (1998, 1137-1152) expanded on previously identified broad categories of mtDNA haplogroups in Europe as: four European-specific haplogroups (H, I, J, and K) and haplogroups T, U, V, W, and X (of which T, V, and W are Caucasoid-specific and U and X are shared between Europeans and Africans, and Europeans and Northern Amerinds, respectively). "Founders" were identified by determining identical or matching sequences found within the European and Near Eastern phylogeny (Richards et al. 2000, 1255). These results were combined with archaeological and palaeo-climatalogical information to assume four major migrations from the Near East into Europe that would account for the arrival of mtDNA clusters arriving within broad age classes. These were identified as occurring in the early Upper Palaeolithic age class at 45000 years BP, in the middle Upper Palaeolithic at 26000 years BP, in the late Upper Palaeolithic at 14500 years BP and in the Neolithic at 9000 years BP (Richards et al. 2000, 1256). For example, the 26000 years BP date allows for the arrival of clusters between the middle and Upper Palaeolithic, between 30000 and 20000 BP, and take into account palaeo-climate fluctuation. A fifth classification is placed at 3000 years BP. It has been proposed (Richards et al. 2000; Bailey et al. 1997) that the first colonisation in Central Europe may have originated from the Near East, as well as expansion prior to the LGM from Western Europe.

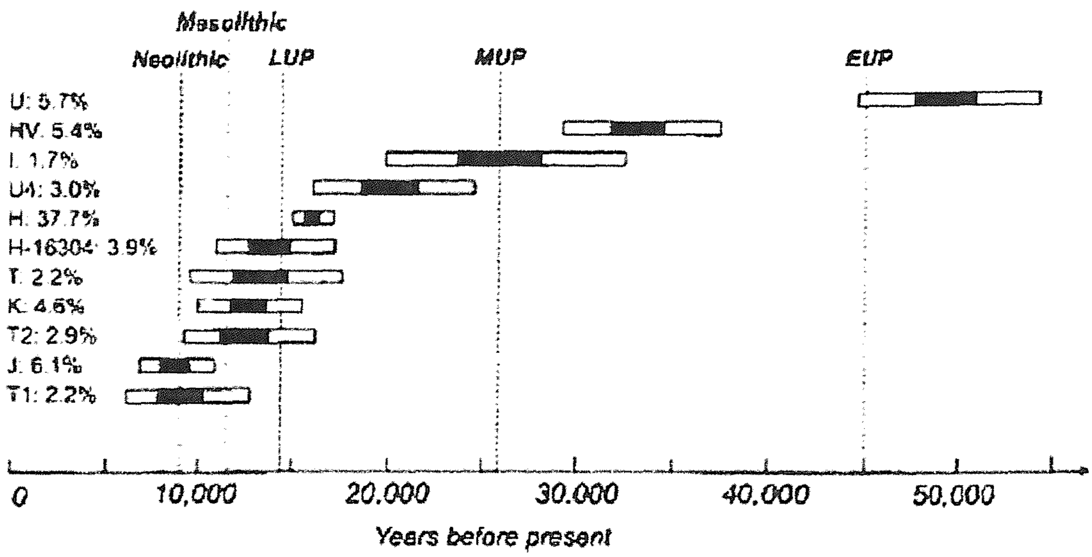


Figure 7.1: Age ranges for major founder clusters. The proportion of lineages in each cluster is indicated. The age classes used in the partition analysis are also indicated. After Richards et al. (2000, figure 1).

Percentage, of Extant European mtDNA Pool, in Each Migration Event, by Region

	Mean ± Root-Mean-Square Error, for									
	Southeastern Europe (n = 166)	Eastern Mediterranean (n = 233)	Central Mediterranean (n = 302)	Alps (n = 218)	North-Central Europe (n = 332)	Western Mediterranean (n = 217)	Basque Country (n = 156)	Northwestern Europe (n = 456)	Scandinavia (n = 316)	Northeastern Europe (n = 407)
Migration Event:										
Bronze Age/recent	8.2 ± 3.3	19.5 ± 3.7	4.6 ± 1.6	6.9 ± 2.7	8.9 ± 3.5	6.3 ± 2.5	5.4 ± 2.6	4.6 ± 1.5	7.4 ± 3.3	5.5 ± 3.0
Neolithic	19.7 ± 6.0	10.7 ± 5.0	9.2 ± 5.1	15.1 ± 5.4	17.1 ± 5.6	12.0 ± 4.2	6.7 ± 4.7	21.7 ± 4.5	11.7 ± 4.5	18.0 ± 4.5
LUP	44.1 ± 6.5	43.0 ± 4.9	49.1 ± 5.8	54.4 ± 5.8	52.2 ± 12.1	56.3 ± 5.0	58.8 ± 4.7	52.7 ± 4.5	52.8 ± 4.7	43.3 ± 4.4
MUP	14.6 ± 4.9	13.2 ± 4.7	21.1 ± 4.4	14.7 ± 4.8	11.8 ± 11.7	14.4 ± 4.8	13.0 ± 3.4	12.2 ± 2.9	12.4 ± 4.0	16.0 ± 3.5
EUP	10.9 ± 3.2	11.2 ± 3.6	12.6 ± 3.1	7.5 ± 3.0	8.6 ± 3.0	4.5 ± 3.3	13.6 ± 2.6	7.5 ± 2.6	14.1 ± 1.8	14.6 ± 2.6
Error	2.6	2.4	3.3	1.4	1.5	6.5	2.6	1.3	1.6	2.7

Note.—Partitioning is under the five-migration model and the f_S criterion.

Table 7.1: Percentage of extant European mtDNA Pool, in each migration event, by region (after Richards et al. 2000, table 5).

The results obtained by Richards et al. (2000) substantiate the radiocarbon evidence for the late Upper Palaeolithic recolonisation of Central Europe and aids in placing the results of my research within the context of greater Europe (Figure 7.1; Table 7.1). First, regional analysis suggests that continuity may be anticipated for the Central Mediterranean region that would indicate that the arrival of "founders of haplogroup H" and others may have taken place prior to the LGM and, with the onset of the LGM "suffered reductions in diversity, as a result of population contractions", and subsequent re-expansion (Richards et al. 2000, 1272). This is consistent with the radiocarbon evidence as it is presented in my research (Chapters Three, Four and Six), and the predictive model produced in Chapter Five of this thesis. I have shown through my analyses of the LGM that colonising populations became reduced in numbers and concentrated more into definable locales.

Second, the analysis suggests that western and central Europe were repopulated from the southwest when the climate improved (Housley et al. 1997; Torroni et al. 1998; Richards et al. 2000, 1272). Torroni et al. (1998, table 6, figure 4) identify "a major Palaeolithic population expansion" from Southwest Europe after the Last Glacial Maximum between 10,000 and 15,000 years ago (see figure 7.2). Haplogroup V appears to have evolved within Europe. Allowances for multiple expansion revealed that the early Upper Palaeolithic component consisted of mainly Haplogroup U5, which are highest in southern and Eastern Europe and in Scandinavia. Though there is no direct archaeological evidence, palaeo-botanical evidence promotes the presence of human populations in Southwest Norway as early as 11800 - 11000 BP (Bang-Andersen 1996, 219). Fischer (1996, 157) has suggested that "the pioneer inhabitants of West Sweden and Norway were from their arrival during the Ahrensburgian epoch already exploiting the marine environment intensively. It is possible that coastal - adapted societies also existed much further back in the Palaeolithic along the now submerged sea shores of western and southern Europe". Certainly spatial modeling (Chapter Five) has shown that this latter suggestion is plausible.

My research has indicated that if distinctions between rockshelter and open-air site occupations are taken into account along with technological differences, multiple expansions as suggested in the mtDNA research corresponding to the period following the Oldest Dryas as it is presented here can be supported (see Chapter Six, 230-233).

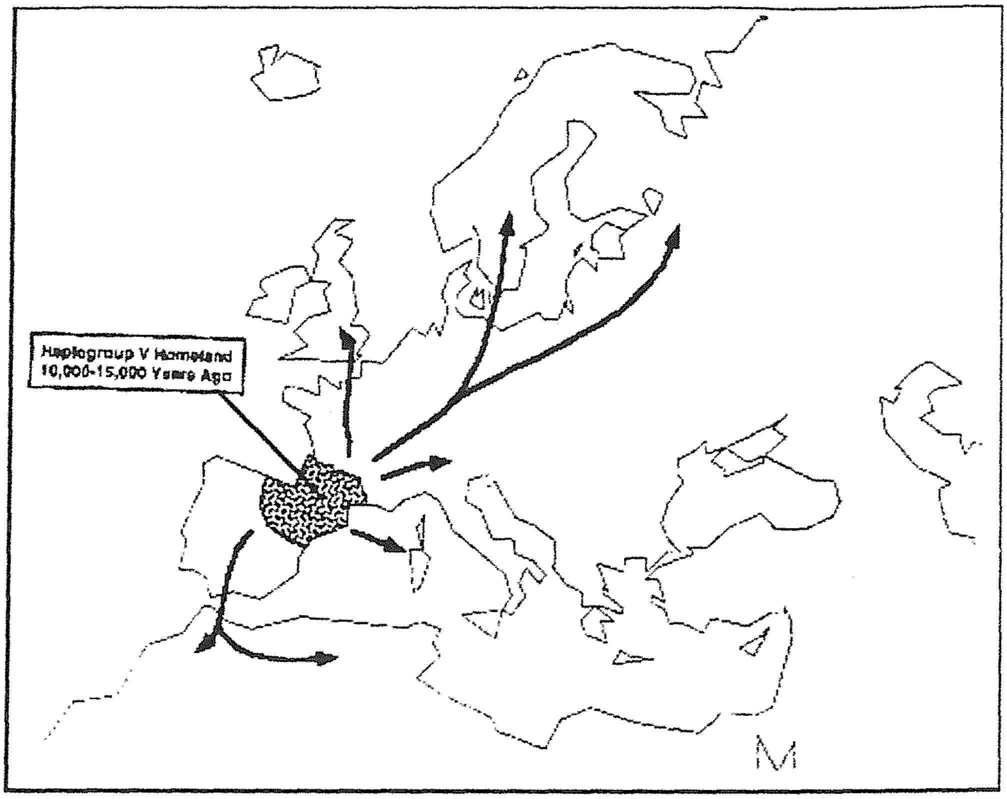


Figure 7.2: Map depicting probable homeland of Haplogroup V and potential diffusion (after Torroni et al. 1998, figure 4).

Summary

Renfrew (2000, 23) has summarized the successive phases in the population history of Europe in the late Palaeolithic based on the mtDNA evidence put forth by Torroni (1998), Richards (2000) and others (Malaspina et al. 1998; Sykes 1999). He identifies these phases as:

A. the first *sapiens* population episode in the Late Pleistocene *c.* 40,000 years ago;
B. the retreat to southern refugia during the Late Glacial Maximum of *c.* 18,000 to 15,000 BC;
C. the final Pleistocene from *c.* 15,000 BC and the retreat of the ice.

It is important to note that unwittingly Renfrew's classification of the Late Glacial Maximum correlates to the Oldest Dryas period as described in my Chapter Three of this thesis.

7.3 A SUMMARY OF THE RECOLONISATION PROCESS

Combining the various lines of evidence at the scale of a greater Europe allows me to offer the following summation of the late Upper Palaeolithic recolonisation of Central Europe.

Prior to the LGM

- Immigration of new populations from the Near East into the Caucasus, Greece and Bulgaria.
- Expansion of existing populations from Western Europe, and expansion of existing populations in Eastern Europe.
- Dominated by open-air site occupation and associated subsistence strategies.

LGM

- Contraction and expansion of existing populations in the North East regions, the Mediterranean and the North Central regions.
- Contraction episode at the LGM cold maximum into existing established areas (may be considered as refuge zones with caution). At the cold maximum there is re-adaptation to rockshelter habitation as well as established open-air sites.

LGM – Oldest Dryas

- Re-expansion of existing populations.

Oldest Dryas

- Retreat to southern areas of refuge. The Carpathian Basin acted as a refuge zone.
- Drastically reduced populations.
- Switch from open-air habitation to rockshelter adaptations – in partial response to extreme cold temperature.

Post – Oldest Dryas

- Recolonisation of Central and Eastern Europe.
- Possible coastal migration route from the southeast.
- Rockshelters remain dominant form of habitation.

Alleröd

- Open-air habitation is resumed contemporarily with rockshelter occupation. Technologically distinct groups co-exist.
- New coastal adaptation following the retreat of glacial ice along the Baltic coast.
- Recolonisation of northern latitudes.

7.4 PROBLEMS AND PERSPECTIVES

The overview presented above must however be followed by a necessary health warning. In Chapter One of this thesis, I outlined a number of problematic issues inherent in Upper Palaeolithic hunter-gatherer studies. These included concerns about inconsistency in available data due to variable preservation of the archaeological record, quality control (of both the archaeological record and the analytical method), the question of scale in large colonisation studies, and the idea that Upper Palaeolithic large scale studies, temporally and spatially are particularly prone to environmental determinism. In this section I will discuss these in terms of the amount of success obtained in this research to address such issues. I will also comment on additional concerns that have come to the forefront during the process of my research.

7.4.1 Data Quality and Control

The primary issues of concern which influence our judgement about archaeological data (in this case the radiocarbon data) are:

1) *quality control* that must somehow define the degree of confidence by which we set the acceptability threshold of the radiocarbon date;
2) *variability within the dataset* which must include the processes by which samples are retrieved and dated, and series of dates vs. the single date;
3) *soundness of method* to ensure limited bias.

In Chapter Two I addressed the issue of quality control and data acceptability for raw radiocarbon data, and proposed a means of qualifying and quantifying that data such that it could be used successfully in large-scale colonisation research. This involved obtaining as much detail as possible about the data and assessing its quality by interpreting the level of agreement between the data, palaeo-climate information and the archaeological record. Then, a method for obtaining a threshold of acceptability by which the data could be ranked and recorded, either in degrees of acceptable use or elimination from the dataset. The measure of success in this part of my work is difficult to determine.

I recognise that the method needs further refinement. While I remain convinced that the objectives are correct, and that basic results were achieved, the question of how best to apply the quality controlled data to colonisation studies may lead to substantiated criticism. I am referring to three primary concerns in the method used to achieve the working database.

In the first case, there will no doubt be criticism over the elimination of radiocarbon data from the analytical dataset. While this may not be ideal, I defend the idea that some form of control must be maintained. Where no additional data was available, data marked for elimination did remain in the dataset. To date, I remain unconvinced of a more appropriate means of determining the acceptability of radiocarbon data, though caution is most certainly warranted.

Second, a serious concern was the means of radiocarbon calibration. As pointed out in Chapter Two, this method of correlating radiocarbon age with calendrical age is constantly being revised and updated. At present, the choice of calibration curve and associated calibrating program is usually at the discretion of the researcher and as such, the results are prone to some bias in this respect. Calibration took place following the determination of acceptability of each date, and prior to the development of the working database.

Finally, perhaps the most problematic issue is that of finding the most appropriate means of applying radiocarbon data to spatial-temporal studies such that they could be used more effectively as archaeological indicators, with the goal of achieving meaningful results from colonisation analyses. This is perhaps the most complex problem associated with this research. While I am convinced that the subsequent working database allowed for the successful interpretation of colonisation processes in the late Upper Palaeolithic of Central Europe, I believe that the method used to achieve the working database must be revised.

In Chapter Two the working database was developed. In the case where a series of, or multiple, calibrated dates existed for a single archaeological cultural level, the mean calibrated date was used to represent that cultural level in both time and space. This method may be deemed over-simplified, and I will not argue this point. The resolution of the best approach for using radiocarbon data as archaeological indicators remains unresolved in my opinion. However, the results obtained in this research are supported by empirical archaeological and genetic evidence, and have shown that not only are radiocarbon data suitable to more complex temporal and spatial analyses, but that the simple method presented here can provide a basis for future research into radiocarbon usability.

7.4.2 The Problem of Scale

The issue of scale is reflected in colonisation research and the conceptualisation of the idea of region and regional variability (Conkey 1987; Wobst 1990). In a large-scale research framework, there are multiple and variable levels of scale within a single study. The grouping of sites spatially, temporally and culturally, can be problematic and can result in misrepresentations of the past. Conkey (1987, 9) suggests that the resolution to this problem rests in changing the way we view the archaeological record - away from assuming that the investigated archaeological record comprises the past regional patterning, toward the development of models "for a particular prehistoric context that then structures our archaeological inquiry... ". It is therefore considered acceptable, and even appropriate, that largely variable cultural complexes are grouped according to broader classifications in an effort to maintain a more manageable research framework (Chapter One, 8-9; Kozlowski 1986; Bouquet-Appel and Demars 1998).

Conkey (1987, 10) suggests that modelling large-scale regional landscapes does not allow for the analysis of small-scale regional variation and notes that this raises concerns about post-depositional processes inferring an evolutionary bias in long temporal studies.

In this research I have tried to address these concerns. In Chapter Three, the temporal analysis incorporated the moving sum method developed by Rick (1987) and adopted by Holdaway and Porch (1995) and Housley et al. (1997). The purpose of the method was to amplify the data such that patterns of occupation based on radiocarbon indicators would be more boldly defined. The method was applied to the working calibrated radiocarbon database by applying divisions to the data that would enable simple patterns in social differentiation to be ascertained. The results were successful in that both large-scale temporal patterns and broadly categorised cultural patterns were identifiable. In Chapter Four, the same method was applied spatially and correlated with kriging analysis with similar success to ascertain large-scale and regional settlement patterning, both temporally and culturally.

7.4.3 Environmental Determinism

Environmental determinism is a particular pitfall to large-scale colonisation studies, providing readily acceptable explanations (or justifications for explanation) for interpreting population dispersal and consequently social behaviour. An example attempting to incorporate an ecological approach to an environmentally deterministic scenario is provided by Bang-Andersen (1996) whose examination of colonisation in Southwest Norway is referenced to palaeo-environmental research. While the character of colonisation is such that hunter-gatherers are given the primary active role in the space - time - social relationship, modelling this relationship in a fashion more suitable to current theoretical constraints for human dispersal, requires a cautious approach. Arguably, that approach must distance itself from the "cause and effect" implied in environmental determinism. This is an issue I have tried to both address and avoid in my research.

In this work, I have applied archaeological data in the form of radiocarbon data as the primary source of modelling the colonisation processes. The method, as shown in Chapter Five, does make use of environmental characteristics of the late Upper Palaeolithic (data that must also be controlled for quality), however, it tests, rather than depends on such data. In Chapters Three and Four, palaeo-climate is used as comparative empirical data, and in Chapter Five reconstructed palaeo-topography is used as geographic space over which populations moved, rather than were hindered by. Perhaps the only exception is the assumption that glacial ice acts as a barrier to colonisation routes. Reconstructed palaeo-shorelines were only used as boundaries to the geographic framework of this research.

The most important means of addressing environmental determinism is to be aware of it. I hope that I have shown in this research that hunter-gatherer research of the Palaeolithic can be approached within current ecological frameworks while avoiding a deterministic dependence on both environmental data and traditional typological approaches.

7.5 FUTURE RESEARCH

During the writing of this thesis, I have come to realize the considerable potential for future research colonisation studies can provide at both a continental and regional scale. To achieve this potential however, requires that two primary methodological considerations be addressed further.

First, of course, is the need to develop meaningful ways of exploiting radiocarbon data without losing the integrity of either the data or the method of analysis. In light of ongoing and continuous growth in the development of excavation and recording strategies, dating procedures, and calibration techniques, I expect the resolution of an acceptable approach to more effective usage of radiocarbon data is to be a long time in coming. However, attempts such as the one conducted in this project and others (e.g. Dolukhanov 1999) are hopefully incentive enough to encourage further methodological refinement.

Second, the development of suitable methods to model colonisation are naturally dependent on the research questions and the availability of data. This research is partially based on the application of GIS modelling techniques to produce a predictive model that could be used to determine colonisation patterns in both time and space. The application of such procedures (e.g. Steele et al. 1998; Hosfield 1999; Anderson and Gillam 1999; Warren and Asch 2000), in my opinion, is advantageous to the successful interpretation of large-scale colonising processes, and should be considered a worthwhile direction in the formulation of new methods in colonisation research.

My research has also raised new questions about the settlement processes of late Upper Palaeolithic hunter-gatherers, which are of cultural and temporal significance. The most significant of these is the evidence to suggest that the Oldest Dryas, and not the Last Glacial Maximum represents the primary date leading to the recolonisation of Central Europe. This is correlated with the genetic evidence illustrated in section 7.1 of this chapter. It also represents a shift in site occupation type.

Bailey et al. (1997, 521-536) addressed the relationships between rockshelters and open-air sites in "Rockshelters and Open-air Sites: Survey Strategies and Regional Site Distributions", part of a detailed examination of Palaeolithic settlement and Quaternary landscapes in northwest Greece (Bailey, ed., 1997). They suggest that for this region there is "no evidence to support the notion of a general shift from open-air locations to rockshelters during the Upper Palaeolithic". My research does not contradict this conclusion. Rather, I agree that at the micro-regional scale of the LGM, both rockshelters and open-air sites are in use contemporarily. But, at the macro-regional level, the radiocarbon data clearly distinguishes that such a shift does take place during the Oldest Dryas. Following the Oldest Dryas, as seen in Chapters Three and Four, technologically distinct groups occupying rockshelters and open-air sites co-exist. The implications of this for hunter-gatherer research must be addressed. For example, it is shown in this that the cold temperatures of the Oldest Dryas must have influenced both population size and choice of occupation site. How significant was this? To what extent does influence (either cultural or environmental) have on diversity in social behaviour between rockshelter inhabitants and open-air site inhabitants given a) that populations either switched adaptation strategies due to climate change and/or b) chose adaptation strategies based on sociological knowledge and ideas? How can this be identified and/or interpreted in the archaeological record?

I have proposed that the Carpathian Basin is a likely zone of refugia during the Oldest Dryas. Stefan et al. (2001) and Malaspina et al. (1998) suggest that in Central Europe the Carpathian Mountains coincide with a genetic boundary where the area east of the Carpathians is characterised by much higher frequencies of mtDNA haplogroup distribution than those west of the Carpathians, implying that genetic discontinuity might not be coincidental considering that the Carpathians also represent an ecological boundary (Stefan et al. 2001, 27-33). Stefan et al. (2001) note that there is poor genetic overlap between the peopling of steppe and plain *vs* mountain environments. I would add that the settlement patterns revealed in the radiocarbon data (Chapter Four) would support further exploration of the role of the Carpathian Basin in regional Upper Palaeolithic mobility and refugia.

Gamble (1993) has expressed concern that refugia can be used to explain discontinuity in colonisation processes. Soffer has also argued that while there may be some evidence for demographic shifts, there is no way of discerning the disappearance of local populations, nor the use of refuge zones as we would define them (1987, 344). I would agree to some extent. Unlike other assumed places of refuge in the North Eastern regions, there is evidence that the Carpathian Basin was not continually occupied. Rather, it was a likely route of dispersal during climate amelioration and population expansion, and a retreat during cold periods.

I have proposed in Chapter One that the character of refugia might be less rigidly defined. I have suggested that refugium, in the context of colonisation processes, should be considered bounded only in terms of hunter-gatherer mobility and behaviour. Of course, ecological niches and range extension are assumed to exist, but the boundaries of these must be flexible. This may allow researchers to account for issues of continuity and discontinuity in the archaeological record. The role of refugium in colonisation research is one that also belongs to a spatial, temporal and social landscape. I have tried to address this as much as possible within the framework my research. While the evidence provided through environmental and genetic studies appears to support a more definitive approach to the definition (i.e. a bounded region with high population density) of refugium, radiocarbon evidence and predictive modelling favour the arguments of Soffer (1987) and Gamble (1993). The issue of refugium as a concept must be re-addressed if it is to contribute more meaningfully to colonisation research. Perhaps refugium is more of an ethnocentric concept and a useful starting point for analysis, than it is a dynamic contributor to cultural change and/or continuity.

It has not been my intent to propose that all of the objectives laid out in this research could be resolved successfully, but I believe that the work conducted here offers a new foundation on which to re-examine the late Upper Palaeolithic in Central Europe. I look forward to the future.

APPENDIX A

The Original Database

Key

OA = open-air site

RS = rockshelter

p/m = uncal BP ±

ra = radiocarbon acceptability

aa = archaeological acceptability

ta = total acceptability

A = acceptability threshold

Site	Layer ID	Country	Lon	Lat	OA/RS	TC	Lab Ref	uncal BP	p/m	AMS	Sample Type	ra	aa	ta	A
Abri am Kaufertserg bei Lierheim	lower (level 1)	Germany	10.35	48.5	RS	Magdalenian	OxA-5751	12610	90	yes	used reindeer bone	3	2	5	3
Abri Tagliente	10	Italy	11.20	45.7	RS	Epigravettian	OxA-3530	12650	160	yes		3	2	5	3
Abri Tagliente	10	Italy	11.20	45.7	RS	Epigravettian	OxA-3531	13070	170	yes		3	2	5	3
Abri Tagliente	10	Italy	11.20	45.7	RS	Epigravettian	OxA-3532	13270	170	yes		3	2	5	3
Abri Tagliente	14	Italy	11.20	45.7	RS	Epigravettian	R-604	12000	450	no		2	2	4	2
Abri Tagliente	10 to 8	Italy	11.20	45.7	RS	Epigravettian	R-371	12040	170	no		2	2	4	2
Abri Tagliente	15 and 16	Italy	11.20	45.7	RS	Epigravettian	R-605	13330	160	no		2	2	4	2
Abri Tagliente	15 and 16	Italy	11.20	45.7	RS	Epigravettian	R-605a	13430	180	no		2	2	4	2
Aggsbach	B	Austria	15.42	48.28	OA	Gravettian	unknown	22450		no		1	1	2	1
Aggsbach	C	Austria	15.42	48.28	OA	Aurignacian	GrN-2513	26800	200	no	charcoal from hearth	2	1	3	2
Aggsbach	H/K/S	Austria	15.42	48.28	OA	Aurignacian	GrN-1354	25760	170	no	charcoal from hearth	2	1	3	2
Aggsbach		Austria	15.42	48.28	OA	Gravettian	GrN-1327	22670	100	no	charcoal from hearth	2	1	3	2
Akhshtyr Cave		Russia	39.59	43.32	RS	Eastern Gravettian	GIN-66	19500	500	no	charcoal from hearth	1	2	3	2
Alberndorf		Austria	14.42	48.40	OA	Gravettian	VRI-1272	20500		no	bone, antler	1	1	2	1
Amvrosievka	culture layer; bone bed	Ukraine	39.02	47.3	OA	Eastern Epigravettian	LE-1637	15250	150	no	bone	1	2	3	2
Amvrosievka	horizon I	Ukraine	39.02	47.3	OA	Eastern Gravettian	OxA-4890	18700	240	yes	bone	3	3	6	3
Amvrosievka	horizon I	Ukraine	39.02	47.3	OA	Eastern Gravettian	OxA-4891	18860	220	yes	bone	3	3	6	3
Amvrosievka	horizon II; bone bed	Ukraine	39.02	47.3	OA	Eastern Gravettian	LE-3403	21500	340	no	tooth	2	3	5	3
Amvrosievka	horizon II-III	Ukraine	39.02	47.3	OA	Eastern Gravettian	OxA-4892	18700	220	yes	bone	3	3	6	3
Amvrosievka	horizon II-III	Ukraine	39.02	47.3	OA	Eastern Gravettian	OxA-4893	18620	220	yes	bone	3	3	6	3
Amvrosievka	horizon IV	Ukraine	39.02	47.3	OA	Eastern Gravettian	OxA-4894	18220	200	yes	bone	3	3	6	3
Amvrosievka	horizon VI	Ukraine	39.02	47.3	OA	Eastern Gravettian	OxA-4895	18660	220	yes	bone	3	3	6	3
Amvrosievka	top of culture layer; bone bed	Ukraine	39.02	47.3	OA	Eastern Gravettian	LE-1805	20620	150	no	bone	2	3	4	2
Anetovka 2		Ukraine	31.06	47.38	OA	Eastern Gravettian	LE-2424	18040	150	no	bison bone	2	1	3	2
Anetovka 2		Ukraine	31.06	47.38	OA	Eastern Gravettian	LE-2624	24600	150	no	mammoth tooth	2	1	3	2
Anetovka 2		Ukraine	31.06	47.38	OA	Eastern Gravettian	LE-2947	19170	120	no	burned bone	2	3	5	3
Anetovka 2		Ukraine	31.06	47.38	OA	Eastern Gravettian	LE-4066	18265	1650	no	bison bone	0	1	1	0
Anetovka 2		Ukraine	31.06	47.38	OA	Eastern Gravettian	LE-4610	19090	980	no	burned bone	1	3	4	2
Arka	lower	Hungary	21.30	48.3	OA	Eastern Gravettian	A-518	18700	190	no		2	1	3	2
Arka	lower	Hungary	21.30	48.3	OA	Eastern Gravettian	GrN-4038	17050	350	no	charcoal from hearth	2	2	3	2
Arka	upper	Hungary	21.30	48.3	OA	Eastern Epigravettian	GrN-4218	13230	85	no		2	1	3	2
Asprochaliko Rockshelter	10	Greece	20.98	39.25	RS	Gravettian	I 1956	26100	900	no		1	1	2	1
Asprochaliko Rockshelter	10	Greece	20.98	39.25	RS	Gravettian	OxA-775	18000	300	yes	amino acids	3	1	4	2
Asprochaliko Rockshelter	10	Greece	20.98	39.25	RS	Epigravettian	OxA-776	14000	600	yes	amino acids	2	1	3	2
Asprochaliko Rockshelter	10	Greece	20.98	39.25	RS	Gravettian	OxA-777	25100	700	yes	amino acids	2	1	3	2
Ataki	II	Ukraine	26.50	48.34	OA	Eastern Epiravettian	SOAN-143	15375	830	no		1	1	2	1

Ataki	III	Ukraine	26.50	48.34	OA	Eastern Gravettian	SOAN-144	16600	750	no		1	1	2	1
Avdeevo		Russia	36.03	51.44	OA	Eastern Gravettian	GIN-1569d	21200	200	no	burned bone	2	1	3	2
Avdeevo		Russia	36.03	51.44	OA	Eastern Gravettian	GIN-1570a	19800	1200	no	burned bone	0	1	1	0
Avdeevo		Russia	36.03	51.44	OA	Eastern Gravettian	GIN1571a	22700	700	no	burned bone	1	1	2	1
Avdeevo		Russia	36.03	51.44	OA	Eastern Gravettian	GIN-1571b	17200	1800	no	same sample as GIN-1571a	0	1	1	0
Avdeevo		Russia	36.03	51.44	OA	Eastern Gravettian	GIN-1746	20100	500	no	burned bone; hearth 6	1	1	2	1
Avdeevo		Russia	36.03	51.44	OA	Eastern Gravettian	GIN-1747	20800	200	no	burned bone; hearth 6	2	1	3	2
Avdeevo		Russia	36.03	51.44	OA	Eastern Gravettian	GIN-1748	21000	200	no	burned bone; hearth 1	2	1	3	2
Avdeevo		Russia	36.03	51.44	OA	Eastern Gravettian	GIN1969	22400	600	no	burned bone; hearth	1	1	2	1
Avdeevo		Russia	36.03	51.44	OA	Eastern Gravettian	GIN-1970	22200	700	no	burned bone	1	1	2	1
Avdeevo		Russia	36.03	51.44	OA	Eastern Gravettian	GIN-2535	21000	800	no	burned bone; sq. 3-7	1	1	2	1
Avdeevo		Russia	36.03	51.44	OA	Eastern Gravettian	GIN-4693	21600	400	no	burned bone; hearth	2	1	3	2
Avdeevo		Russia	36.03	51.44	OA	Eastern Gravettian	GIN-6592	20100	300	no	burned bone; hearth (1987)	2	1	3	2
Avdeevo		Russia	36.03	51.44	OA	Eastern Gravettian	GIN-6593	20100	200	no	burned bone; hearth, sq. 3-2	2	1	3	2
Avdeevo		Russia	36.03	51.44	OA	Eastern Gravettian	GIN-6594	20100	400	no	burned bone; hearth, sq. r-1	2	1	3	2
Avdeevo		Russia	36.03	51.44	OA	Eastern Gravettian	GIN-7727	19500	500	no	mammoth tooth	1	1	2	1
Avdeevo		Russia	36.03	51.44	OA	Eastern Gravettian	GIN-7729	23400	700	no	mammoth tooth	1	1	2	1
Avdeevo		Russia	36.03	51.44	OA	Eastern Epigravettian	IGAN-151	11950	310	no	mammoth tooth	2	1	3	2
Avdeevo		Russia	36.03	51.44	OA	Eastern Epigravettian	IGAN-78	13900	200	no	mammoth tooth	2	1	3	2
Avdeevo		Russia	36.03	51.44	OA	Eastern Gravettian	QC-270	16565	270	no	burned bone	2	1	3	2
Avdeevo		Russia	36.03	51.44	OA	Eastern Gravettian	QC-621	16960	420	no	bone (1978)	2	1	3	2
Avdeevo		Russia	36.03	51.44	OA	Eastern Gravettian	QC-886	16565	270	no	bone (1948)	2	1	3	2
Avdeevo		Russia	36.03	51.44	OA	Eastern Gravettian	QC-887	18500	2100	no	bone (1948)	0	1	1	0
Avdeevo		Russia	36.03	51.44	OA	Eastern Gravettian		16969	425	unknown		1	1	2	1
Badanj	13 17C13	Bosnia-Hertz.	17.58	43.04	RS	Eastern Epigravettian	OxA-2196	13200	150	yes	burnt bone	3	1	4	2
Badanj	6 17B6	Bosnia-Hertz.	17.58	43.04	RS	Eastern Epigravettian	OxA-2197	12380	110	yes	burnt bone	3	1	4	2
Balatonszabadi		Hungary	17.50	46.7	OA	Eastern Gravettian		21725	660	unknown		1	1	2	1
Bärenkeller (Königsee-Garsitz)		Germany	11.50	50.58	RS	Magdalenian	Bln-220	13700	380	no	bone-charcoal	1	1	3	2
Berdyzh		Belarus	30.58	52.5	OA	Eastern Gravettian	GIN-2695	22500	200	no	mammoth tooth	2	1	3	2
Berdyzh		Belarus	30.58	52.5	OA	Eastern Gravettian	LU-104	23430	180	no	mammoth tooth	2	1	3	2
Berdyzh		Belarus	30.58	52.5	OA	Eastern Epigravettian	OxA-716	15100	250	yes	mammoth tooth	3	1	4	2
Bockstein-Torle	level VI	Germany	10.06	48.56	OA	Gravettian	H-4058-3355	20400	220	no		2	1	3	2
Bockstein-Torle	level VI	Germany	10.06	48.56	OA	Gravettian	H-4058-3526	23440	290	no		2	1	3	2
Boila Rockshelter	II	Greece	39.98	20.8	RS	Magdelanian	OxA-5246	13810	130	yes	burnt bone	3	1	4	2
Boila Rockshelter	IIIa	Greece	39.98	20.8	RS	Magdelanian	OxA-5241	12480	120	yes	burnt bone	3	1	4	2

Boila Rockshelter	IIIa	Greece	39.98	20.8	RS	Magdelanian	OxA-5242	13240	110	yes	burnt bone	3	1	4	2
Borshchevo 1		Russia	39.06	51.2	OA	Eastern Gravettian	GIN-8085	15600	70	no	mammoth bone, 1923	2	1	3	2
Borshchevo 1		Russia	39.06	51.2	OA	Eastern Gravettian	LE-3727	17200	150	no	mammoth bone, 1980	2	1	3	2
Borshchevo 2		Russia	39.06	51.2	OA	Eastern Epigravettian	GIN-8084	10400	200	no	horse burned bones (1925)	2	1	3	2
Borshchevo 2		Russia	39.06	51.2	OA	Eastern Epigravettian	GIN-8415	10900	300	no	horse burned bones (1925)	2	1	3	2
Borshchevo 2	1; upper	Russia	39.06	51.2	OA	Eastern Epigravettian	GIN-88	12300	100	no	humus with plant remains	2	1	3	2
Borshchevo 2	1; upper	Russia	39.06	51.2	OA	Eastern Epigravettian	LU-742	13210	270	no	charcoal	2	1	3	2
Borshchevo 2	1; upper	Russia	39.06	51.2	OA	Eastern Epigravettian	Mo-636	11760	240	no	humus	2	1	3	2
Borshchevo 2	horizon II	Russia	39.06	51.2	OA	Eastern Epigravettian	LE-4867	14030	200	no	humus	2	1	3	2
Borshchevo 2	I cultural layer	Russia	39.06	51.2	OA	Eastern Epigravettian	LE-4837	13480	720	no	charcoal	1	1	3	2
Borshchevo 2	lower horizon	Russia	39.06	51.2	OA	Eastern Epigravettian	GIN-3261	12550	200	no	Gyttja	2	1	3	2
Borshchevo 2	upper cultural layer, horizon I	Russia	39.06	51.2	OA	Eastern Epigravettian	LE-4865	9520	300	no		2	1	3	2
Borshchevo 2	upper cultural layer, horizon I	Russia	39.06	51.2	OA	Eastern Epigravettian	LE-4866	9330	390	no		2	1	3	2
Brînzeni I	III	Moldova	27.07	48.06	RS	Eastern Gravettian	OxA-4118	19220	180	yes	reindeer tooth	3	2	5	3
Brînzeni I	III	Moldova	27.07	48.06	RS	Eastern Gravettian	OxA-4119	22530	250	yes	horse tooth	3	2	5	3
Brînzeni I	III	Moldova	27.07	48.06	RS	Eastern Epigravettian	OxA-4120	14700	130	yes	horse bone	3	2	5	3
Brînzeni I	III	Moldova	27.07	48.06	RS	Eastern Gravettian	OxA-4121	22330	230	yes	horse bone	3	2	5	3
Brînzeni I	III	Moldova	27.07	48.06	RS	Eastern Gravettian	OxA-4122	26600	370	yes	reindeer bone	3	2	5	3
Brînzeni I	III	Moldova	27.07	48.06	RS	Eastern Epigravettian	OxA-4123	16600	160	yes	horse tooth	3	2	5	3
Brînzeni I	III	Moldova	27.07	48.06	RS	Eastern Gravettian	OxA-4124	26200	360	yes	horse bone	3	2	5	3
Brînzeni I	III	Moldova	27.07	48.06	RS	Eastern Gravettian	OxA-4898	20140	260	yes	horse mandible	3	2	5	3
Brînzeni I	III	Moldova	27.07	48.06	RS	Eastern Gravettian	OxA-4899	19780	260	yes	horse bone	3	2	5	3
Brno-Vídenská (Konevova)		Czech Rep.	16.65	49.95	OA	Epigravettian	GrN-9350	14450	90	no	bone	2	1	3	2
Buran-Kaya III	cultural layer VI, horizon 8	Ukraine	34.25	45	RS	Eastern Epigravettian	OxA-4126	11900	150	yes	bone	3	1	4	2
Buran-Kaya III	cultural layer VI, horizon 9	Ukraine	34.25	45	RS	Eastern Epigravettian	OxA-4127	11950	130	yes	bone	3	1	4	2
Calowanie	I	Poland	20.65	52.4	OA	Magdelanian	CAMS-20868	11890		yes	charcoal	1	2	3	2
Calowanie	III	Poland	20.65	52.4	OA	Magdelanian	Gd-4165	11740		no	charcoal	1	2	3	2
Calowanie	III	Poland	20.65	52.4	OA	Magdelanian	GrN-5967	11380		no	charcoal	1	2	3	2

Calowanie	IV	Poland	20.65	52.4	OA	Magdelanian	Gd-2723	10900		no	charcoal	1	2	3	2
Calowanie	IV	Poland	20.65	52.4	OA	Magdelanian	Gd-2882	11770		no	charcoal	1	2	3	2
Calowanie	IV	Poland	20.65	52.4	OA	Magdelanian	GrN-5410	11190		no	charcoal	1	2	3	2
Cejkov		Slovakia	21.69	48.61	OA	Eastern Gravettian	KN-?	19600	340	no		1	1	2	1
Cejkov		Slovakia	21.69	48.61	OA	Eastern Gravettian	Bln-?	19755	240	no		1	1	2	1
Chulatovo I		Ukraine	33.07	51.5	OA	Eastern Epigravettian	OxA-715	14700	250	yes	mammoth tooth	3	1	4	2
Cosaoutsi		Ukraine	28.17	48.13	OA	Eastern Gravettian	OxA-5233	17900		yes	bone	2	2	4	2
Cosaoutsi		Ukraine	28.17	48.13	OA	Eastern Gravettian	OxA-5234	17900		yes	bone	2	2	4	2
Cosaoutsi		Ukraine	28.17	48.13	OA	Eastern Gravettian	OxA-5235	18000		yes	bone	2	2	4	2
Cosaoutsi		Ukraine	28.17	48.13	OA	Eastern Gravettian	OxA-5236	17840		yes	bone	2	2	4	2
Cosaoutsi		Ukraine	28.17	48.13	OA	Eastern Gravettian	OxA-5237	18000		yes	bone	2	2	4	2
Cosaoutsi		Ukraine	28.17	48.13	OA	Eastern Gravettian	OxA-5238	18060		yes	bone	2	2	4	2
Cosaoutsi		Ukraine	28.17	48.13	OA	Eastern Gravettian	OxA5247	18140		yes	bone	2	2	4	2
Cosaoutsi		Ukraine	28.17	48.13	OA	Eastern Gravettian	OxA-5248	18780		yes	bone	2	2	4	2
Cosaoutsi		Ukraine	28.17	48.13	OA	Eastern Gravettian	OxA-5249	18940		yes	bone	2	2	4	2
Cosaoutsi		Ukraine	28.17	48.13	OA	Eastern Gravettian	OxA-5250	18980		yes	bone	2	2	4	2
Cosaoutsi		Ukraine	28.17	48.13	OA	Eastern Gravettian	OxA-5251	19060		yes	bone	2	2	4	2
Cosaoutsi		Ukraine	28.17	48.13	OA	Eastern Gravettian	OxA-5252	19060		yes	bone	2	2	4	2
Cosaoutsi		Ukraine	28.17	48.13	OA	Eastern Gravettian	OxA-5253	19080		yes	bone	2	2	4	2
Cosaoutsi		Ukraine	28.17	48.13	OA	Eastern Gravettian	OxA-5254	18980		yes	bone	2	2	4	2
Cosaoutsi		Ukraine	28.17	48.13	OA	Eastern Gravettian	OxA-5255	18860		yes	bone	2	2	4	2
Cosaoutsi		Ukraine	28.17	48.13	OA	Eastern Gravettian	OxA-5256	18560		yes	bone	2	2	4	2
Cosaoutsi		Ukraine	28.17	48.13	OA	Eastern Gravettian	OxA-5257	17840		yes	bone	2	2	4	2
Cosaoutsi	1	Ukraine	28.17	48.13	OA	Eastern Gravettian	GIN-4146	17200	300	no	charcoal	2	1	3	2
Cosaoutsi	2 (a+b)	Ukraine	28.17	48.13	OA	Eastern Gravettian	LE-3304	16860	770	no	charcoal	1	1	2	1
Cosaoutsi	2a	Ukraine	28.17	48.13	OA	Eastern Gravettian	GrN-21792	17230	140	no	charcoal	2	1	3	2
Cosaoutsi	2a	Ukraine	28.17	48.13	OA	Eastern Gravettian	SOAN-2460	16940	1215	no	charcoal	0	1	1	0
Cosaoutsi	2b	Ukraine	28.17	48.13	OA	Eastern Gravettian	GIN-4148	18200	500	no	charcoal	1	1	2	1
Cosaoutsi	2b	Ukraine	28.17	48.13	OA	Eastern Epigravettian	LE-3305	15520	800	no	charcoal	1	1	2	1
Cosaoutsi	2b	Ukraine	28.17	48.13	OA	Eastern Gravettian	SOAN-2461	19620	925	no	charcoal	1	1	2	1
Cosaoutsi	2c	Ukraine	28.17	48.13	OA	Eastern Gravettian	GrN-21793	17620	210	no	charcoal	2	1	3	2
Cosaoutsi	3	Ukraine	28.17	48.13	OA	Eastern Gravettian	GIN-4149	16160	250	no	charcoal	2	1	3	2
Cosaoutsi	3	Ukraine	28.17	48.13	OA	Eastern Gravettian	GrN-21359	18030	150	no	charcoal	2	1	3	2
Cosaoutsi	3	Ukraine	28.17	48.13	OA	Eastern Epigravettian	KIGN-273	11210	350	no	charcoal	2	1	3	2
Cosaoutsi	3	Ukraine	28.17	48.13	OA	Eastern Epigravettian	KIGN-274	12040	400	no	charcoal	2	1	3	2
Cosaoutsi	3	Ukraine	28.17	48.13	OA	Eastern Gravettian	LE-3301	17400	340	no	charcoal	2	1	3	2
Cosaoutsi	3	Ukraine	28.17	48.13	OA	Eastern Gravettian	SOAN-2462	17840	550	no	charcoal	1	1	2	1
Cosaoutsi	3a + 4	Ukraine	28.17	48.13	OA	Eastern Gravettian	GIN-4150	17100	250	no	charcoal	2	1	3	2

Cosaoutsi	3b	Ukraine	28.17	48.13	OA	Eastern Gravettian	GrN-21360	17910	80	no	charcoal	2	1	3	2
Cosaoutsi	3b	Ukraine	28.17	48.13	OA	Eastern Gravettian	LE-3307	17390	580	no	charcoal	1	1	2	1
Cosaoutsi	4	Ukraine	28.17	48.13	OA	Eastern Gravettian	GrN-21794	17950	100	no	charcoal	2	1	3	2
Cosaoutsi	4	Ukraine	28.17	48.13	OA	Eastern Gravettian	LE-3308	17640	830	no	charcoal	1	1	2	1
Cosaoutsi	5	Ukraine	28.17	48.13	OA	Eastern Gravettian	GIN-4142	17030	180	no	charcoal	2	1	3	2
Cosaoutsi	6b	Ukraine	28.17	48.13	OA	Eastern Gravettian	AA-4804	18140	165	yes	charcoal	2	1	3	2
Cosaoutsi	6b	Ukraine	28.17	48.13	OA	Eastern Gravettian	GrN-21361	19200	130	no	charcoal	2	1	3	2
Cosaoutsi	6c	Ukraine	28.17	48.13	OA	Eastern Gravettian	AA-4803	18935	160	yes		2	1	3	2
Cosaoutsi	9	Ukraine	28.17	48.13	OA	Eastern Gravettian	GrN-21795	19410	100	no		2	1	3	2
Cuina Turcului		Romania	22.07	44.53	OA	Eastern Epigravettian	Bln-803	12600	120	no		2	1	3	2
Cuintu	3	Moldova	27.10	48.15	OA	Eastern Gravettian	OxA-4125	18510	200	yes		3	1	4	2
Cuintu	3	Moldova	27.10	48.15	OA	Eastern Gravettian	OxA-4426	21000	220	yes		3	2	5	3
Cuintu	3; base	Moldova	27.10	48.15	OA	Eastern Gravettian	OxA-4774	22100	220	yes		3	1	4	2
Descrowa Cave		Poland	19.53	50.583	RS	Gravettian	GO-10212	17480	150	no	horn	2	2	4	2
Dobranitchevka		Ukraine	31.44	50.1	OA	Eastern Epigravettian	OxA-778	12700	200	yes	mammoth tooth	3	1	4	2
Dolni Vestonice I		Czech Rep.	16.40	48.53	OA	Eastern Gravettian	Ly-1303	22250	570	no		1	1	2	1
Dolni Vestonice II	420cm	Czech Rep.	16.40	48.53	OA	Eastern Epigravettian	GrN-2102	15350	1000	no	humus	0	1	1	1
Dolni Vestonice II	560cm	Czech Rep.	16.40	48.53	OA	Eastern Epigravettian	GrN-2093	18400	700	no	humus	1	1	2	1
Dolni Vestonice II		Czech Rep.	16.40	48.53	OA	Eastern Gravettian	CU-715	22368	749	no		1	1	2	1
Dolni Vestonice III		Czech Rep.	16.40	48.53	OA	Eastern Gravettian	GrN-20392	24560	660	no	charcoal	1	2	3	2
Druška pec		Croatia	13.90	45.1	RS	Epigravettian	Z-330	17000	250	no	bone breccia	2	2	4	2
Dudka		Poland	21.00	54	OA	Magdalenian	Ki-5733	11145	65	no		2	3	5	3
Dunaföldvár	upper	Hungary	18.56	46.48	OA	Eastern Epigravettian	Hv-1657	12110	315	no		2	1	3	2
Dunaszekcsô		Hungary	18.75	46.08	OA	Eastern Gravettian	Hv-4189	21740	320	no		2	1	3	2
Eliseevitichii 1		Ukraine	33.62	46.48	OA	Eastern Epigravettian	GIN-4135	14080	70	no	burned bone; ashpit	2	1	3	2
Eliseevitichii 1		Ukraine	33.62	46.48	OA	Eastern Epigravettian	GIN-4136	14590	140	no	mammoth tooth (from mandible)	2	1	3	2
Eliseevitichii 1		Ukraine	33.62	46.48	OA	Eastern Epigravettian	GIN-4137	12630	360	no	mammoth tooth; pit 1	2	1	3	2
Eliseevitichii 1		Ukraine	33.62	46.48	OA	Eastern Gravettian	GIN-4138	16850	120	no	mammoth tooth	2	1	3	2
Eliseevitichii 1		Ukraine	33.62	46.48	OA	Eastern Epigravettian	GIN-4139	14100	400	no	mammoth tooth	2	1	3	2
Eliseevitichii 1		Ukraine	33.62	46.48	OA	Eastern Epigravettian	GIN-5475	14240	120	no	burned bone	2	1	3	2
Eliseevitichii 1		Ukraine	33.62	46.48	OA	Eastern Gravettian	LE-450	20570	430	no	charcoal	2	1	3	2
Eliseevitichii 1		Ukraine	33.62	46.48	OA	Eastern Epigravettian	LU-102	12970	140	no	burned bone	2	1	3	2

Eliseevitichii 1		Ukraine	33.62	46.48	OA	Eastern Epigravettian	LU-126	14470	100	no	mammoth tooth	2	1	3	2
Eliseevitichii 1		Ukraine	33.62	46.48	OA	Eastern Gravettian	LU-360	17340	170	no	mammoth tooth	2	1	3	2
Eliseevitichii 1		Ukraine	33.62	46.48	OA	Eastern Gravettian	QC-889	15600	1350	no	burned bone	0	1	1	0
Eliseevitichii 2		Ukraine	33.62	46.48	OA	Eastern Gravettian	IGAN-556	15620	200	no	mammoth tooth	2	1	3	2
Esztergom-Gyurgyalag		Hungary	18.45	47.48	OA	Eastern Gravettian	Deb-1160	16160	200	no		2	1	3	2
Franchthi Cave	II	Greece	23.35	37.45	RS	Gravettian	I-6140	22330	1270	no		0	1	1	0
Franchthi Cave	II	Greece	23.35	37.45	RS	Gravettian	P-2233	21480	350	no		2	1	3	2
Franchthi Cave	IV	Greece	23.35	37.45	RS	Epigravettian	P-1827	12540	180	no		2	1	3	2
Franchthi Cave	V	Greece	23.35	37.45	RS	Epigravettian	P-1923	11240	140	no		2	1	3	2
Franchthi Cave	VI	Greece	23.35	37.45	RS	Epigravettian	I-6129	10800	160	no		2	1	3	2
Franchthi Cave	VI	Greece	23.35	37.45	RS	Epigravettian	I-6139	10460	210	no		2	1	3	2
Franchthi Cave	VI	Greece	23.35	37.45	RS	Epigravettian	P-2231	10260	110	no		2	1	3	2
Franchthi Cave	VI	Greece	23.35	37.45	RS	Epigravettian	P-2232	10840	510	no		2	1	3	2
Gagarino		Russia	38.54	52.42	OA	Eastern Gravettian	GIN-1872	21800	300	no	burned bone	2	2	4	2
Gagarino		Russia	38.54	52.42	OA	Eastern Gravettian	GIN-1990	19160	130	no	mammoth tusk	2	2	4	2
Gagarino		Russia	38.54	52.42	OA	Eastern Gravettian	GIN-7989	21600	140	no	mammoth tusk	2	2	4	2
Gagarino		Russia	38.54	52.42	OA	Eastern Gravettian	GIN-7991	17900	120	no	mammoth tusk	2	2	4	2
Gagarino		Russia	38.54	52.42	OA	Aurignacian	IGAN-83	30000	1900	no	mammoth tooth	0	2	2	0
Gagarino		Russia	38.54	52.42	OA	Eastern Gravettian	LE-1432	20820	300	no	mammoth tooth	2	2	4	2
Gagarino		Russia	38.54	52.42	OA	Eastern Gravettian	LE-1432	20150	300	no	mammoth tooth	2	2	4	2
Gagarino		Russia	38.54	52.42	OA	Eastern Gravettian	LE-1432a	17930	100	no	mammoth tooth	2	2	4	2
Garla Mare	level W	Romania	27.00	46	OA	Eastern Gravettian	GrN12662	20140	140	no		2	3	5	3
Gontsy		Ukraine	32.49	50.1	OA	Eastern Epigravettian	GIN-8410	13700	100	no	burned bone	2	1	3	2
Gontsy		Ukraine	32.49	50.1	OA	Eastern Epigravettian	ISGS-1739	14350	190	no	burned bone	2	1	3	2
Gontsy		Ukraine	32.49	50.1	OA	Eastern Epigravettian	ISGS-1740	13200	270	no	burned bone	2	1	3	2
Gontsy		Ukraine	32.49	50.1	OA	Eastern Epigravettian	OxA-5932	14550	150	yes	bone	3	1	4	2
Gontsy		Ukraine	32.49	50.1	OA	Eastern Epigravettian	OxA-5933	14400	110	yes	bone	3	1	4	2
Gontsy		Ukraine	32.49	50.1	OA	Eastern Epigravettian	OxA-717	14600	200	yes	mammoth tooth	3	1	4	2
Gontsy		Ukraine	32.49	50.1	OA	Eastern Epigravettian	QC-898	13400	185	no	burned bone	2	1	3	2
Grubgraben	1B	Austria	18.20	48.5	OA	Gravettian	Lv-1825	16800	280	no		2	1	3	2
Grubgraben	2A	Austria	18.20	48.5	OA	Gravettian	Lv-1823	18070	270	no		2	1	3	2
Grubgraben	2B	Austria	18.20	48.5	OA	Gravettian	Lv-1821	17350	270	no		2	1	3	2
Grubgraben	2B	Austria	18.20	48.5	OA	Gravettian	Lv-1822	18600	220	no		2	1	3	2
Grubgraben	3	Austria	18.20	48.5	OA	Gravettian	Lv-1810	18030	270	no	bone	2	1	3	2
Grubgraben	3/4	Austria	18.20	48.5	OA	Gravettian	Lv-1660	18170	300	no	bone	2	1	3	2

Grubgraben	4	Austria	18.20	48.5	OA	Gravettian	AA-1746	18960	290	yes		2	1	3	2
Grubgraben	4	Austria	18.20	48.5	OA	Gravettian	GrN-21790	19270	80	no		2	1	3	2
Grubgraben	4	Austria	18.20	48.5	OA	Gravettian	GrN-21893	18820	160	no		2	1	3	2
Grubgraben	4	Austria	18.20	48.5	OA	Gravettian	Lv-1680	18400	330	no		2	1	3	2
Hohlenstein bei Ederheim		Germany	10.35	48.5	RS	Magdalenian	OxA5752	12410	90	yes	cutmarked bone	3	1	4	2
Hohlenstein-Kleine Scheuer	level III	Austria	10.35	48.5	OA	Magdelanian	H-4183-3416	13252	98	no		2	1	3	2
Hohlenstein-Stadel	level III	Austria	10.35	48.5	OA	Magdelanian	H-3779-3044	13550	130	no		2	1	3	2
Hohlenstein-Stadel	level III	Austria	10.35	48.5	OA	Magdelanian	H-3799-3045	13110	160	no		2	1	3	2
Horn		Austria	15.40	48.4	OA	Gravettian	VRI-676	23210	510	no	bone	1	2	3	2
Hostim		Bohemia	14.08	49.95	OA	Magdalenian	Ly-1108	12420	470	no		2	1	3	2
Hrustovaca		Bosnia	16.65	44.7	RS	Epigravettian	Z-863	12000	200	no	speleothem on bone (cave bear)	2	1	3	2
Jaskinia Maszycka (Maszycka Cave)	level III	Poland	19.99	50.01	RS	Magdalenian	Ly-2454	15490	310	no	reindeer antler	2	3	5	3
Jaskinia Maszycka (Maszycka Cave)	level I-II	Poland	19.99	50.01	RS	Magdalenian	Ly-2453	14520	240	no	bone	2	3	5	3
Jaszfelsoszent Gyorgy	upper	Hungary	20.15	47.4	OA	Eastern Gravettian	Deb-1674	18500	400	no		2	1	3	2
Kamennaya Balka II		Russia	39.21	47.16	OA	Eastern Epigravettian	AA-4797	14670	105	yes	burned bone	2	1	3	2
Kamennaya Balka II		Russia	39.21	47.16	OA	Eastern Epigravettian	GIN-2940	15400	1200	no	burned bone	0	1	1	0
Kamennaya Balka II		Russia	39.21	47.16	OA	Eastern Epigravettian	GIN-2940a	12050	2100	no	burned bone	0	1	1	0
Kamennaya Balka II		Russia	39.21	47.16	OA	Eastern Epigravettian	GIN-2941	13200	500	no	burned bone	1	1	2	1
Kamennaya Balka II		Russia	39.21	47.16	OA	Eastern Epigravettian	GIN-3472	15350	550	no	burned bone	1	1	2	1
Kamennaya Balka II		Russia	39.21	47.16	OA	Eastern Epigravettian	GIN-3716	11400	1300	no	bone	0	1	1	0
Kamennaya Balka II		Russia	39.21	47.16	OA	Eastern Epigravettian	GIN-3772	15100	700	no	burned bone	1	1	2	1
Kamennaya Balka II		Russia	39.21	47.16	OA	Eastern Epigravettian	GIN-4024	10000	750	no	bone	1	1	2	1
Kamennaya Balka II		Russia	39.21	47.16	OA	Eastern Epigravettian	GIN-7921	14800	400	no	burned bone	2	1	3	2
Kamennaya Balka II		Russia	39.21	47.16	OA	Eastern Epigravettian	GIN-7922	12700	700	no	burned bone	1	1	2	1
Kamennaya Balka II		Russia	39.21	47.16	OA	Eastern Epigravettian	OxA-699	10900	400	yes	burned bone; hearth	2	2	4	2
Kamennaya Balka II		Russia	39.21	47.16	OA	Eastern Epigravettian	OxA-778	13600	180	yes	same as OxA-699, carbonate component	3	2	5	3
Kasov		Slovakia	21.69	48.61	OA	Eastern Gravettian	Gd-6569	18600	390	no		2	1	3	2
Kasoznskaya cave		Russia	41.20	50.01	RS	Eastern Gravettian	LE-4986	21200	390	no		2	3	5	3

Kasoznskaya cave		Russia	41.20	50.01	RS	Eastern Epigravettian	LE-4987	10400	340	no		2	3	5	3
Kasoznskaya cave		Russia	41.20	50.01	RS	Eastern Gravettian	LE-4988	20030	650	no		1	3	4	2
Kastritsa Rockshelter	2	Greece	20.91	39.62	RS	Epigravettian	I 1960	13400	210	no		2	1	3	2
Kastritsa Rockshelter	15	Greece	20.91	39.62	RS	Gravettian	I 2465	19900	370	no		2	1	3	2
Kastritsa Rockshelter	20	Greece	20.91	39.62	RS	Gravettian	I 2466	20800	810	no		2	1	3	2
Kastritsa Rockshelter	21	Greece	20.91	39.62	RS	Gravettian	I 2468	20200	480	no		2	1	3	2
Kastritsa Rockshelter	21	Greece	20.91	39.62	RS	Gravettian	I 2476	21800	470	no		2	1	3	2
Kaufertsberg		Germany	10.35	48.5	OA	Magdelanian	OxA5751	12610	90	yes	reindeer antler	3	1	4	2
Khotylevo 2		Russia	34.19	53.12	OA	Eastern Gravettian	GIN-8406	22700	200	no	mammoth tooth	2	2	4	2
Khotylevo 2		Russia	34.19	53.12	OA	Eastern Gravettian	GIN-8495	21720	170	no	mammoth tooth	2	2	4	2
Khotylevo 2		Russia	34.19	53.12	OA	Eastern Gravettian	GIN-8496	22660	170	no	mammoth tooth	2	2	4	2
Khotylevo 2		Russia	34.19	53.12	OA	Eastern Gravettian	GIN-8497	21170	260	no	mammoth tooth	2	2	4	2
Khotylevo 2		Russia	34.19	53.12	OA	Eastern Gravettian	GIN-8497a	23300	300	no	mammoth tooth	2	2	4	2
Khotylevo 2		Russia	34.19	53.12	OA	Eastern Gravettian	GIN-8886	21850	170	no	burned bone	2	2	4	2
Khotylevo 2		Russia	34.19	53.12	OA	Eastern Gravettian	GrN-21899	24220	110	no	bone	2	2	4	2
Khotylevo 2		Russia	34.19	53.12	OA	Eastern Gravettian	GrN-22216	23870	160	no		2	2	4	2
Khotylevo 2		Russia	34.19	53.12	OA	Eastern Gravettian	IGAN-73	24960	400	no	mammoth tooth	2	2	4	2
Khotylevo 2		Russia	34.19	53.12	OA	Eastern Gravettian	LU-359	23660	270	no	bone	2	2	4	2
Kirillovskaya		Ukraine	30.31	50.26	OA	Eastern Gravettian	OxA-718	19200	350	yes	mammoth tooth	3	2	5	3
Kirillovskaya		Ukraine	30.45	50.55	OA	Eastern Gravettian		19200	350	unknown		2	1	3	2
Klimaoutsy 2	I (lower)	Moldova	28.17	48.13	OA	Eastern Gravettian	LU-2351	24880	410	no		2	1	3	2
Klimaoutsy 2	II (upper)	Moldova	28.17	48.13	OA	Eastern Gravettian	LU-2481	20350	230	no		2	1	3	2
Klithi Rockshelter	1	Greece	20.41	39.58	RS	Epigravettian	OxA-136	16300	400	yes	amino acids	3	3	6	3
Klithi Rockshelter	1	Greece	20.41	39.58	RS	Epigravettian	OxA-137	17000	400	yes	amino acids	3	3	6	3
Klithi Rockshelter	4	Greece	20.41	39.58	RS	Epigravettian	OxA-2327	16250	170	yes	burnt bone	3	3	6	3
Klithi Rockshelter	5	Greece	20.41	39.58	RS	Epigravettian	OxA-2328	15460	260	yes	burnt bone	3	3	6	3
Klithi Rockshelter	5	Greece	20.41	39.58	RS	Epigravettian	OxA-2971	16650	190	yes	burnt bone	3	3	6	3
Klithi Rockshelter	5	Greece	20.41	39.58	RS	Epigravettian	OxA-2972	16140	150	yes	burnt bone	3	3	6	3
Klithi Rockshelter	6	Greece	20.41	39.58	RS	Epigravettian	OxA-1746	15960	200	yes	charcoal	3	3	6	3
Klithi Rockshelter	6	Greece	20.41	39.58	RS	Epigravettian	OxA-2329	15580	380	yes	burnt bone	3	3	6	3
Klithi Rockshelter	6	Greece	20.41	39.58	RS	Epigravettian	OxA-2330	15960	130	yes	burnt bone	3	3	6	3
Klithi Rockshelter	6	Greece	20.41	39.58	RS	Epigravettian	OxA-2332	15950	120	yes	charcoal	3	3	6	3
Klithi Rockshelter	6	Greece	20.41	39.58	RS	Epigravettian	OxA-2970	14290	140	yes	burnt bone	3	3	6	3
Klithi Rockshelter	7	Greece	20.41	39.58	RS	Epigravettian	OxA-2331	13640	100	yes	charcoal	3	3	6	3
Klithi Rockshelter	7	Greece	20.41	39.58	RS	Epigravettian	OxA-3732	14570	130	yes	burnt bone	3	3	6	3
Klithi Rockshelter	7	Greece	20.41	39.58	RS	Epigravettian	OxA-749	14200	200	yes	charcoal	3	3	6	3
Klithi Rockshelter	7	Greece	20.41	39.58	RS	Epigravettian	OxA-750	14060	200	yes	charcoal	3	3	6	3
Klithi Rockshelter	8	Greece	20.41	39.58	RS	Epigravettian	OxA-502	12300	200	yes	charcoal	3	3	6	3
Klithi Rockshelter	9	Greece	20.41	39.58	RS	Epigravettian	OxA-3941	13940	110	yes	burnt bone	3	3	6	3
Klithi Rockshelter	10	Greece	20.41	39.58	RS	Epigravettian	OxA-2834	13940	130	yes	burnt bone	3	3	6	3
Klithi Rockshelter	core 2	Greece	20.41	39.58	RS	Epigravettian	OxA-1155	15600	160	yes	bone	3	3	6	3

Klithi Rockshelter	core 3	Greece	20.41	39.58	RS	Epigravettian	OxA-1091	15220	200	yes	burnt bone	3	3	6	3
Klithi Rockshelter	core 3	Greece	20.41	39.58	RS	Epigravettian	OxA-1092	16490	220	yes	burnt bone	3	3	6	3
Kniegrotte	lower	Germany	11.33	50.4	RS	Magdalenian	Bln-1564	13582	165	no	red deer bone	2	1	3	2
Kniegrotte	lower	Germany	11.33	50.4	RS	Magdalenian	OxA-4851	14470	140	yes	mammoth vertebra	3	3	6	3
Kniegrotte	lower	Germany	11.33	50.4	RS	Magdalenian	OxA-4852	13520	130	yes	cut horse vertebra	3	3	6	3
Kniegrotte	lower	Germany	11.33	50.4	RS	Magdalenian	OxA-4853	13090	130	yes	skull	3	3	6	3
Kniegrotte	middle	Germany	11.33	50.4	RS	Magdalenian	OxA-4848	13150	130	yes	modified horse metatarsus	3	3	6	3
Kniegrotte	middle	Germany	11.33	50.4	RS	Magdalenian	OxA-4849	13130	120	yes	horn core	3	3	6	3
Kniegrotte	middle	Germany	11.33	50.4	RS	Magdalenian	OxA-4850	13160	140	yes	bone	3	3	6	3
Kniegrotte	upper	Germany	11.33	50.4	RS	Magdalenian	OxA-4832	13310	110	yes	cut reindeer scapula	3	3	6	3
Kniegrotte	upper	Germany	11.33	50.4	RS	Magdalenian	OxA-4845	13120	130	yes	marrow-fracture reindeer tibia	3	3	6	3
Kniegrotte	upper	Germany	11.33	50.4	RS	Magdalenian	OxA-4846	13190	130	yes	horse femur	3	3	6	3
Kniegrotte	upper	Germany	11.33	50.4	RS	Gravettian	OxA-4847	25340	440	yes	cut bear humerus	3	3	6	3
Königsaue		Germany	11.24	51.49	OA	Magdalenian	H-106/89	13250	280	no		2	1	3	2
Kopacina	layer b: 75cm	Croatia	16.53	43.36	OA	Epigravettian	Z-2404	11850		no	red deer bone	1	2	3	2
Kopacina	layer c: 50cm	Croatia	16.53	43.36	OA	Epigravettian	Z-2403	12935		no	red deer bone	1	2	3	2
Korman 4	V	Ukraine	27.14	48.34	OA	Eastern Gravettian	GIN-719	18000	400	no	charcoal	2	1	3	2
Korman 4	V	Ukraine	27.14	48.34	OA	Eastern Gravettian	SOAN-145	18560	2000	no	charcoal	0	1	1	0
Korman 4	VII	Ukraine	27.14	48.34	OA	Eastern Gravettian	GIN-1099	24500	500	no	charcoal	1	1	2	1
Korman 4	VII	Ukraine	27.14	48.34	OA	Eastern Gravettian	LU-586	25140	350	no	charcoal	2	1	3	2
Korolevo 1	Ia	Ukraine	29.14	50.32	OA	Eastern Gravettian	GIN-2773	25700	400	no	burned bone	2	2	4	2
Korpatch	layer IV	Ukraine	27.31	48.17	OA	Eastern Gravettian	GrN-9758	25250	300	no		2	1	3	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	AA-4799	20855	260	yes	burned bone	3	2	5	3
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	AA-4800	20315	200	yes	burned bone	3	2	5	3
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-1870	22300	230	no	burned bone; sq. N-M-5-6	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-2527	23500	200	no	burned bone; dugout 'A', central chamber	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-2528	23000	500	no	burned bone; dugout 'A', central chamber	1	2	3	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-2529	24100	500	no	burned bone; dugout 3	1	2	3	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-2530	22800	200	no	burned bone; dugout 'K'	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-2533	22300	200	no	burned bone; dugout 'A', central chamber	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-2534	21300	400	no	burned bone; dugout 'A', central chamber	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-3632	22800	300	no	burned bone; dugout 'A'	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-3633	22600	300	no	burned bone; sq. H-62, hearth	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-3634	22200	300	no	Burned bone, pit B, 65-67	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-4230	21800	300	no	burned bone; sq. H, O-72, 73, hearth	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-4231	21150	200	no	burned bone, pit, sq. P-73	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-4851	20800	300	no	burned bone; sq. O-73, 74, pit	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-4903	22200	500	no	burned bone; dugout T, Y, S-72-75	1	2	3	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-6249	22600	300	no	mammoth tooth; sq. II-69	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-8041	21950	250	no	mammoth tooth; cultural layer	3	2	5	3
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GrA-5243	24030	440	yes	charcoal; sq. II-74, pit	3	2	5	3
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GrA-5244	23600	410	yes	charcoal; dugout E-3-72-74, floor	2	2	4	2

Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GrN-17118	22330	150	no	charcoal; sq. H-79, hearth	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GrN-17119	21180	100	no	burned bone; sq. H-79, hearth	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GrN-17120	20950	100	no	burned bone, sq. P-78	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	LE-2800	22760	250	no	mammoth tooth; sq. K-70	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	LE-2801	21800	200	no	object (with a wall)	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	LE-2949	19860	200	no	mammoth tooth	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	LE-2950	19010	120	no	mammoth tooth; sq. IIP-72, storage pit	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	LE-2951	23770	200	no	mammoth tooth; dugout T-X-72-25	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	LE-2969	22700	250	no	mammoth tooth; sq. II-69	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	LE-3276	23010	300	no	mammoth tooth; sq. JI-78	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	LE-3277	20100	680	no	burned bone	1	2	3	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	LE-3279	21680	700	no	mammoth tooth; sq. JI-77	1	2	3	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	LE-3280	18230	620	no	burned bone	1	2	3	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	LE-3281	19620	460	no	burned bone; sa. O-78	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	LE-3282	22020	310	no	Mammouth tooth, storage-pit, sq. K-78	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	LE-3283	23640	320	no	mammoth tusk; sq. K-78, pit	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	LE-3286	23490	420	no	burned bone; dugout T-X-72-75	2	2	4	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	LE-3289	23260	680	no	mammoth tooth; dugout T-X-72-25	1	2	3	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	LE-3290	22060	500	no	Bone, sq. II-76	1	2	3	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	LE-3292	19540	580	no	burned bone; sq. H-76, pit	1	2	3	2
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	LE-4351	18400	3300	no	mammoth tooth; sq. II-70	0	2	2	0
Kostenki 1 (Poliakov Site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	LE-4352	24570	3930	no	mammoth tooth fragments; dugout 'H'	0	2	2	0
Kostenki 1 (Poliakov Site)	III	Russia	39.01	51.25	OA	Aurignacian	AA-5590	38080	5460	yes	charcoal	0	2	2	0
Kostenki 1 (Poliakov Site)	III	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-2942	22000		no	mammoth tusk; sq. -72	1	2	3	2
Kostenki 1 (Poliakov Site)	III	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-4848	20900	1600	no	charcoal; sq. -72	0	2	2	0
Kostenki 1 (Poliakov Site)	III	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-4849	25900	2200	no	charcoal; sq. -72	0	2	2	0
Kostenki 1 (Poliakov Site)	III	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-4850	24500	1300	no	charcoal; sq. -72	0	2	2	0
Kostenki 1 (Poliakov Site)	III	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-4852	25600	100	no	burned bone; sq. -72	2	2	4	2
Kostenki 1 (Poliakov Site)	III	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-4885	26200	1500	no	charcoal; sq. -74	0	2	2	0
Kostenki 1 (Poliakov Site)	III	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-4902	25700	600	no	burned bone; sq. -72	1	2	3	2
Kostenki 1 (Poliakov Site)	III	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-6248	25400	400	no	charcoal; sq. -72	2	2	4	2
Kostenki 1 (Poliakov Site)	III	Russia	39.01	51.25	OA	Aurignacian	GrN-17117	32600	1100	no	charcoal	0	2	2	0
Kostenki 1 (Poliakov Site)	III	Russia	39.01	51.25	OA	Eastern Gravettian	LE-3541	25730	1800	no	charcoal	0	2	2	0
Kostenki 1 (Poliakov Site)	III	Russia	39.01	51.25	OA	Eastern Epigravettian	LE-4834	13540	300	no	charcoal	2	2	4	2
Kostenki 1 (Poliakov Site)	III	Russia	39.01	51.25	OA	Aurignacian	Ox-7073	32600	1100	no	human bone	0	2	2	0
Kostenki 1 (Poliakov Site)	V	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-6247	18800		no	charcoal	1	2	3	2
Kostenki 1 (Poliakov Site)	V	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-8022	19800	210	no	mammoth bone	2	2	4	2
Kostenki 1 (Poliakov Site)	V	Russia	39.01	51.25	OA	Aurignacian	GrA-5245	34900	350	yes	charcoal	2	2	4	2
Kostenki 1 (Poliakov Site)	V	Russia	39.01	51.25	OA	Aurignacian	GrA-5245	37900	2800	yes	charcoal	0	2	2	0
Kostenki 1 (Poliakov Site)	V	Russia	39.01	51.25	OA	Aurignacian	GrA-5557	32300	220	yes	charcoal	2	2	4	2
Kostenki 1 (Poliakov Site)	V	Russia	39.01	51.25	OA	Aurignacian	LE-2030	27390	300	no	mammoth tooth	2	2	4	2

Kostenki 1 (Poliakov Site)	V	Russia	39.01	51.25	OA	Aurignacian	LE-3542	30170	570	no	charcoal	1	2	3	2
Kostenki 10 (Anosovka 1)		Russia	39.01	51.25	OA	Aurignacian	GIN-8027	28250	300	no	mammoth bone	2	2	4	2
Kostenki 10 (Anosovka 1)		Russia	39.01	51.25	OA	Eastern Gravettian	GIN-8573	22600	1000	no	mammoth bone bone (poor preservation) and bison bone	0	2	2	0
Kostenki 11 (Anosovka 2)	Ia	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-2532	19900	350	no	burned bone	2	2	4	2
Kostenki 11 (Anosovka 2)	Ia	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-8079	18700	80	no	mammoth bone	2	2	4	2
Kostenki 11 (Anosovka 2)	Ia	Russia	39.01	51.25	OA	Eastern Epigravettian	LE-1403	12000	100	no	mammoth bone	2	2	4	2
Kostenki 11 (Anosovka 2)	Ia	Russia	39.01	51.25	OA	Eastern Epigravettian	LE-1637	14610	120	no	mammoth bone	2	2	4	2
Kostenki 11 (Anosovka 2)	Ia	Russia	39.01	51.25	OA	Eastern Gravettian	LE-17046	17310	280	no		2	2	4	2
Kostenki 11 (Anosovka 2)	Ia	Russia	39.01	51.25	OA	Eastern Gravettian	LE-1704a	16040	120	no	bone	2	2	4	2
Kostenki 11 (Anosovka 2)	Ia	Russia	39.01	51.25	OA	Eastern Gravettian	LE-1704b	17310	280	no	bone	2	2	4	2
Kostenki 11 (Anosovka 2)	II	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-2531	21800	200	no	burned bone	2	2	4	2
Kostenki 11 (Anosovka 2)	II	Russia	39.01	51.25	OA	Eastern Epigravettian	TA-34	15200	300	no	bone	2	2	4	2
Kostenki 11 (Anosvoska 2)	III	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-8080	20500	300	no	mammoth bone	2	2	4	2
Kostenki 11 (Anosvoska 2)	III	Russia	39.01	51.25	OA	Eastern Gravettian	LE-1638a	16040	120	no	bone	2	2	4	2
Kostenki 11 (Anosvoska 2)	III	Russia	39.01	51.25	OA	Eastern Gravettian	LE-1638b	22760	340	no	bone	2	2	4	2
Kostenki 12 (Volkov site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-8019	24000	800	no	mammoth pelvis bone	1	2	3	2
Kostenki 12 (Volkov site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-8574	26300	300	no	bison bone	2	2	4	2
Kostenki 12 (Volkov site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-89	23600	300	no	humus	2	2	4	2
Kostenki 12 (Volkov site)	I-Ia	Russia	39.01	51.25	OA	Eastern Gravettian	LU-1749	24420	310	no	humus; horizon II	2	2	4	2
Kostenki 12 (Volkov site)	I-Ia	Russia	39.01	51.25	OA	Aurignacian	LU-1821	29030	560	no	humus; horizon III-d	1	2	3	2
Kostenki 12 (Volkov site)	I-Ia	Russia	39.01	51.25	OA	Eastern Gravettian	TA-154	20900	390	no	bone	2	2	4	2
Kostenki 14 (Markina gora)	I	Russia	39.02	51.22	OA	Eastern Gravettian	GIN-8024	19900	850	no	mammoth rib (1987)	1	2	3	2
Kostenki 14 (Markina gora)	I	Russia	39.02	51.22	OA	Eastern Gravettian	LE-5269	20100	1500	no	bone (1982)	0	2	2	0
Kostenki 14 (Markina gora)	I	Russia	39.02	51.22	OA	Eastern Gravettian	LE-5274	22500	1000	no	bone (1994)	0	2	2	0
Kostenki 14 (Markina gora)	I	Russia	39.02	51.22	OA	Eastern Gravettian	OxA-4114	22780	250	yes	bone (1987)	2	2	4	3
Kostenki 14 (Markina gora)	II	Russia	39.02	51.22	OA	Eastern Gravettian	GIN-8030	25600	400	no	bone	2	2	4	2
Kostenki 14 (Markina gora)	II	Russia	39.02	51.22	OA	Aurignacian	GrN-12598	28380	220	no	charcoal	2	2	4	2
Kostenki 14 (Markina gora)	II	Russia	39.02	51.22	OA	Eastern Gravettian	LE-1400	19300	200	no	bone	2	2	4	1
Kostenki 14 (Markina gora)	II	Russia	39.02	51.22	OA	Eastern Gravettian	LE-1400	25090	310	no	same sample as LE-1400; lab. LU	2	2	4	2
Kostenki 14 (Markina gora)	II	Russia	39.02	51.22	OA	Eastern Gravettian	LU-59a	26400	660	no	bone fragment 'A'	1	2	3	2
Kostenki 14 (Markina gora)	II	Russia	39.02	51.22	OA	Aurignacian	LU-59b	28200	700	no	bone fragment 'B'	1	2	3	2
Kostenki 14 (Markina gora)	II	Russia	39.02	51.22	OA	Aurignacian	OxA-4115	28580	420	yes	bone	2	2	4	3
Kostenki 14 (Markina gora)	III	Russia	39.02	51.22	OA	Eastern Epigravettian	GIN-79	14300	460	no	horse bone	2	3	5	3
Kostenki 14 (Markina gora)	III	Russia	39.02	51.22	OA	Aurignacian	GrN-21802	30080	590	no	charcoal	1	2	3	2
Kostenki 14 (Markina gora)	II-III	Russia	39.02	51.22	OA	Eastern Epigravettian	AA-4798	14355	120	yes	charcoal; lower horizon of upper humic bed	2	2	4	2

Kostenki 14 (Markina gora)	II-III	Russia	39.02	51.22	OA	Eastern Epigravettian	GrN-10510	15260	260	no	charcoal; upper humic bed	2	2	4	2
Kostenki 15 (Gordozovskaia site)		Russia	39.01	51.25	OA	Eastern Gravettian	GIN-8020	25700	250	no	bison bone; dwelling construction	2	2	4	2
Kostenki 15 (Gordozovskaia site)		Russia	39.01	51.25	OA	Eastern Gravettian	LE-1430	21720	570	no	bone	1	2	3	2
Kostenki 17 (Spitzyn site)	I	Russia	39.01	51.24	OA	Eastern Gravettian	GIN-8074	23000	800	no	mammoth bone; sq. -2 (1980)	1	2	3	2
Kostenki 17 (Spitzyn site)	I	Russia	39.01	51.24	OA	Eastern Gravettian	GIN-8075	24300	500	no	mammoth bone; sq. -3 (1980)	1	2	3	2
Kostenki 17 (Spitzyn site)	I	Russia	39.01	51.24	OA	Eastern Gravettian	GIN-8076	21100	600	no	mammoth bone; sq. -2 (1980 r.)	1	2	3	2
Kostenki 17 (Spitzyn site)	I	Russia	39.01	51.24	OA	Eastern Gravettian	GrN-10511	26750	700	no	charcoal	1	2	3	2
Kostenki 17 (Spitzyn site)	II	Russia	39.01	51.24	OA	Eastern Gravettian	GIN-78	20100	20	no	loam	2	2	4	2
Kostenki 18 (Khvoikovskaia site)		Russia	39.01	51.25	OA	Eastern Gravettian	GIN-8028	17900	300	no	mammoth bone; overhead cover of burial pit	2	2	4	2
Kostenki 18 (Khvoikovskaia site)		Russia	39.01	51.25	OA	Eastern Gravettian	GIN-8032	20600	140	no	mammoth bone; overhead cover of burial pit	2	2	4	2
Kostenki 18 (Khvoikovskaia site)		Russia	39.01	51.25	OA	Eastern Gravettian	GIN-8576	19300	200	no	mammoth bone; overhead cover of burial pit	2	2	4	2
Kostenki 18 (Khvoikovskaia site)		Russia	39.01	51.25	OA	Eastern Gravettian	OxA-7128	21020	180	yes	human bone (vertebra); burial	3	2	5	3
Kostenki 18 (Khvoikovskaia site)	4a	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-77	20000	350	no	loam	2	2	4	2
Kostenki 18 (Khvoikovskaia site)	4a	Russia	39.01	51.25	OA	Eastern Epigravettian	GIN-85	9610	190	no	bone	2	2	4	2
Kostenki 19 (Valukinskogo site)		Russia	39.01	51.25	OA	Eastern Epigravettian	GIN-107	11800	500	no	bone	1	2	3	2
Kostenki 19 (Valukinskogo site)		Russia	39.01	51.25	OA	Eastern Gravettian	GIN-8577	18700	600	no	mammoth bone	1	2	3	2
Kostenki 19 (Valukinskogo site)		Russia	39.01	51.25	OA	Eastern Gravettian	LE-1705a	17420	150	no	bone	2	2	4	2
Kostenki 19 (Valukinskogo site)		Russia	39.01	51.25	OA	Eastern Gravettian	LE-1705b	18900	300	no	bone	2	2	4	2
Kostenki 2 (Zamiatnin site)		Russia	39.01	51.24	OA	Eastern Gravettian	GIN-7992	23800	150	no	mammoth pelvis bone	2	2	4	2
Kostenki 2 (Zamiatnin site)		Russia	39.01	51.24	OA	Aurignacian	GIN-7993	37900	900	no	mammoth bone	1	2	3	2
Kostenki 2 (Zamiatnin site)		Russia	39.01	51.24	OA	Eastern Gravettian	GIN-8570	17300	160	no	mammoth bone	2	2	4	2
Kostenki 2 (Zamiatnin site)		Russia	39.01	51.24	OA	Eastern Epigravettian	GIN-93	11000	200	no	bone	2	2	4	2
Kostenki 2 (Zamiatnin site)		Russia	39.01	51.24	OA	Eastern Gravettian	LE-1599	16190	150	no	bone	2	2	4	2
Kostenki 21 (Gmielin site)	II	Russia	39.01	51.25	OA	Eastern Gravettian	LE-1427c	22900	150	no	bone (complex method)	2	2	4	2
Kostenki 21 (Gmielin site)	II	Russia	39.01	51.25	OA	Eastern Gravettian	LE-1437a	19100	150	no	bone (Longuine method)	2	2	4	2
Kostenki 21 (Gmielin site)	II	Russia	39.01	51.25	OA	Eastern Gravettian	LE-1437b	20250	100	no	bone (Arslanov method)	2	2	4	2
Kostenki 21 (Gmielin site)	III	Russia	39.01	51.25	OA	Eastern Gravettian	GrN-10513	21260	340	no	charcoal	2	1	3	2
Kostenki 21 (Gmielin site)	III	Russia	39.01	51.25	OA	Eastern Gravettian	GrN-7363	22270	150	no	charcoal; same sample as LE-1043	2	1	3	2
Kostenki 21 (Gmielin site)	III	Russia	39.01	51.25	OA	Eastern Gravettian	LE-1043	16960	300	no	charcoal	2	1	3	2
Kostenki 3 (Glinishche)		Russia	39.01	51.25	OA	Eastern Gravettian	GIN-8022	19800	210	no	mammoth bone	2	2	4	2
Kostenki 4 (Alexandrovskaia site)		Russia	39.01	51.25	OA	Eastern Gravettian	GIN-7994	23000	300	no	horse bone (phalanx) (1927-28)	2	2	4	2
Kostenki 4 (Alexandrovskaia site)		Russia	39.01	51.25	OA	Eastern Gravettian	GIN-7995	22800	120	no	mammoth bone (rib) (1937)	2	2	4	2
Kostenki 5 (Sviatoi log)	II	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-7996	20600	140	no	mammoth bone (rib)	2	2	4	2
Kostenki 5 (Sviatoi log)	II	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-8029	20900	100	no	mammoth bone	2	2	4	2
Kostenki 5 (Sviatoi log)	II	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-8571	22920	140	no	horse bone	2	2	4	2
Kostenki 6 (Streletskaia 2)		Russia	39.01	51.25	OA	Eastern Gravettian	GIN-8023	21100	200	no	mammoth bone	2	2	4	2
Kostenki 6 (Streletskaia 2)		Russia	39.01	51.25	OA	Aurignacian	GIN-8572	31200	500	no	horse bone (1952 r.)	1	2	3	2
Kostenki 8 (Telmanskaia site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-7997	22900	120	no	tooth, mammoth bone (rib); sa. -45	2	2	4	2

Kostenki 8 (Telmanskaia site)	I	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-7998	22000	160	no	mammoth bone (rib); sa. -44	2	2	4	2
Kostenki 8 (Telmanskaia site)	II	Russia	39.01	51.25	OA	Eastern Gravettian	GIN-7999	24500	450	no	horse bone (1959)	2	2	4	2
Kostenki 8 (Telmanskaia site)	II	Russia	39.01	51.25	OA	Eastern Gravettian	GrN-10509	27700	750	no	charcoal	1	1	2	1
Kostenki 8 (Telmanskaia site)	II	Russia	39.01	51.25	OA	Eastern Gravettian	OxA-7109	23020	320	yes	burned bone fragments of human skull	3	3	6	3
Koulytchivka		ssw	27.14	48.34	OA	Eastern Gravettian	GrN-9758	25250	300	no	burned bone; hearth	2	3	5	3
Koulytchivka	Ia	ssw	27.14	48.34	OA	Eastern Gravettian	GIN-2773	25700	400	no		2	1	3	2
Kraków Spadzista St B	Level 6	Poland	19.55	50.05	OA	Gravettian	GrN-6636	23040	170	no	charcoal	2	2	4	2
Kraków Spadzista St B	Level 6	Poland	19.55	50.05	OA	Gravettian	Ly-631	20600	1050	no	ivory	0	2	2	0
Kraków Spadzista St C2	Level 6, Layer II	Poland	19.55	50.05	OA	Epigravettian	Ly-2541	17400	310	no	bone	2	3	5	3
Kraków Spadzista St C2	Level 6, Layer III	Poland	19.55	50.05	OA	Gravettian	GrN-11006	24380	180	no	charcoal	2	2	4	2
Kraków Spadzista St C2	Level 6, Layer III	Poland	19.55	50.05	OA	Gravettian	Ly-2542	21000	900	no	bone	1	3	4	2
Kraków Spadzista St C2	Level 6, Layer III	Poland	19.55	50.05	OA	Gravettian	OxA-635	20200	350	yes	ivory	3	3	6	3
Kraków Spadzista St F	Level 6	Poland	19.55	50.05	OA	Gravettian	Ki-3712	22900	600	no	bone	1	3	4	2
Kraków Spadzista St F	Level 6, Layer II	Poland	19.55	50.05	OA	Gravettian	Ki-3713	23600	1400	no	bone	0	3	2	0
Kraków-Spadzista	lower	Poland	19.55	50.05	OA	Gravettian	Ly-2544	21000	300	no		2	1	3	2
Kraków-Spadzista	upper	Poland	19.55	50.05	OA	Epigravettian	Ly-2545	17480	310	no		2	1	3	2
Krucza Skala		Poland	18.35	49.93		Magdalenian	Lod-407	11400	200	no	charcoal	2	1	3	2
Krumpa		Germany	11.84	51.8	OA	Magdalenian	OxA-4498	11660	100	yes	terrestrial plant remains	3	1	4	2
Krumpa		Germany	11.84	51.8	OA	Magdalenian	OxA-4499	11810	100	yes	terrestrial plant remains	3	1	4	2
Krumpa		Germany	11.84	51.8	OA	Magdalenian	OxA-4500	12460	110	yes	wood	3	1	4	2
Kulna	layer 4	Czech. Rep.	16.90	48.2	RS	Magdalenian	GrN-6102	11470	105	no		2	1	3	2
Kulna	layer 6	Czech. Rep.	16.90	48.2	RS	Magdalenian	GrN-11053	11450	90	no		2	1	3	2
Kulna	layer 6	Czech. Rep.	16.90	48.2	RS	Magdalenian	GrN-5097	11590	80	no		2	1	3	2
Kursk I		Russia	36.10	51.4	OA	Eastern Epigravettian	GIN-94	11600	200	no	fossil bone	2	2	4	2
Langmanensdorf	A	Austria	15.68	48.34	OA	Gravettian	GrN-6585	19340	100	no		2	1	3	2
Langmanensdorf	A	Austria	15.68	48.34	OA	Gravettian	GrN-6660	20260	200	no	bone, antler	2	1	3	2
Langmanensdorf	B	Austria	15.68	48.34	OA	Gravettian	GrN-6659	20580	170	no	bone, antler	2	1	3	2
Langmanensdorf		Austria	15.68	48.34	OA	Gravettian	GrN-6586	19520	120	no		2	1	3	2
Leski		Russia	39.51	49.9	OA	Eastern Gravettian	LE-2946	19200	200	no	mammoth tooth	2	2	4	2
Leski		Russia	39.51	49.9	OA	Eastern Gravettian	LE-4456	23770	1540	no	mammoth tooth	0	1	1	0
Lukenjska jama		Slovenia	15.06	45.49	RS	Epigravettian	Z-1036	12200	250	no	charcoal from hearth	2	2	4	2
Lvov 7 (shelter Romana - Tchertova Skelia)	I	ssw	26.50	48.34	RS	Eastern Epigravettian	Ki-5414	11800	90	no	bone	2	2	4	2
Lvov 7 (shelter Romana - Tchertova Skelia)	II	ssw	26.50	48.34	RS	Eastern Epigravettian	Ki-5412	13500	110	no	bone	2	2	4	2
Madaras		Hungary	19.16	46.03	OA	Eastern Gravettian	Hv-1619	18080	405	no		2	1	3	2
Mališina Stijena	upper	Bosnia-Hertz.	16.02	44.89	RS	Epigravettian	OxA-1894	13780	140	yes	burnt bone	3	1	4	2
Megalakkos Rockshelter	Unit 2	Greece	20.41	39.58	RS	Epigravettian	OxA-1093	15410	210	yes	burnt seed	3	3	6	3
Megalakkos Rockshelter	Unit 4	Greece	20.41	39.58	RS	Epigravettian	OxA-1249	16100	160	yes	burnt bone	3	3	6	3
Mezhigirtsy 1		Ukraine	31.65	49.54	OA	Eastern Gravettian	Ki-5605	17560	270	no	bone	2	1	3	2

Mezhigirtsy 1		Ukraine	31.65	49.54	OA	Eastern Gravettian	Ki-5606	17200	250	no	bone	2	1	3	2
Mezhiritch		Ukraine	31.24	49.38	OA	Eastern Epigravettian	AA-1317	14420	190	yes	mammoth tooth; dwelling 3	2	2	4	2
Mezhiritch		Ukraine	31.24	49.38	OA	Eastern Epigravettian	GIN-2593	14700	500	no	mammoth tooth; dwelling 2	1	2	3	2
Mezhiritch		Ukraine	31.24	49.38	OA	Eastern Epigravettian	GIN-2595	14530	300	no	burned bone; dwelling 2	2	2	4	2
Mezhiritch		Ukraine	31.24	49.38	OA	Eastern Epigravettian	GIN-2596	14300	300	no	burned bone; dwelling 4	2	2	4	2
Mezhiritch		Ukraine	31.24	49.38	OA	Eastern Epigravettian	GIN-2597	11700	800	no	burned bone	1	1	2	1
Mezhiritch		Ukraine	31.24	49.38	OA	Eastern Gravettian	Ki-1054	17855	950	no	burned bone; dwelling 4	1	2	3	2
Mezhiritch		Ukraine	31.24	49.38	OA	Eastern Gravettian	Ki-1055	18020	600	no	burned mammoth tooth	1	1	2	1
Mezhiritch		Ukraine	31.24	49.38	OA	Eastern Gravettian	Ki-1056	18470	550	no	burned bone	1	1	2	1
Mezhiritch		Ukraine	31.24	49.38	OA	Eastern Gravettian	Ki-1057	19100	500	no	burned bone	1	1	2	1
Mezhiritch		Ukraine	31.24	49.38	OA	Eastern Gravettian	Ki-1058	19280	600	no	mammoth tooth; dwelling 1	1	2	3	2
Mezhiritch		Ukraine	31.24	49.38	OA	Eastern Epigravettian	OxA-709	12900	200	yes	mammoth tooth; dwelling	2	2	4	2
Mezhiritch		Ukraine	31.24	49.38	OA	Eastern Epigravettian	OxA-712	14400	250	yes	mammoth tooth; dwelling 2	2	2	4	2
Mezhiritch		Ukraine	31.24	49.38	OA	Eastern Epigravettian	QC-897	14320	270	no	mammoth tooth; dwelling	2	2	4	2
Mezhiritch		Ukraine	31.24	49.38	OA	Eastern Epigravettian	QC-900	15245	1080	no	mammoth tooth; dwelling	0	2	2	0
Mezin		Ukraine	33.05	51.45	OA	Eastern Gravettian	GIN-4	21600	2200	no	mammoth tooth	0	1	1	0
Mezin		Ukraine	33.05	51.45	OA	Eastern Gravettian	Ki-1051	27500	800	no	Mammoth tooth (1953)	1	1	2	1
Mezin		Ukraine	33.05	51.45	OA	Aurignacian	Ki-1052	29100	700	no	shell (1953)	1	1	2	1
Mezin		Ukraine	33.05	51.45	OA	Aurignacian	Ki-1053	29700	800	no	shell (1953)	1	1	2	1
Mezin		Ukraine	33.05	51.45	OA	Eastern Epigravettian	OxA-719	15100	200	yes	mammoth tooth; dwelling 1	2	2	4	2
Milovice	level 3	Poland	14.08	49.95	OA	Eastern Gravettian	ISGS-1690	22900	490	no		2	1	3	2
Milovice	level I	Poland	14.08	49.95	OA	Eastern Gravettian	ISGS-1901	22080	530	no		1	1	2	1
Milovice		Poland	14.08	49.95	OA	Eastern Gravettian	GrN-14825	22100	1100	no	mammoth deposit	0	1	1	0
Mitoc-Malul Galben	2a	Romania	26.63	47.72	OA	Eastern Gravettian	GrN-13765	20150	210	no		2	2	3	2
Mitoc-Malul Galben	2b	Romania	26.63	47.72	OA	Eastern Gravettian	GrN-14031	20300	700	no		1	2	3	2
Mitoc-Malul Galben	3b	Romania	26.63	47.72	OA	Eastern Gravettian	GrA-5000	20540	110	yes		2	2	4	2
Mitoc-Malul Galben	4a	Romania	26.63	47.72	OA	Eastern Gravettian	GrA-1353	23850	100	yes		2	2	4	2
Mitoc-Malul Galben	4b	Romania	26.63	47.72	OA	Eastern Gravettian	GX-9422	24620	810	no		1	2	3	2
Mitoc-Malul Galben	4b	Romania	26.63	47.72	OA	Eastern Gravettian	OxA-1779	23650	400	yes	bone	3	2	5	3
Mitoc-Malul Galben	5a	Romania	26.63	47.72	OA	Eastern Gravettian	GrN-14034	23830	330	no		2	2	4	2
Mitoc-Malul Galben	5a	Romania	26.63	47.72	OA	Eastern Gravettian	OxA-1780	24650	450	yes	bone	3	2	5	3
Mitoc-Malul Galben	5b	Romania	26.63	47.72	OA	Eastern Gravettian	GX-9425	24820	850	no		1	2	3	2
Mitoc-Malul Galben	6b	Romania	26.63	47.72	OA	Eastern Gravettian	GrA-1354	26450	130	yes		2	2	4	2

Mitoc-Malul Galben	6b	Romania	26.63	47.72	OA	Eastern Gravettian	GrN-14035	26750	600	no		1	2	3	2
Mitoc-Malul Galben	6b	Romania	26.63	47.72	OA	Eastern Gravettian	GrN-15450	25610	220	no		2	2	4	2
Mitoc-Malul Galben	6b	Romania	26.63	47.72	OA	Eastern Gravettian	GrN-18811	26180	290	no		2	2	4	2
Mitoc-Malul Galben		Romania	26.63	47.72	OA	Aurignacian	OxA-1646	31100	900	yes	charcoal	2	1	3	2
Mitoc-Malul Galben		Romania	26.63	47.72	OA	Aurignacian	OxA-1778	27500	600	yes	bone	2	1	3	2
Mitoc-Malul Galben		Romania	26.63	47.72	OA	Eastern Gravettian	OxA-2033	24800	430	yes	bone	2	1	3	2
Mogyorósbánya	upper	Hungary	18.36	47.44	OA	Eastern Gravettian	Deb-1169	19930	300	no		2	1	3	2
Molodova 1	above culture layer	Moldova	26.45	48.35	OA	Eastern Gravettian	GIN-72	22850	120	no	shell above culture layer	2	2	4	2
Molodova 5	VI	Moldova	26.30	48.25	OA	Eastern Gravettian		17500	180	unknown		1	1	2	0
Molodova 5	I	Moldova	26.30	48.25	OA	Eastern Gravettian	GIN-105	16750	250	no	loam with campfire charcoal	2	3	5	3
Molodova 5	I	Moldova	26.30	48.25	OA	Eastern Gravettian	GIN-52	17100	180	no	loam with campfire charcoal	2	3	5	3
Molodova 5	I	Moldova	26.30	48.25	OA	Eastern Epigravettian	GIN-54	10940	150	no	loam with campfire charcoal	2	3	5	3
Molodova 5	I	Moldova	26.30	48.25	OA	Eastern Epigravettian	GIN-56	12300	140	no	loam with campfire charcoal	2	3	5	3
Molodova 5	Ia	Moldova	26.30	48.25	OA	Eastern Epigravettian	GIN-7	10590	230	no	bone	2	2	4	2
Molodova 5	Ic	Moldova	26.30	48.25	OA	Aurignacian	LU-156	28100	1000	no	charcoal	0	2	2	0
Molodova 5	II	Moldova	26.30	48.25	OA	Eastern Epigravettian	GIN-8	11900	230	no	bone	2	2	4	2
Molodova 5	III	Moldova	26.30	48.25	OA	Eastern Epigravettian	GIN-9	13370	540	no	charcoal	1	2	3	2
Molodova 5	IV	Moldova	26.30	48.25	OA	Eastern Gravettian	GIN-147	17100	1400	no	charcoal	0	2	2	0
Molodova 5	IX	Moldova	26.30	48.25	OA	Aurignacian	LU-15a	29650	1320	no	charcoal	0	2	2	0
Molodova 5	VII	Moldova	26.30	48.25	OA	Eastern Gravettian	GIN-10	23700	320	no	fossil soil	2	2	4	2
Molodova 5	VII	Moldova	26.30	48.25	OA	Eastern Gravettian	Mo-11	23000	800	no	charcoal	1	2	3	2
Molodova 5	VIII	Moldova	26.30	48.25	OA	Eastern Gravettian	LU-14	24600		no	charcoal	1	2	3	2
Molodova 5	X	Moldova	26.30	48.25	OA	Eastern Gravettian	GIN-106	23100	400	no	fossil soil	2	2	4	2
Moravany-Zakovska		Slovakia	17.85	48.55	OA	Eastern Gravettian	Gd-4915	18100	350	no		2	1	3	2
Mosty B St 13		Poland	14.95	53.55	OA	Magdalenian	Lod-107	11290	280	no	charcoal	2	2	4	2
Mucheln		Germany	11.80	51.18	OA	Gravettian	OxA-4501	24100	280	yes	wood	3	1	4	2
Muralovka		Russia	39.02	47.29	OA	Eastern Gravettian	GrN-7761	25550	350	no		2	1	3	2
Muralovka		Russia	39.02	47.29	OA	Eastern Gravettian	LE-1438	18780	300	no	bone	2	1	3	2
Muralovka		Russia	39.02	47.29	OA	Eastern Gravettian	LE-1601	19630	200	no	bone	2	1	3	2
Nitra-Cermán		Slovakia	18.40	48.17	OA	Gravettian	GrN-2249	23000	330	no		2	1	3	2
Nitra-Cermán		Slovakia	18.40	48.17	OA	Gravettian	GrN-2449	22860	400	no	charcoal from hearth	2	1	3	2
Nitra-Cermán		Slovakia	18.40	48.17	OA	Gravettian	GrN-2456	24220	640	no		1	1	2	1
Nová Drátenická Cave		Czech. Rep.	16.78	49.38	RS	Magdelanian	OxA-1952	11670	150	yes	dark culture layer tr. 1	3	1	4	2
Nová Drátenická Cave		Czech. Rep.	16.78	49.38	RS	Magdelanian	OxA-1953	13870	140	yes	culture layer, tr. 4	3	1	4	2
Nová Drátenická Cave		Czech. Rep.	16.78	49.38	RS	Magdelanian	OxA-1954	12900	140	yes	red clay, tr. 1	3	1	4	2
Novgorod-Severskii		Ukraine	33.16	51.99	RS	Eastern Gravettian	OxA-698	19800	350	yes	mammoth tooth	3	1	4	2
Oblazowa Cave	layer VIII	Poland	20.10	49.25	RS	Eastern Gravettian	OxA-3694	18160	260	yes	mammoth ivory boomerang	3	1	4	2

Oblazowa Cave	layer VIII	Poland	20.10	49.25	RS	Aurignacian	OxA-4584	32400	650	yes	engraved horn-core	2	2	4	2
Oblazowa Cave	layer VIII	Poland	20.10	49.25	RS	Aurignacian	OxA-4586	31000	550	yes	human distal phalange	2	2	4	2
Oblazowa Cave	layer VIII/IX	Poland	20.10	49.25	RS	Aurignacian	OxA-4585	30600	550	yes	bone	2	1	3	2
Oblazowa Cave	layer XI	Poland	20.10	49.25	RS	Eastern Gravettian	OxA-3695	23420	380	yes	horn-core rod	3	1	4	2
Oelknitz		Germany	11.40	50.5	OA	Magdalenian	OxA-5709	12270	120	yes	cut horse bone	3	2	5	3
Oelknitz		Germany	11.40	50.5	OA	Magdalenian	OxA-5710	12080	110	yes	cut horse bone	3	2	5	3
Oelknitz		Germany	11.40	50.5	OA	Magdalenian	OxA-5711	12050	110	yes	cut horse bone	3	2	5	3
Oelknitz		Germany	11.40	50.5	OA	Magdalenian	OxA-5712	12270	110	yes	cut reindeer radius	3	2	5	3
Oelknitz		Germany	11.40	50.5	OA	Magdalenian	OxA-5713	12740	120	yes	cut horse phalanx	3	2	5	3
Oelknitz		Germany	11.40	50.5	OA	Magdalenian	OxA-5714	12620	120	yes	cut reindeer maxilla	3	2	5	3
Oelknitz		Germany	11.40	50.5	OA	Magdalenian	OxA-5715	11810	110	yes	cut horse bone	3	2	5	3
Oelknitz		Germany	11.40	50.5	OA	Magdalenian	OxA-5716	12790	110	yes	cut horse bone	3	2	5	3
Oelknitz		Germany	11.40	50.5	OA	Magdalenian	OxA-5717	12670	110	yes	cut reindeer bone	3	2	5	3
Olbrachcice St 8		Poland	14.95	51.79	OA	Magdalenian	Lod-111	12685	235	no	charcoal	2	2	4	2
Ovca Jama	lower 4	Slovenia	14.35	45.75	RS	Gravettian	KN-48	19540	500	no		1	1	2	1
Pavlov	b	Czech. Rep.	16.40	48.52	OA	Eastern Gravettian	GrN-1325	25020	150	no	charcoal	2	1	3	2
Pavlov		Czech. Rep.	16.40	48.52	OA	Eastern Gravettian	GrN-104	26000	350	no		2	1	3	2
Pavlov		Czech. Rep.	16.40	48.52	OA	Eastern Gravettian	Gro-1242	26400	230	no		2	1	3	2
Pavlov		Czech. Rep.	16.40	48.52	OA	Eastern Gravettian	Gro-1325	24800	150	no		2	1	3	2
Pecine u Brini	2m	Croatia	16.17	43.83	OA	Gravettian		18388		unknown	flowstone on bison bone	1	1	2	1
Pekárna Cave	g and h	Czech. Rep.	16.75	49.38	RS	Eastern Epigravettian	GrN-14828	12670	80	no	modified mammoth bone	2	1	3	2
Pekárna Cave	g and h	Czech. Rep.	16.75	49.38	RS	Eastern Epigravettian	Ly-2553	12940	250	no		2	1	3	2
Pekárna Cave	g and h	Czech. Rep.	16.75	49.38	RS	Eastern Epigravettian	OxA-5972	12500	110	yes		3	1	4	2
Petrkovice		Poland	18.33	49.75	OA	Eastern Gravettian	GrA-891	23370	160	yes	charcoal	2	1	3	2
Petrkovice		Poland	18.33	49.75	OA	Eastern Gravettian	GrN-19540	20790	270	no	charcoal	2	1	3	2
Pieny 1		Russia	33.17	52.11	OA	Eastern Gravettian	LE-1434	23100	280	no	bone	2	1	3	2
Pieny 1		Russia	33.17	52.11	OA	Eastern Gravettian	LE-1434	25200	350	no	bone	2	1	3	2
Pieny 1		Russia	33.17	52.11	OA	Eastern Gravettian	LE-1434	21600	350	no	bone	2	1	3	2
Pieny 2		Russia	33.17	52.11	OA	Eastern Gravettian	GIN-8408	17570	120	no	reindeer bone	2	1	3	2
Pieny 2		Russia	33.17	52.11	OA	Eastern Gravettian	GIN-8408a	17200	300	no	mammoth bone	2	1	3	2
Pieny 2		Russia	33.17	52.11	OA	Eastern Gravettian	GIN-8409	17640	130	no	bone (hocopora)	2	1	3	2
Pieny 2		Russia	33.17	52.11	OA	Eastern Gravettian	GIN-8409a	16600	180	no	bison bone	2	1	3	2
Pilismarót-Palrét		Hungary	18.45	47.48	OA	Eastern Epigravettian	Hv-1615	16750	400	no		2	1	3	2
Pogon		Russia	33.17	52.11	OA	Eastern Gravettian	LU-361	18690	770	no	bone	1	1	2	1
Poushkari 1		Russia	33.17	52.11	OA	Eastern Gravettian	AA-1389	19010	220	yes	burned bone	2	1	3	2
Poushkari 1		Russia	33.17	52.11	OA	Eastern Gravettian	GIN-3382	21100	400	no	burned bone	2	1	3	2
Poushkari 1		Russia	33.17	52.11	OA	Eastern Gravettian	GIN-8529	20600	1300	no	mammoth tooth	0	1	1	0

Poushkari 1		Russia	33.17	52.11	OA	Eastern Epigravettian	QC-899	16775	605	no	burned bone	1	1	2	1
Predmosti		Czech. Rep	17.41	49.45	OA	Eastern Gravettian	OxA-5971	25040	320	yes		3	1	4	2
Radomyshl'		Ukraine	29.14	50.53	OA	Eastern Gravettian	OxA-697	19000	300	yes	mammoth tooth	3	1	4	2
Rydno, Hematite-mining	Cut III/79	Poland	20.90	50.5	OA	Magdalenian	Gd-713	10910	220	no	charcoal	2	2	4	2
Rydno, Hematite-mining	Cut III/79	Poland	20.90	50.5	OA	Magdalenian	Gd-714	10710	250	no	charcoal	2	2	4	2
Rydno, Hematite-mining	Cut III/79	Poland	20.90	50.5	OA	Magdalenian	Gd-724	11940	300	no	charcoal	2	2	4	2
Rydno, Hematite-mining	Cut III/79	Poland	20.90	50.5	OA	Magdalenian	Gd-725	12290	210	no	charcoal	2	2	4	2
Rydno, Hematite-mining	Trench I/7	Poland	20.90	50.5	OA	Magdalenian	Bln-2037	11970	125	no	charcoal	2	2	4	2
Rydno, Hematite-mining	Trench I/7	Poland	20.90	50.5	OA	Magdalenian	Gd-710	10360	320	no	charcoal	2	2	4	2
Sagaidak 1		Ukraine	32.21	47.41	OA	Eastern Gravettian	LE-1602a	21240	200	no	mammoth tooth	2	1	3	2
Sagaidak 1		Ukraine	32.21	47.41	OA	Eastern Gravettian	LE-1602b	20300	200	no	mammoth tooth	2	1	3	2
Šandalja II	B	Croatia	13.53	44.53	RS	Epigravettian	Z-2421	10140	160	no		2	1	3	2
Šandalja II	B/C	Croatia	13.53	44.53	RS	Epigravettian	Z-2423	13050	220	no		2	1	3	2
Šandalja II	B; base	Croatia	13.53	44.53	RS	Epigravettian	GrN-4978	12320	105	no		2	1	3	2
Šandalja II	B; top	Croatia	13.53	44.53	RS	Epigravettian	GrN-4976	10830	50	no		2	1	3	2
Šandalja II	C; base	Croatia	13.53	44.53	RS	Gravettian	Z-193	21740	450	no		2	1	3	2
Šandalja II	C; top	Croatia	13.53	44.53	RS	Epigravettian	Z-2424	13120	230	no		2	1	3	2
Šandalja II	E	Croatia	13.53	44.53	RS	Gravettian	GrN-5013	23540	180	no		2	1	3	2
Šandalja II	F	Croatia	13.53	44.53	RS	Gravettian	GrN-4977	25340		no		1	1	2	1
Šandalja II	F	Croatia	13.53	44.53	RS	Gravettian	Z-536	22660		no		1	1	2	1
Šandalja II	G	Croatia	13.53	44.53	RS	Aurignacian	GrN-4976	26970	632	no		1	1	2	1
Šandalja II	G	Croatia	13.53	44.53	RS	Aurignacian	Z-537	27800	850	no		1	1	2	1
Šandalja II	H	Croatia	13.53	44.53	RS	Gravettian	Z-2422	17600	370	no		2	1	3	2
Sávgár	lower	Hungary	17.45	46.5	OA	Gravettian	GrN-1783	18900	100	no		2	1	3	2
Sávgár	lower	Hungary	17.45	46.5	OA	Gravettian	Gro-1783	18600	150	no		2	1	3	2
Sávgár	upper	Hungary	17.45	46.5	OA	Gravettian	GrN-1959	17760	350	no		2	1	3	2
Sávgár	upper	Hungary	17.45	46.5	OA	Gravettian	Gro-1959	17400	100	no		2	1	3	2
Savudrija	layers a-h 7m	Slovenia	13.73	45.33	OA	Epigravettian	Z-488	11155	209	no	limestone concretetion	2	1	3	2
Semonovka 1		Ukraine	30.15	46.36	OA	Eastern Epigravettian	Ki-5510	13600	160	no		2	2	4	2
Semonovka 2		Ukraine	30.15	46.36	OA	Eastern Epigravettian	Ki-5509	14200	180	no		2	2	4	2
Sevsk mammoth locality	lower horizon	Russia	33.17	52.11	OA	Eastern Epigravettian	GIN-5778	13950	70	no	bone	2	1	3	2
Sevsk mammoth locality	upper horizon	Russia	33.17	52.11	OA	Eastern Epigravettian	GIN-6209	13680	60	no	mammoth tooth	2	1	3	2
Skalistiy		Ukraine	33.98	44.48	RS	Eastern Epigravettian	Leuven	15510		no	charcoal	1	2	3	1
Skalistiy	3\2	Ukraine	33.98	44.48	RS	Eastern Epigravettian	OxA-5164	11620	110	yes	charcoal	3	2	4	3
Skalistiy	3\3	Ukraine	33.98	44.48	RS	Eastern Epigravettian	OxA-4888	12820	140	yes	bone	2	2	4	2

Skalistiy	3\3	Ukraine	33.98	44.48	RS	Eastern Gravettian	OxA-4889	18380	220	yes	bone	2	2	4	2
Skalistiy	3\3	Ukraine	33.98	44.48	RS	Eastern Epigravettian	OxA-5165	11750	120	yes	charcoal	3	2	4	3
Skalistiy	4	Ukraine	33.98	44.48	RS	Eastern Epigravettian	OxA-5166	14570	140	yes	charcoal	3	2	4	3
Skalistiy	6	Ukraine	33.98	44.48	RS	Eastern Epigravettian	OxA-5167	15020	150	yes	charcoal	3	2	4	3
Skalistiy	7	Ukraine	33.98	44.48	RS	Eastern Epigravettian	OxA-5161	14880	180	yes	charcoal	3	2	4	3
Souponevo		Russia	34.23	46.3	OA	Eastern Epigravettian	GIN-3381	13500	100	no	mammoth tooth	2	2	4	2
Souponevo		Russia	34.23	46.3	OA	Eastern Epigravettian	GIN-3719	14260	120	no	mammoth tooth	2	2	4	2
Souponevo		Russia	34.23	46.3	OA	Eastern Epigravettian	GIN-7729a	13920	140	no	mammoth bone	2	2	4	2
Soutchkino	2	Russia	33.14	52.4	OA	Eastern Gravettian	GIN-5869	23000	300	no	burnt bone	2	2	4	2
Soutchkino		Russia	33.14	52.4	OA	Eastern Gravettian	GIN-5870	19900	1500	no	burnt bone; hearth	0	2	2	0
Stanistea		Romania	26.63	47.72	OA	Eastern Gravettian	Blm-14431I	19460	220	no	mammoth tooth	2	2	4	2
Stránská Skála	4	Czech. Rep.	16.65	49.95	OA	Eastern Gravettian	GrN-13945	18220	120	no	bone	2	3	5	3
Stránská Skála	4	Czech. Rep.	16.65	49.95	OA	Eastern Gravettian	GrN-14351	17740	90	no	bone	2	3	5	3
Tchoulatovo 1		Ukraine	33.07	51.51	OA	Eastern Epigravettian	OxA-715	14700	250	yes		3	1	4	2
Tchountou Rockshelter	3	Moldova	27.07	48.06	RS	Eastern Gravettian	OxA-4125	18510	200	yes	bone	3	2	5	3
Tchountou Rockshelter	3	Moldova	27.07	48.06	RS	Eastern Gravettian	OxA-4426	21000	220	yes	horse tooth	3	2	5	3
Tchountou Rockshelter	3	Moldova	27.07	48.06	RS	Eastern Gravettian	OxA-4774	22100	220	yes	bone	3	2	5	3
Temnata Cave	2	Bulgaria	24.78	42.65	RS	Epigravettian	Gd-4022	10880	480	no	charcoal	2	1	3	2
Temnata Cave	3	Bulgaria	24.78	42.65	RS	Epigravettian	Gd-2578	16600	300	no	bone	2	2	4	2
Temnata Cave	3	Bulgaria	24.78	42.65	RS	Gravettian	Gd-4028	20100	900	no	charcoal	1	1	2	1
Temnata Cave	3d	Bulgaria	24.78	42.65	RS	Gravettian	Gd-2581	24800	700	no	bone	1	2	3	2
Temnata Cave	3d; base	Bulgaria	24.78	42.65	RS	Gravettian	Gd-4030	21200	2200	no		0	1	1	0
Temnata Cave	6 & 7a,b	Bulgaria	24.78	42.65	RS	Gravettian	Gd-2785	21200	380	no	bone	2	2	4	2
Temnata Cave	6 & 7a,b	Bulgaria	24.78	42.65	RS	Gravettian	Gd-4230	22400	900	no	bone	1	2	3	2
Temnata Cave	6 & 7a,b	Bulgaria	24.78	42.65	RS	Gravettian	Gd-6126	24400	600	no	bone	2	2	4	2
Teufelsbrücke	1	Germany	11.25	50.35	RS	Magdalenian	OxA-5725	12900	130	yes	cut tibia	3	3	6	3
Teufelsbrücke	2	Germany	11.25	50.35	RS	Magdalenian	OxA-5722	12860	130	yes	cut horse phalanx	3	3	6	3
Teufelsbrücke	2	Germany	11.25	50.35	RS	Magdalenian	OxA-5723	13080	140	yes	cut bone	3	3	6	3
Teufelsbrücke	2	Germany	11.25	50.35	RS	Magdalenian	OxA-5724	12940	140	yes	possible cut bone	3	3	6	3
Teufelsbrücke	3	Germany	11.25	50.35	RS	Magdalenian	Bln-1573	13025	85	no		2	3	5	3
Teufelsbrücke	3	Germany	11.25	50.35	RS	Magdalenian	Bln-1821	12300	85	no		2	3	5	3
Teufelsbrücke	3	Germany	11.25	50.35	RS	Magdalenian	Bln-1924	12315	100	no		2	3	5	3
Teufelsbrücke	3	Germany	11.25	50.35	RS	Magdalenian	OxA-5726	12640	130	yes	marrow-fracture reindeer humerus	3	3	6	3
Teufelsbrücke	3	Germany	11.25	50.35	RS	Magdalenian	OxA-5727	10040	120	yes	cut horse mandible	3	3	6	3
Teufelsbrücke	4	Germany	11.25	50.35	RS	Magdalenian	Bln-1727	12480	90	no		2	3	5	3

Timonovka 1		Russia	34.22	53.11	OA	Eastern Epigravettian	GIN-2003	15300	700	no	bone (1932) (burned bone?)	2	1	3	2
Timonovka 1		Russia	34.22	53.11	OA	Eastern Epigravettian	GIN-8413	14750	120	no	mammoth bone	2	1	3	2
Timonovka 1		Russia	34.22	53.11	OA	Eastern Epigravettian	GIN-8414	14530	120	no	mammoth bone	2	1	3	2
Timonovka 1		Russia	34.22	53.11	OA	Eastern Epigravettian	IGAN-82	12200	300	no	mammoth tooth	2	1	3	2
Timonovka 2		Russia	34.22	53.11	OA	Eastern Epigravettian	LU-358	15110	530	no	bone	1	1	2	1
Tokaj		Hungary	21.50	48.15	OA	Eastern Gravettian	Hv-1775	20350	470	no		2	1	3	2
Trencianské-Bohuslavice		Slovakia	18.25	48.7	OA	Eastern Gravettian	Gd-2490	23700	500	no		2	1	3	2
Velika Pecina		Croatia	16.02	46.17	RS	Epigravettian	GrN-4976	10830	50	no		2	1	3	2
Velika Pecina		Croatia	16.02	46.17	RS	Gravettian	GrN-4977	25340	170	no		2	1	3	2
Velika Pecina		Croatia	16.02	46.17	RS	Epigravettian	GrN-4978	12320	100	no		2	1	3	2
Velika Pecina		Croatia	16.02	46.17	RS	Gravettian	GrN-5013	23540	180	no		2	1	3	2
Velika Pecina		Croatia	16.02	46.17	RS	Gravettian	Z-193	21750	450	no		2	1	3	2
Velika Pecina		Croatia	16.02	46.17	RS	Epigravettian	Z-2423	12700	100	no		2	1	3	2
Velika Pecina		Croatia	16.02	46.17	RS	Epigravettian	Z-2424	12750	100	no		2	1	3	2
Velika Pecina		Croatia	16.02	46.17	RS	Gravettian	Z-536	22500		no		1	1	2	1
Velke Pavlovice		Slovakia	21.80	48.6	OA	Eastern Epigravettian	GrN-16139	14460	230	no	bone	2	1	3	2
Vindija Cave	2	Croatia	16.04	46.2	RS	Gravettian	Z-612	24000	3300	no	charcoal	0	1	1	0
Vindija Cave		Croatia	16.04	46.2	RS	Gravettian	Z-2447	18500	300	no		2	2	4	2
Willendorf	8-B2	Austria	15.65	48.35	OA	Gravettian	GrN-11191	25800	800	no		1	1	2	1
Willendorf	8-B2	Austria	15.65	48.35	OA	Gravettian	GrN-17801	25230	320	no		2	1	3	2
Willendorf	8-B2	Austria	15.65	48.35	OA	Gravettian	GrN-17802	25660	350	no		2	1	3	2
Willendorf	8-B2	Austria	15.65	48.35	OA	Gravettian	GrN-20767	25440	170	no		2	1	3	2
Willendorf	8-B2	Austria	15.65	48.35	OA	Gravettian	GrN-21690	25400	170	no		2	1	3	2
Willendorf	8-B2	Austria	15.65	48.35	OA	Gravettian	GrN-894	24710	180	no		2	1	3	2
Willendorf	8-B2	Austria	15.65	48.35	OA	Gravettian	GrN-917	22180	190	no		2	1	3	2
Willendorf	9-B1	Austria	15.65	48.35	OA	Gravettian	GrA-5005	23180	120	yes		2	1	3	2
Willendorf	9-B1	Austria	15.65	48.35	OA	Gravettian	GrA-5006	24910	150	yes		2	1	3	2
Willendorf	9-B1	Austria	15.65	48.35	OA	Gravettian	GrN-21898	23860	270	no		2	1	3	2
Willendorf	9-B1	Austria	15.65	48.35	OA	Gravettian	GrN-22208	24370	290	no		2	1	3	2
Willendorf	below 9-B1	Austria	15.65	48.35	OA	Gravettian	GrA-493	23400	190	yes		2	1	3	2
Willendorf	below 9-B1	Austria	15.65	48.35	OA	Gravettian	GrA-494	23670	120	yes		2	1	3	2
Willendorf	below 9-B1	Austria	15.65	48.35	OA	Gravettian	GrA-893	23200	140	yes		2	1	3	2
Willendorf II	5	Austria	15.65	48.35	OA	Gravettian	GrN-11194	23830	190	no		2	1	3	2
Yudinovo		Russia	33.17	52.4	OA	Eastern Epigravettian	AA-4801	14470	160	yes	bone	2	1	3	2
Yudinovo		Russia	33.17	52.4	OA	Eastern Epigravettian	AA-4802	14650	105	yes	bone	2	1	3	2

Yudinovo		Russia	33.17	52.4	OA	Eastern Epigravettian	GIN-5588	14500	200	no	burned bone	2	1	3	2
Yudinovo		Russia	33.17	52.4	OA	Eastern Epigravettian	GIN-5661	14610	60	no	burned bone	2	1	3	2
Yudinovo		Russia	33.17	52.4	OA	Eastern Epigravettian	ISGS-2084	14300	110	no	burned bone	2	1	3	2
Yudinovo		Russia	33.17	52.4	OA	Eastern Epigravettian	ISGS-2085	13980	110	no	burned bone	2	1	3	2
Yudinovo		Russia	33.17	52.4	OA	Eastern Epigravettian	LE-3301	15790	320	no	bone	2	1	3	2
Yudinovo		Russia	33.17	52.4	OA	Eastern Gravettian	LE-3302	17800	810	no	burned bone	1	1	2	1
Yudinovo		Russia	33.17	52.4	OA	Eastern Epigravettian	LE-3303	13720	210	no	bone	2	1	3	2
Yudinovo		Russia	33.17	52.4	OA	Eastern Gravettian	LE-3401	18630	320	no	burned bone	2	1	3	2
Yudinovo		Russia	33.17	52.4	OA	Eastern Epigravettian	LE-3835	14870	150	no	mammoth bone	2	1	3	2
Yudinovo		Russia	33.17	52.4	OA	Eastern Epigravettian	LU-103	13830	850	no	burned bone	1	1	2	1
Yudinovo		Russia	33.17	52.4	OA	Eastern Gravettian	LU-125	26470	420	no	Mammouth tooth	2	1	3	2
Yudinovo		Russia	33.17	52.4	OA	Eastern Epigravettian	LU-127	15660	180	no	mammoth bone	2	1	3	2
Yudinovo		Russia	33.17	52.4	OA	Eastern Epigravettian	LU-153	13650	200	no	mammoth tooth	2	1	3	2
Yudinovo		Russia	33.17	52.4	OA	Eastern Epigravettian	OxA-695	13300	200	yes	burned bone	2	1	3	2
Yudinovo		Russia	33.17	52.4	OA	Eastern Epigravettian	OxA-696	12300	200	yes	burned bone	2	1	3	2
Zalaegerszeg	upper	Hungary	16.51	46.51	OA	Eastern Epigravettian	Hv-1816	12125	300	no		2	1	3	2
Zaraisk		Russia	38.52	54.45	OA	Eastern Gravettian	GIN-3726	16700	1200	no	cultural layer	0	2	2	0
Zaraisk		Russia	38.52	54.45	OA	Eastern Gravettian	GIN-3727	18300	200	no	mammoth tooth; pit 4	2	2	4	2
Zaraisk		Russia	38.52	54.45	OA	Eastern Gravettian	GIN-3998	22300	300	no	mammoth tooth; pit 1	2	2	4	2
Zaraisk		Russia	38.52	54.45	OA	Eastern Gravettian	GIN-6035	15600	300	no	cultural layer	2	2	4	2
Zaraisk		Russia	38.52	54.45	OA	Eastern Gravettian	GIN-8396	19200	300	no	burned bone; sq. H-3, pit	2	2	4	2
Zaraisk		Russia	38.52	54.45	OA	Eastern Gravettian	GIN-8397	19100	200	no	burned bone	2	2	4	2
Zaraisk		Russia	38.52	54.45	OA	Eastern Gravettian	GIN-8397a	23000	400	no	bone; sq. O-2	2	2	4	2
Zaraisk		Russia	38.52	54.45	OA	Eastern Gravettian	GIN-8484	21000	430	no	mammoth tooth; sq. E-4	2	2	4	2
Zaraisk		Russia	38.52	54.45	OA	Eastern Gravettian	GIN-8485	21600	300	no	mammoth tooth (1994)	2	2	4	2
Zaraisk		Russia	38.52	54.45	OA	Eastern Gravettian	GIN-8486	19900	260	no	bone; sq. H-2	2	2	4	2
Zaraisk		Russia	38.52	54.45	OA	Eastern Gravettian	GIN-8487	19000	200	no	burned bone	2	2	4	2
Zaraisk		Russia	38.52	54.45	OA	Eastern Gravettian	GIN-8488	21400	50	no	burned bone; hearth 2	2	3	5	3
Zaraisk		Russia	38.52	54.45	OA	Eastern Epigravettian	GIN-8489	16200	1000	no	cultural layer	0	2	2	0

Zaraisk		Russia	38.52	54.45	OA	Eastern Gravettian	GIN-8865	17900	200	no	humus, fossil soil; upper horizon of cultural layer	2	1	3	2
Zaraisk		Russia	38.52	54.45	OA	Eastern Gravettian	GIN-8975	19100	260	no	burned bone; hearth 3	2	3	5	3
Zaraisk		Russia	38.52	54.45	OA	Eastern Gravettian	RTL-307	22000	5000	no	raddish loam; cultural layer	0	2	2	0
Zaraisk		Russia	38.52	54.45	OA	Eastern Gravettian	RTL-308	19000	4500	no	raddish loam	0	2	2	0
Zaraisk		Russia	38.52	54.45	OA	Eastern Gravettian	RTL-310	20000	5000	no	upper level of fossil humus; cultural layer	0	1	1	0
Zaraisk		Russia	38.52	54.45	OA	Aurignacian	RTL-313	35000	9000	no	fossil soil	0	1	1	0
Zolotovka I		Russia	40.26	47.85	OA	Eastern Gravettian	GIN-1968	17400	700	no	burnt bone	1	1	2	1
Zolotovka I		Russia	40.26	47.85	OA	Eastern Epigravettian	GIN-8002	13600	1000	no	bison bone	0	1	1	0
Županov Spodmol	level 2; AB	Slovenia	14.36	45.71	RS	Epigravettian	GrN-5288	16780	150	no		2	2	4	2
Županov Spodmol	level 2; AB/D	Slovenia	14.36	45.71	RS	Epigravettian	GrN-5100	13500	175	no		2	2	4	2
Županov Spodmol	level 2; D	Slovenia	14.36	45.71	RS	Epigravettian	GrN-5098	12410	70	no		2	2	4	2

APPENDIX B

The Working Database

(Data sorted by Region)

Key

SE = South East Region

ME = Mediterranean Region

A = Alpine Region

NC = North Central Region

NEw = North East west Region

NEe = North East east Region

TC = technocomplex

OA = open-air site

RS = rockshelter

SiteLayer ID	Country	Lon	Lat	Region	OA/RS	TC	cal BC
Arka, lower	Hungary	21.30	48.30	SE	OA	Eastern Gravettian	19025
Arka, upper	Hungary	21.30	48.30	SE	OA	Eastern Epigravettian	13825
Badanj, 13 17C13	Bosnia-Hertz.	17.58	43.04	SE	RS	Eastern Epigravettian	13815
Badanj, 6 17B6	Bosnia-Hertz.	17.58	43.04	SE	RS	Eastern Epigravettian	12735
Balatonszabadi	Hungary	17.50	46.70	SE	OA	Eastern Gravettian	22905
Cuina Turcului	Romania	22.07	44.53	SE	OA	Eastern Epigravettian	12935
Dunaföldvár, upper	Hungary	18.56	46.48	SE	OA	Eastern Epigravettian	12455
Dunaszekcsô	Hungary	18.75	46.08	SE	OA	Eastern Gravettian	23045
Esztergom-Gyurgyalag	Hungary	18.45	47.48	SE	OA	Eastern Gravettian	16835
Garla Mare, level W	Romania	27.00	46.00	SE	OA	Eastern Gravettian	21460
Grubgraben, 1B	Austria	18.20	48.50	SE	OA	Gravettian	17760
Grubgraben, 2	Austria	18.20	48.50	SE	OA	Gravettian	19247
Grubgraben, 3	Austria	18.20	48.50	SE	OA	Gravettian	19395
Grubgraben, 4	Austria	18.20	48.50	SE	OA	Gravettian	20160
Hrustovača	Bosnia	16.65	44.70	SE	RS	Eastern Epigravettian	12055
Jaszfelsoszent Gyorgy, upper	Hungary	20.15	47.40	SE	OA	Eastern Gravettian	19900
Kopacina, layer b: 75cm	Croatia	16.53	43.36	SE	OA	Epigravettian	11865
Kopacina, layer c: 50cm	Croatia	16.53	43.36	SE	OA	Epigravettian	13455
Kulna, layer 4	Czech. Rep.	16.90	48.20	SE	RS	Epigravettian	11525
Kulna, layer 6	Czech. Rep.	16.90	48.20	SE	RS	Epigravettian	11573
Lukenjska jama	Slovenia	15.06	45.49	SE	RS	Epigravettian	12550
Madaras	Hungary	19.16	46.03	SE	OA	Eastern Gravettian	19430
Mališina Stijena, upper	Bosnia-Hertz.	16.02	44.89	SE	RS	Eastern Epigravettian	14380
Mitoc-Malul Galben, 2a	Romania	26.63	47.72	SE	OA	Eastern Gravettian	21598
Mitoc-Malul Galben, 3b	Romania	26.63	47.72	SE	OA	Eastern Gravettian	21850
Mitoc-Malul Galben, 4a	Romania	26.63	47.72	SE	OA	Eastern Gravettian	25250
Mitoc-Malul Galben, 5a	Romania	26.63	47.72	SE	OA	Eastern Gravettian	25985
Mitoc-Malul Galben, 6b	Romania	26.63	47.72	SE	OA	Eastern Gravettian	27925
Mogyorósbánya, upper	Hungary	18.36	47.44	SE	OA	Eastern Gravettian	21310
Moravany-Zakovska	Slovakia	17.85	48.55	SE	OA	Eastern Gravettian	19445
Oblazowa Cave, layer VIII	Poland	20.10	49.25	SE	RS	Aurignacian	32830
Oblazowa Cave, layer VIII/IX	Poland	20.10	49.25	SE	RS	Aurignacian	31860
Oblazowa Cave, layer XI	Poland	20.10	49.25	SE	RS	Eastern Gravettian	24400
Pecine u Brini, 2m	Croatia	16.17	43.83	SE	OA	Gravettian	19595
Pilismarót-Palrét	Hungary	18.45	47.48	SE	OA	Eastern Epigravettian	17715
Sávgár, lower	Hungary	17.45	46.50	SE	OA	Eastern Gravettian	20050
Sávgár, upper	Hungary	17.45	46.50	SE	OA	Eastern Gravettian	18695
Stanistea	Romania	26.63	47.72	SE	OA	Eastern Gravettian	20750
Temnata Cave, 1	Bulgaria	24.78	42.65	SE	RS	Eastern Epigravettian	10310
Temnata Cave, 2	Bulgaria	24.78	42.65	SE	RS	Eastern Epigravettian	10700
Temnata Cave, 3	Bulgaria	24.78	42.65	SE	RS	Eastern Gravettian	21370
Temnata Cave, 6 & 7a,b	Bulgaria	24.78	42.65	SE	RS	Eastern Gravettian	23525
Temnata Cave, Litho-strat 3a	Bulgaria	24.78	42.65	SE	RS	Eastern Epigravettian	14555

Temnata Cave, Litho-strat 3c	Bulgaria	24.78	42.65	SE	RS	Eastern Epigravettian	10200
Temnata Cave, Litho-strat 3d	Bulgaria	24.78	42.65	SE	RS	Eastern Gravettian	21848
Tokaj	Hungary	21.50	48.15	SE	OA	Eastern Gravettian	21765
Trencianské-Bohuslavice	Slovakia	18.25	48.70	SE	OA	Eastern Gravettian	25365
Velika Pećina	Croatia	16.02	46.17	SE	RS	Epigravettian	18023
Vindija Cave	Croatia	16.04	46.20	SE	RS	Gravettian	19890
Zalaegerszeg, upper	Hungary	16.51	46.51	SE	OA	Eastern Gravettian	21470
Anetovka 2	Ukraine	31.06	47.38	NEw	OA	Eastern Gravettian	20378
Ataki, II	Ukraine	26.50	48.34	NEw	OA	Eastern Gravettian	16185
Ataki, III	Ukraine	26.50	48.34	NEw	OA	Eastern Gravettian	17600
Brînzeni I, III	Moldova	27.07	48.06	NEw	RS	Eastern Gravettian	21505
Buran-Kaya III, cultural layer VI, horizon 8	Ukraine	34.25	45.00	NEw	RS	Eastern Epigravettian	11920
Cosaoutsi, 1	Ukraine	28.17	48.13	NEw	OA	Eastern Gravettian	18210
Cosaoutsi, 2	Ukraine	28.17	48.13	NEw	OA	Eastern Gravettian	18560
Cosaoutsi, 3	Ukraine	28.17	48.13	NEw	OA	Eastern Gravettian	18270
Cosaoutsi, 4	Ukraine	28.17	48.13	NEw	OA	Eastern Gravettian	18895
Cosaoutsi, 5	Ukraine	28.17	48.13	NEw	OA	Eastern Gravettian	18070
Cosaoutsi, 6	Ukraine	28.17	48.13	NEw	OA	Eastern Gravettian	19335
Cosaoutsi, 9	Ukraine	28.17	48.13	NEw	OA	Eastern Gravettian	20805
Cuintu, 3	Moldova	27.10	48.15	NEw	OA	Eastern Gravettian	22320
Dobranitchevka	Ukraine	31.44	50.10	NEw	OA	Eastern Epigravettian	12995
Eliseevitichii 1	Ukraine	33.62	46.48	NEw	OA	Eastern Epigravettian	15275
Eliseevitichii 2	Ukraine	33.62	46.48	NEw	OA	Eastern Gravettian	16285
Gontsy	Ukraine	32.49	50.10	NEw	OA	Eastern Epigravettian	15125
Kirillovskaya	Ukraine	30.45	50.55	NEw	OA	Eastern Gravettian	20385
Klimaoutsy 2, I (lower)	Moldova	28.17	48.13	NEw	OA	Eastern Gravettian	26155
Klimaoutsy 2, II (upper)	Moldova	28.17	48.13	NEw	OA	Eastern Gravettian	21690
Korman 4, V	Ukraine	27.14	48.34	NEw	OA	Eastern Gravettian	19245
Korman 4, VII	Ukraine	27.14	48.34	NEw	OA	Eastern Gravettian	26298
Korolevo 1, Ia	Ukraine	29.14	50.32	NEw	OA	Eastern Gravettian	27180
Korpatch, layer IV	Ukraine	27.31	48.17	NEw	OA	Eastern Gravettian	26810
Koulytchivka	Ukraine	27.14	48.34	NEw	OA	Eastern Gravettian	26810
Koulytchivka, Ia	Ukraine	27.14	48.34	NEw	OA	Eastern Gravettian	27180
Lvov 7 (shelter Romana - Tchertova Skelia), I	Ukraine	26.50	48.34	NEw	RS	Eastern Epigravettian	11830
Lvov 7 (shelter Romana - Tchertova Skelia), II	Ukraine	26.50	48.34	NEw	RS	Eastern Epigravettian	14115
Mezhigirtsy 1	Ukraine	31.65	49.54	NEw	OA	Eastern Gravettian	18438
Mezhiritch	Ukraine	31.24	49.38	NEw	OA	Eastern Epigravettian	15300
Molodova 5, I	Moldova	26.45	48.35	NEw	OA	Eastern Epigravettian	12665
Molodova 5, II	Moldova	26.45	48.35	NEw	OA	Eastern Epigravettian	11935
Molodova 5, III	Moldova	26.45	48.35	NEw	OA	Eastern Epigravettian	13865
Molodova 5, VII	Moldova	26.45	48.35	NEw	OA	Eastern Gravettian	24590
Molodova 5, VIII	Moldova	26.45	48.35	NEw	OA	Eastern Gravettian	25975
Molodova 5, X	Moldova	26.45	48.35	NEw	OA	Eastern Gravettian	24125
Molodova I, above culture layer	Moldova	26.45	48.35	NEw	OA	Eastern Gravettian	23935

Radomyshl'	Ukraine	29.14	50.53	NEw	OA	Eastern Gravettian	20245
Sagaidak 1	Ukraine	32.21	47.41	NEw	OA	Eastern Gravettian	22103
Semonovka 1	Ukraine	30.15	46.36	NEw	OA	Eastern Epigravettian	14215
Semonovka 2	Ukraine	30.15	46.36	NEw	OA	Eastern Epigravettian	14920
Skalistiy, 3\2	Ukraine	33.98	44.48	NEw	RS	Eastern Epigravettian	11665
Skalistiy, 3\3	Ukraine	33.98	44.48	NEw	RS	Eastern Epigravettian	13075
Skalistiy, 4	Ukraine	33.99	44.48	NEw	RS	Eastern Epigravettian	15375
Skalistiy, 6	Ukraine	33.98	44.48	NEw	RS	Eastern Epigravettian	15775
Skalistiy, 7	Ukraine	33.98	44.48	NEw	RS	Eastern Epigravettian	15650
Souponevo	Russia	34.23	46.30	NEw	OA	Eastern Epigravettian	14535
Tchountou Rockshelter, 3	Moldova	27.07	48.06	NEw	RS	Eastern Gravettian	22320
Akhshtyr Cave	Russia	39.59	43.32	NEe	RS	Eastern Gravettian	20650
Amvrosievka,culture layer; bone bed	Ukraine	39.02	47.30	NEe	OA	Eastern Gravettian	18953
Amvrosievka,horizon I	Ukraine	39.02	47.30	NEe	OA	Eastern Gravettian	20083
Amvrosievka,horizon II; bone bed	Ukraine	39.02	47.30	NEe	OA	Eastern Gravettian	22800
Amvrosievka,horizon II-III	Ukraine	39.02	47.30	NEe	OA	Eastern Gravettian	19993
Amvrosievka,horizon IV	Ukraine	39.02	47.30	NEe	OA	Eastern Gravettian	19475
Amvrosievka,horizon VI	Ukraine	39.02	47.30	NEe	OA	Eastern Gravettian	19995
Avdeevo	Russia	36.03	51.44	NEe	OA	Eastern Gravettian	21818
Berdyzh	Belarus	30.58	52.50	NEe	OA	Eastern Gravettian	23685
Borshchevo 1	Russia	39.06	51.20	NEe	OA	Eastern Gravettian	17288
Borshchevo 2, lower? horizon II	Russia	39.06	51.20	NEe	OA	Eastern Epigravettian	13775
Borshchevo 2, upper cultural layer, horizon I	Russia	39.06	51.20	NEe	OA	Eastern Epigravettian	11800
Gagarino	Russia	38.54	52.42	NEe	OA	Eastern Gravettian	21530
Kamennaya Balka II	Russia	39.21	47.16	NEe	OA	Eastern Epigravettian	14225
Kasoznskaya cave	Russia	40.02	44.50	NEe	RS	Eastern Gravettian	21375
Khotylevo 2	Russia	34.19	53.12	NEe	OA	Eastern Gravettian	24048
Kostenki 1 (Poliakov Site), I	Russia	39.01	51.25	NEe	OA	Eastern Gravettian	23423
Kostenki 1 (Poliakov Site), III	Russia	39.01	51.25	NEe	OA	Eastern Gravettian	26895
Kostenki 1 (Poliakov Site), V	Russia	39.01	51.25	NEe	OA	Aurignacian	30315
Kostenki 10 (Anosovka 1)	Russia	39.01	51.25	NEe	OA	Aurignacian	30480
Kostenki 11 (Anosovka 2), Ia	Russia	39.01	51.25	NEe	OA	Eastern Gravettian	17500
Kostenki 11 (Anosovka 2), II	Russia	39.01	51.25	NEe	OA	Eastern Gravettian	19515
Kostenki 11 (Anosovka 2), III	Russia	39.01	51.25	NEe	OA	Eastern Gravettian	21855
Kostenki 12 (Volkov site), I	Russia	39.02	51.25	NEe	OA	Eastern Gravettian	25780
Kostenki 14 (Markina gora), I	Russia	39.02	51.22	NEe	OA	Eastern Gravettian	22515
Kostenki 14 (Markina gora), II	Russia	39.02	51.22	NEe	OA	Eastern Gravettian	28150
Kostenki 14 (Markina gora), III	Russia	39.02	51.22	NEe	OA	Eastern Gravettian	23165
Kostenki 14 (Markina gora), II-III	Russia	39.02	51.22	NEe	OA	Eastern Epigravettian	15555
Kostenki 15 (Gordozovskaia site)	Russia	39.02	51.25	NEe	OA	Eastern Gravettian	25323
Kostenki 17 (Spitzyn site), I	Russia	39.01	51.24	NEe	OA	Eastern Gravettian	25023
Kostenki 17 (Spitzyn site), II	Russia	39.01	51.24	NEe	OA	Eastern Gravettian	21405
Kostenki 18 (Khvoikovskaia site)	Russia	39.02	51.25	NEe	OA	Eastern Gravettian	21218
Kostenki 18 (Khvoikovskaia site), 4a	Russia	39.02	51.25	NEe	OA	Eastern Epigravettian	15175
Kostenki 19 (Valukinskogo site)	Russia	39.02	51.25	NEe	OA	Eastern Gravettian	19308

Kostenki 2 (Zamiatnin site)	Russia	39.01	51.24	NEe	OA	Eastern Gravettian	18430
Kostenki 21 (Gmielin site), II	Russia	39.01	51.25	NEe	OA	Eastern Gravettian	21555
Kostenki 21 (Gmielin site), III	Russia	39.01	51.25	NEe	OA	Eastern Gravettian	22560
Kostenki 3 (Glinishche)	Russia	39.01	51.25	NEe	OA	Eastern Gravettian	21175
Kostenki 4 (Alexandrovskaia site)	Russia	39.01	51.25	NEe	OA	Eastern Gravettian	23970
Kostenki 5 (Sviatoi log), II	Russia	39.01	51.26	NEe	OA	Eastern Gravettian	22225
Kostenki 6 (Streletskaia 2)	Russia	39.01	51.26	NEe	OA	Eastern Gravettian	27718
Kostenki 8 (Telmanskaia site), I	Russia	39.01	51.26	NEe	OA	Eastern Gravettian	23638
Kostenki 8 (Telmanskaia site), II	Russia	39.01	51.26	NEe	OA	Eastern Gravettian	25890
Kursk I	Russia	36.10	51.40	NEe	OA	Eastern Epigravettian	11630
Leski	Russia	39.51	49.90	NEe	OA	Eastern Gravettian	20420
Mezin	Ukraine	33.05	51.45	NEe	OA	Aurignacian	30073
Muralovka	Russia	39.02	47.29	NEe	OA	Eastern Gravettian	21010
Novgorod-Severskii	Ukraine	33.16	51.99	NEe	OA	Eastern Gravettian	21155
Pieny 1	Russia	33.17	52.11	NEe	OA	Eastern Gravettian	24587
Pieny 2	Russia	33.17	52.11	NEe	OA	Eastern Gravettian	18490
Pogon	Russia	33.17	52.11	NEe	OA	Eastern Gravettian	19990
Poushkari 1	Russia	33.17	52.11	NEe	OA	Eastern Gravettian	20250
Sevsk mammoth locality, lower horizon	Russia	33.17	52.11	NEe	OA	Eastern Epigravettian	14433
Soutchkino, 2	Russia	33.14	52.40	NEe	OA	Eastern Gravettian	24040
Tchoulatovo 1	Ukraine	33.07	51.51	NEe	OA	Eastern Epigravettian	15480
Timonovka 1	Russia	34.22	53.11	NEe	OA	Eastern Epigravettian	15435
Timonovka 2	Russia	34.22	53.11	NEe	OA	Eastern Epigravettian	15785
Yudinovo	Russia	33.17	52.40	NEe	OA	Eastern Epigravettian	15295
Zaraisk	Russia	38.52	54.45	NEe	OA	Eastern Gravettian	20395
Zolotovka I	Russia	40.26	47.85	NEe	OA	Eastern Gravettian	18275
Aggsbach,B	Austria	15.42	48.28	NC	OA	Gravettian	23650
Aggsbach,C	Austria	15.42	48.28	NC	OA	Gravettian	28250
Aggsbach,H/K/S	Austria	15.42	48.28	NC	OA	Gravettian	27760
Albendorf	Austria	14.42	48.40	NC	OA	Gravettian	21795
Bärenkeller (Königsee-Garsitz)	Germany	11.50	50.58	NC	RS	Magdalenian	14355
Brno-Vídenská (Konevova)	Czech Rep.	16.65	49.95	NC	OA	Epigravettian	15250
Calowanie, I	Poland	20.65	52.40	NC	OA	Magdalenian	11910
Calowanie, III	Poland	20.65	52.40	NC	OA	Magdalenian	11563
Calowanie, IV	Poland	20.65	52.40	NC	OA	Magdalenian	11230
Cejkov	Slovakia	21.69	48.61	NC	OA	Eastern Gravettian	20990
Descrowa Cave	Poland	19.53	50.58	NC	RS	Epigravettian	18645
Dolní Věstonice I	Czech Rep.	16.40	48.53	NC	OA	Eastern Gravettian	23425
Dolní Věstonice II	Czech Rep.	16.40	48.53	NC	OA	Eastern Gravettian	21605
Dolní Věstonice III	Czech Rep.	16.40	48.53	NC	OA	Eastern Gravettian	25935
Dudka	Poland	21.00	54.00	NC	OA	Magdalenian	11195
Horn	Austria	15.40	48.40	NC	OA	Gravettian	24265
Hostim	Bohemia	14.08	49.95	NC	OA	Magdalenian	12730
Jaskinia Maszycka (Maszycka Cave), level III	Poland	19.99	50.01	NC	RS	Magdalenian	16165
Jaskinia Maszycka (Maszycka Cave),	Poland	19.99	50.01	NC	RS	Magdalenian	15310

level I-II							
Kasov	Slovakia	21.69	48.61	NC	OA	Eastern Gravettian	19975
Kaufertserg, 1	Germany	10.35	48.50	NC	RS	Magdalenian	12945
Kniegrotte, lower	Germany	11.33	50.40	NC	RS	Magdalenian	14173
Kniegrotte, middle	Germany	11.33	50.40	NC	RS	Magdalenian	13715
Kniegrotte, upper	Germany	11.33	50.40	NC	RS	Magdalenian	13860
Königsaue	Germany	11.24	51.49	NC	OA	Magdalenian	13895
Kraków Spadzista St B, Level 6	Poland	19.55	50.05	NC	OA	Eastern Gravettian	24070
Kraków Spadzista St C2, Level 6, Layer II	Poland	19.55	50.05	NC	OA	Epigravettian	18425
Kraków Spadzista St C2, Level 6, Layer III	Poland	19.55	50.05	NC	OA	Eastern Gravettian	22280
Kraków Spadzista St F, Level 6	Poland	19.55	50.05	NC	OA	Eastern Gravettian	24000
Krucza Skala	Poland	18.35	49.93	NC	OA	Magdalenian	11485
Krumpa	Germany	11.84	51.80	NC	OA	Magdalenian	11840
Langmanensdorf, A	Austria	15.68	48.34	NC	OA	Gravettian	21135
Langmanensdorf, B	Austria	15.68	48.34	NC	OA	Gravettian	21900
Milovice, level 3	Poland	14.08	49.95	NC	OA	Eastern Gravettian	23975
Milovice, level I	Poland	14.08	49.95	NC	OA	Eastern Gravettian	23280
Mosty B St 13	Poland	14.95	53.55	NC	OA	Magdalenian	11390
Mucheln	Germany	11.80	51.18	NC	OA	Gravettian	25675
Nitra-Čermáň	Slovakia	18.40	48.17	NC	OA	Eastern Gravettian	24045
Nová Drátenická Cave	Czech. Rep.	16.78	49.38	NC	RS	Epigravettian	13120
Oelknitz	Germany	11.40	50.50	NC	OA	Magdalenian	12635
Olbrachcice St 8	Poland	14.95	51.79	NC	OA	Magdalenian	12975
Pavlov	Czech. Rep.	16.40	48.52	NC	OA	Eastern Gravettian	27050
Pekárna Cave, g and h	Czech. Rep.	16.75	49.38	NC	RS	Eastern Epigravettian	12990
Petrkoviče	Poland	18.33	49.75	NC	OA	Eastern Gravettian	23213
Predmosti	Czech. Rep	17.41	49.45	NC	OA	Eastern Gravettian	26295
Rydno, Hematite-mining, Cut III/79	Poland	20.90	50.50	NC	OA	Magdalenian	12423
Rydno, Hematite-mining, Trench I/7	Poland	20.90	50.50	NC	OA	Magdalenian	11070
Sesselfelsgrotte, C2, 5, I	Germany	11.50	48.55	NC	RS	Magdalenian	13035
Sesselfelsgrotte, C2, 6, III, B	Germany	11.50	48.55	NC	RS	Magdalenian	12995
Stránská Skála, 4	Czech. Rep.	16.65	49.95	NC	OA	Eastern Gravettian	19205
Teufelsbrücke, 1	Germany	11.25	50.35	NC	RS	Magdalenian	13120
Teufelsbrücke, 2	Germany	11.25	50.35	NC	RS	Magdalenian	13145
Teufelsbrücke, 3	Germany	11.25	50.35	NC	RS	Magdalenian	12670
Teufelsbrücke, 4	Germany	11.25	50.35	NC	RS	Magdalenian	12835
Velke Pavlovice	Slovakia	21.80	48.60	NC	OA	Eastern Epigravettian	15245
Willendorf , 8-B2	Austria	15.65	48.35	NC	OA	Gravettian	27005
Willendorf , 9-B1	Austria	15.65	48.35	NC	OA	Gravettian	25660
Willendorf , below 9-B1	Austria	15.65	48.35	NC	OA	Gravettian	24525
Willendorf II, 5	Austria	15.65	48.35	NC	OA	Gravettian	25005
Abri Tagliente,10	Italy	11.20	45.70	ME	RS	Epigravettian	13495
Abri Tagliente,10 to 8	Italy	11.20	45.70	ME	RS	Epigravettian	12125
Abri Tagliente,14	Italy	11.20	45.70	ME	RS	Epigravettian	12330
Abri Tagliente,15 and 16	Italy	11.20	45.70	ME	RS	Epigravettian	14043

Asprochaliko Rockshelter, 10	Greece	20.98	39.25	ME	RS	Gravettian	22915
Boila Rockshelter, II	Greece	20.80	39.98	ME	RS	Epigravettian	14410
Boila Rockshelter, IIIa	Greece	39.98	20.80	ME	RS	Epigravettian	13343
Druška peć	Croatia	13.90	45.10	ME	RS	Epigravettian	18010
Franchthi Cave, II	Greece	23.35	37.45	ME	RS	Gravettian	22780
Franchthi Cave, IV	Greece	23.35	37.45	ME	RS	Epigravettian	12885
Franchthi Cave, V	Greece	23.35	37.45	ME	RS	Epigravettian	11280
Franchthi Cave, VI	Greece	23.35	37.45	ME	RS	Epigravettian	10488
Kastritsa Rockshelter, 15	Greece	20.91	39.62	ME	RS	Gravettian	21280
Kastritsa Rockshelter, 2	Greece	20.91	39.62	ME	RS	Epigravettian	14080
Kastritsa Rockshelter, 20	Greece	20.91	39.62	ME	RS	Gravettian	22135
Kastritsa Rockshelter, 21	Greece	20.91	39.62	ME	RS	Gravettian	22335
Klithi Rockshelter, 1	Greece	20.41	39.58	ME	RS	Epigravettian	17580
Klithi Rockshelter, 10	Greece	20.41	39.58	ME	RS	Epigravettian	14560
Klithi Rockshelter, 4	Greece	20.41	39.58	ME	RS	Epigravettian	16925
Klithi Rockshelter, 5	Greece	20.41	39.58	ME	RS	Epigravettian	16780
Klithi Rockshelter, 6	Greece	20.41	39.58	ME	RS	Epigravettian	16565
Klithi Rockshelter, 7	Greece	20.42	39.58	ME	RS	Epigravettian	14800
Klithi Rockshelter, 8	Greece	20.41	39.58	ME	RS	Epigravettian	12670
Klithi Rockshelter, 9	Greece	20.41	39.58	ME	RS	Epigravettian	14570
Klithi Rockshelter, core 2	Greece	20.41	39.58	ME	RS	Epigravettian	16265
Klithi Rockshelter, core 3	Greece	20.41	39.58	ME	RS	Epigravettian	16615
Megalakkos Rockshelter, Unit 2	Greece	20.41	39.59	ME	RS	Epigravettian	16100
Megalakkos Rockshelter, Unit 4	Greece	20.41	39.59	ME	RS	Epigravettian	16735
Ovča Jama, lower 4	Slovenia	14.35	45.75	ME	RS	Gravettian	20695
Šandalja II, B	Croatia	13.82	44.86	ME	RS	Epigravettian	11815
Šandalja II, C	Croatia	13.82	44.86	ME	RS	Gravettian	18288
Šandalja II, E	Croatia	13.82	44.86	ME	RS	Gravettian	24430
Šandalja II, F	Croatia	13.82	44.86	ME	RS	Gravettian	25393
Šandalja II, G	Croatia	13.82	44.86	ME	RS	Aurignacian	29113
Šandalja II, H	Croatia	13.82	44.86	ME	RS	Gravettian	18600
Savudrija, layers a-h 7m	Slovenia	13.73	45.33	ME	OA	Epigravettian	11235
Županov Spodmol, level 2; AB/D	Slovenia	14.36	45.71	ME	RS	Epigravettian	14145
Bockstein-Torle, level VI	Germany	10.06	48.56	A	OA	Gravettian	23058
Hohlenstein bei Ederheim	Germany	10.35	48.50	A	RS	Magdalenian	12770
Hohlenstein-Kleine Scheuer, level III	Austria	10.35	48.50	A	RS	Magdalenian	13860

APPENDIX C

Index Of Radiocarbon And Accelerator Mass Spectrometry Laboratories

Radiocarbon Laboratory Facilities mentioned in this Research

Conventional 14C Counting Facilities

VRI Vienna Radium Institute, Austria

Z Rušer Boökoviê Institute, Croatia
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WWW: http://www.irb.hr/zef/c14-lab/

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Ta Prof. Volli Kalm and Dr. Arvi Liiva
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ISGS Chao-li Liu and Hong Wang
Isotope Geochemistry Section
Illinois State Geological Survey, United States
Email: jliu@geoserv.isgs.uiuc.edu

GX Geochron Laboratories, United States

I Teledyne Brown Engineering Environmental Services, United States

P University of Pennsylvania, United States

14C ACCELERATOR FACILITIES (AMS)

[Lab code used in reporting sample dates is listed
to the left of the laboratory address]

GrA Dr. J. van der Plicht
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Email: plicht@phys.rug.nl

OxA R. E. M. Hedges / C. Bronk Ramsey
Oxford Radiocarbon Accelerator Unit
Research Laboratory for Archaeology and the History of Art
Oxford University, United Kingdom
WWW: http://www.rlaha.ox.ac.uk/

AA Dr. D. J. Donahue, Dr. P. E. Damon and Dr. A. J. T. Jull
NSF-Arizona AMS Facility, United States
Email: ams@physics.arizona.edu

CAMS Dr. John Knezovich
Center for Accelerator Mass Spectrometry
Lawrence Livermore National Laboratory, United States
Email: knezovich1@llnl.gov

^{14}C Laboratory Codes – Laboratory Name - Country
*** = laboratories that are no longer operating or have changed their code**

A Arizona, United States
AA NSF, United States
B Bern, Switzerland
Bln Berlin, Germany
CAMS Center for Accelerator Mass Spectrometry, United States
CU Department of Hydrogeology, Prague, Czech Rep.
Deb Debrecen, Hungary
Gd Gliwice, Poland
GIN Geological Institute, Russia
Gro* Groningen, The Netherlands
GrN Groningen, The Netherlands
GrA Groningen Accelerator, The Netherlands
GX Geochron Laboratories, United States
H (Hd) Heidelberg, Germany
Hv Hannover, Germany
I Teledyne Brown Engineering Environmental Services, United States
IGAN Institute of Geography, Russia
ISGS Illinois State USA Geological Survey, United States
KI Kiel, Germany
LE St. Petersburg, Russia
LOD Lodz, Poland
LU St. Petersburg State University, Russia
Lv Louvain-la-Neuve, Belgium
Ly University of Lyon, France
Mo* Verdanski Inst. of Geochemistry, Moscow, Russia
OX* USDA Oxford, Mississippi, United States
OxA Oxford Radiocarbon Accelerator Unit, United Kingdom
P University of Pennsylvania, United States
QC* Queens College, United States
R Rome, Italy
SOAN Institute of Geology and Geophysics, Russia
TA Tartu, Estonia
VRI Vienna Radium Institute, Austria
Z Zagreb, Croatia

APPENDIX D

Radiocarbon Dates as presented by Dolukhanov (1999, 7-23) to characterise archaeological sites/levels of the late Upper Palaeolithic in Eastern Europe

Nos	Sitename	Nci	Si	Xdeg	Xmin	Ydeg	Ymin	Mam	Reind	Ho	Rhino	Bis	Dwel	SP	AP	NAP	Fpl	Ter	WS	Lo	PS	Al	PF
1	*Kostenki 1/1	22458	762	51	22	39	2	10	1	1	0	0	1	1	20	80	0	1	0	1	0	0	1
46	Kostenki 2	23800	150	51	22	39	2	10	1	1	0	0	1	1	20	80	0	1	0	1	0	0	1
48	Kostenki 3	19800	210	51	22	39	2	10	1	1	0	0	1	1	20	80	0	1	0	1	0	0	1
50	Kostenki 4	23000	300	51	22	39	2	10	1	1	0	0	1	1	20	80	0	1	0	1	0	0	1
53	Kostenki 5	22920	140	51	22	39	2	10	1	1	0	0	1	1	20	80	0	1	0	1	0	0	1
54	Kostenki 8	22000	160	51	22	39	2	10	1	1	0	0	1	1	20	80	0	1	0	1	0	0	1
57	Kostenki 10	28250	300	51	22	39	2	10	1	1	0	0	1	1	20	80	0	1	0	1	0	0	1
63	Kostenki 11	19900	350	51	22	39	2	10	1	1	0	0	1	1	20	80	0	1	0	1	0	0	1
64	Kostenki 11/2	21800	200	51	22	39	2	10	1	1	0	0	1	1	20	80	0	1	0	1	0	0	1
68	Kostenki 11/3	20500	300	51	22	39	2	10	1	1	0	0	1	1	20	80	0	1	0	1	0	0	1
72	Kostenki 14	22780	250	51	22	39	2	10	1	1	0	0	1	1	20	80	0	1	0	1	0	0	1
80	Kostenki 19	18700	600	51	22	39	2	10	1	1	0	0	1	1	20	80	0	1	0	1	0	0	1
83	Kostenki 21/2	22900	150	51	22	39	2	10	1	1	0	0	1	1	20	80	0	1	0	1	0	0	1
76	Kostenki 18	21020	180	51	22	39	2	10	1	1	0	0	1	1	20	80	0	1	0	1	0	0	1
	*Kostenki 1/3	24886	450	51	22	39	2	1	1	10	1	1	1	1	60	40	0	1	0	0	1	0	1
114	Kostenki 8	23020	320	51	22	39	2	1	1	10	1	1	1	1	60	40	0	1	0	0	1	0	1
117	Kostenki 12/1	26300	300	51	22	39	2	1	1	10	1	1	1	1	60	40	0	1	0	0	1	0	1
128	Kostenki 12/1a	32700	700	51	22	39	2	1	1	10	1	1	1	1	60	40	0	1	0	0	1	0	1
135	Kostenki 14/ii	28580	420	51	22	39	2	1	1	10	1	1	1	1	60	40	0	1	0	0	1	0	1
139	Kostenki 14/iii	30080	590	51	22	39	2	1	1	10	1	1	1	1	60	40	0	1	0	0	1	0	1
141	Kostenki 15	25700	250	51	22	39	2	1	1	10	1	1	1	1	60	40	0	1	0	0	1	0	1
145	Kostenki 16	28200	500	51	22	39	2	1	1	10	1	1	1	1	60	40	0	1	0	0	1	0	1
155	Kostenki 1/5	37900	2800	51	23	39	2	1	1	10	1	1	1	1	80	20	0	1	0	0	1	0	1
157	Kostenki 6	31200	500	51	22	39	2	1	1	10	1	1	1	1	80	20	0	1	0	0	1	0	1
159	Kostenki 12/iii	36280	360	51	22	39	2	1	1	10	1	1	1	1	80	20	0	1	0	0	1	0	1
161	Kostenki 14/iv	27710	410	51	22	39	2	1	1	10	1	1	1	1	80	20	0	1	0	0	1	0	1
164	Kostenki 14/iva	33280	660	51	22	39	2	1	1	10	1	1	1	1	80	20	0	1	0	0	1	0	1
167	Kostenki 17	36780	1700	51	22	39	2	1	1	10	1	1	1	1	80	20	0	1	0	0	1	0	1
168	Gagarino	21800	300	52	42	38	54	10	1	0	1	1	1	1	nd	nd	0	1	0	1	1	0	0
	*Avdeevo	20990	900	51	44	36	3	10	1	10	1	1	1	1	20	80	1	0	0	0	0	1	1
198	Peny 1	21600	350	51	2	35	50	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
222	Yudinovo	14870	150	52	40	33	14	10	0	1	0	1	1	1	nd	nd	0	0	1	0	1	0	nd
230	Yeliseevichi	15600	1350	53	13	33	44	10	1	1	0	0	1	1	40	60	0	0	1	0	1	0	1
236	Suponevo	13920	140	53	11	34	23	nd	nd	nd	nd	nd	1	1	nd	nd	nd	nd	nd	nd	nd	nd	nd
241	Timonovka 1	14530	120	53	11	34	22	10	1	0	0	0	1	1	20	80	0	0	0	1	0	0	1

UPPER PALAEOLITHIC
East European Plain

245	Pushkari 1	20600	1300	52	11	33	17	10	1	5	0	0	1	1	nd	nd	1	0	0	1	0	0	1
247	Pogon	18690	770	52	11	33	17	1	0	0	0	0	0	0	nd	nd	nd	nd	nd	nd	nd	nd	nd
248	Novg.Sev.	19800	350	51	59	33	17	10	10	5	10	1	1	1	nd	nd	0	1	0	1	0	0	0
249	Chulatovo	14700	250	51	51	33	7	10	1	1	1	1	0	0	nd	nd	0	1	0	1	0	0	0
255	Khotylevo 2	23300	300	53	12	34	19	10	1	0	1	1	1	1	10	90	0	1	0	1	0	0	0
260	Berdyzh	15100	250	52	50	30	58	10	1	1	1	1	1	1	nd	nd	0	1	0	0	1	0	0
263	Yurevichi	26470	420	51	57	29	33	10	0	1	0	0	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
265	Sevsk	13950	70	52	9	34	27	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	*Mezhirichi	14131	500	49	43	31	25	10	1	1	0	1	1	1	10	90	1	0	0	1	0	0	1
280	Dobranichevka	12700	200	50	10	31	44	10	1	1	0	1	1	1	10	90	1	0	0	1	0	0	0
283	Mezin	27500	800	51	42	33	9	10	10	10	1	1	1	1	nd	nd	0	1	0	1	0	0	0
293	Kirillovskaya	14350	190	49	59	33	0	10	10	0	0	1	0	0	nd	nd	0	1	0	1	0	0	0
294	Radomyshl	19200	250	50	22	30	32	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
298	Korolevo 1a	19000	300	50	32	29	14	10	1	1	0	1	1	1	nd	nd	0	1	0	1	0	0	nd
299	Korolevo II	25700	400	48	8	23	4	nd	nd	nd	nd	nd	nd	nd	nd	nd	0	1	0	1	0	0	0
289	Goncy	38500	1000	48	8	23	4	nd	nd	nd	nd	nd	nd	nd	nd	nd	0	1	0	1	0	0	0
329	Amvrosievka	18700	220	47	30	38	0	0	0	0	0	10	0	0	nd	nd	0	1	0	1	0	0	0
333	Muralovka	19630	200	47	16	38	40	0	1	0	0	10	0	0	nd	nd	0	1	0	1	0	0	0
340	Anetovka	18040	150	47	38	31	6	0	1	0	0	10	0	0	nd	nd	0	1	0	1	0	0	0
345	Sagaidak	20300	200	47	41	32	21	0	1	0	0	10	0	0	nd	nd	0	1	0	1	0	0	0
351	Molodova 5-II	11900	230	·48	31	26	10	0	10	1	0	1	1	0	nd	nd	0	1	0	0	0	1	0
352	Molodova 5-III	13370	540	48	31	26	10	1	10	1	0	1	0	0	nd	nd	0	1	0	1	0	0	0
353	Molodova 5-IV	17100	1400	48	31	26	10	5	10	5	0	1	0	0	nd	nd	0	1	0	1	0	0	0
355	Molodova 5-VI	16750	250	48	31	26	10	5	10	5	1	1	1	0	nd	nd	0	1	0	1	0	0	0
360	Molodova 5-IX	29650	1320	48	31	26	10	1	1	1	1	1	1	0	nd	nd	0	1	0	1	0	0	0
368	Korman 4-V	18000	400	48	34	27	14	1	5	10	0	10	0	0	nd	nd	0	1	0	1	0	0	0
370	Korman 4-VII	24500	500	48	34	27	14	0	0	10	0	10	0	0	nd	nd	0	1	0	1	0	0	0
378	Kosauci II	17230	140	48	13	28	17	0	10	1	0	5	0	0	nd	nd	0	1	0	1	0	0	0
381	Kosoucy 1/2b	18200	500	48	13	28	17	1	10	5	0	0	0	0	nd	nd	0	1	0	1	0	0	0
390	Kosoucy 3/4	17100	250	48	13	28	17	1	10	5	0	0	0	0	nd	nd	0	1	0	1	0	0	0
392	Kosoucy 4	17950	100	48	13	28	17	0	10	5	0	0	0	0	nd	nd	0	1	0	1	0	0	0
395	Kosoucy 5/6	19200	130	48	13	28	17	0	10	1	0	0	0	0	nd	nd	0	1	0	1	0	0	0
398	Kosoucy 9	19400	100	48	13	28	17	0	10	1	0	0	0	0	nd	nd	0	1	0	1	0	0	0
408	Brynzeni	26600	370	48	6	27	7	1	1	5	0	1	1	1	nd	nd	RS	@	@	@	@	@	@
426	Sungir'	25500	200	56	10	40	29	10	1	1	0	1	1	1	20	80	0	1	0	0	0	1	1
443	Zaraisk	22300	300	54	45	38	52	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

457	Kapovaya	13930	300	53	26	57	45	1	0	0	0	0	0	0	30	70	RS	@	@	@	@	@	@
455	Talicky	18700	200	58	16	57	27	1	1	1	1	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
465	Ignat'evskaya	14038	192	54	47	57	35	1	1	1	1	1	0	0	nd	nd	RS	@	@	@	@	@	@
499	Cave Bear	17960	200	62	2	59	16	1	1	1	1	1	0	0	nd	nd	RS	@	@	@	@	@	@
495	Byzovaya	25740	500	65	1	57	24	1	1	1	1	1	0	0	nd	nd	RS	@	@	@	@	@	@

LEGEND

Mam - Mammoth;
Reind - Reindeer;
Ho - Horse;
Rhino - Rhinoceros;
Bis - Bison;
Dwel - Dwellings;
SP - Storage pits;
AP - arboreal pollen;
NAP - non-arboreal pollen;
Fpl - floodplain;
Ter - terrace;

WS - watershed;
Lo - loess;
PS - palaeosoil;
Al - alluvium;
PS - palaeosoil;
PF - permafrost features;
RS - rockshelter;
10 - predominant;
5 - many;
1 - present;
0 - absent;
nd - no data

APPENDIX E

Grass Gis Modules Used In Chapter Five

r.in.bin Enables the input of binary data into regions with coordinates.

r.in.ascii Converts an ASCII raster text file into a (binary) raster map layer.

r.mapcalc Performs as a mathematical calculator for raster map layers. New raster map layers can be created which are arithmetic expressions involving existing raster map layers, integer or floating point constants, and functions. The command is usually expressed in the form of an equation.

r.mask Establishes or removes a working mask. This module allows the user to block out certain areas of a map from analysis, by "hiding" them from sight of other GRASS programs. While a mask exists, most GRASS programs will operate only on data falling inside the masked area, and ignore any data falling outside of the mask.

r.surf.idw Surface interpolation utility for raster map layers.

s.in.ascii Converts an ASCII listing of site locations and their descriptions into a GRASS site list file.

s.to.rast Creates a raster map from site list.

r.random Creates a raster map layer and site list file containing randomly located sites.

r.reclass Creates a new map layer whose category values are based upon the user's reclassification of categories in an existing raster map layer.

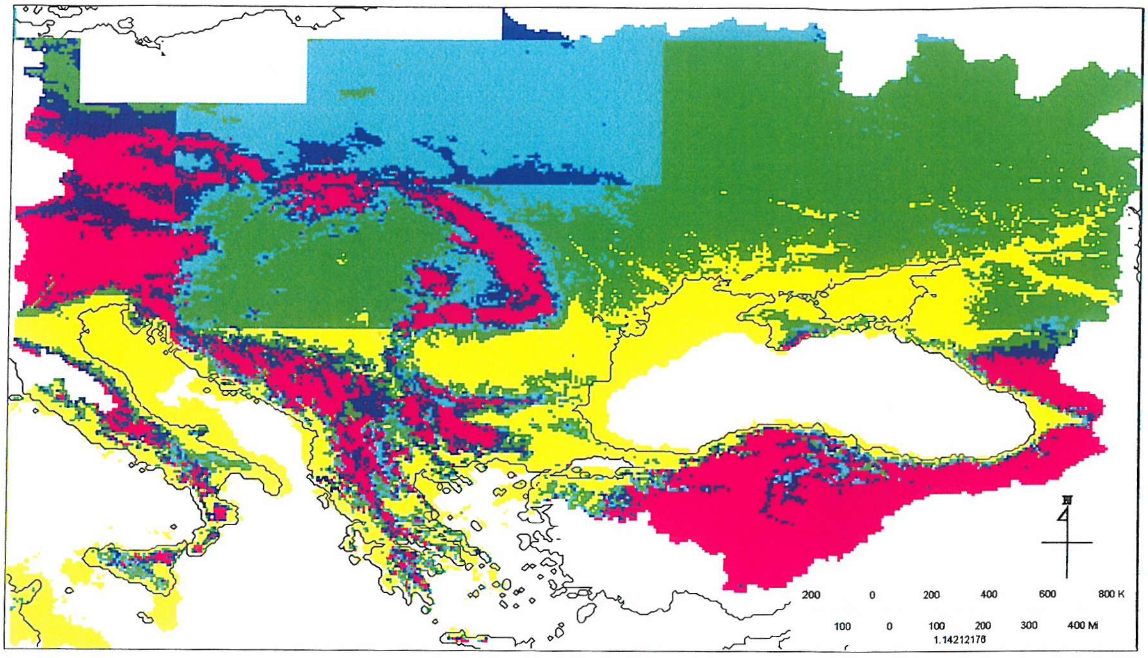
r.slope.aspect Generates raster map layers of slope and aspect from a raster map layer of true elevation values.

r.what Queries and outputs the category values and (optionally) the category labels associated with user-specified locations on raster input map(s).

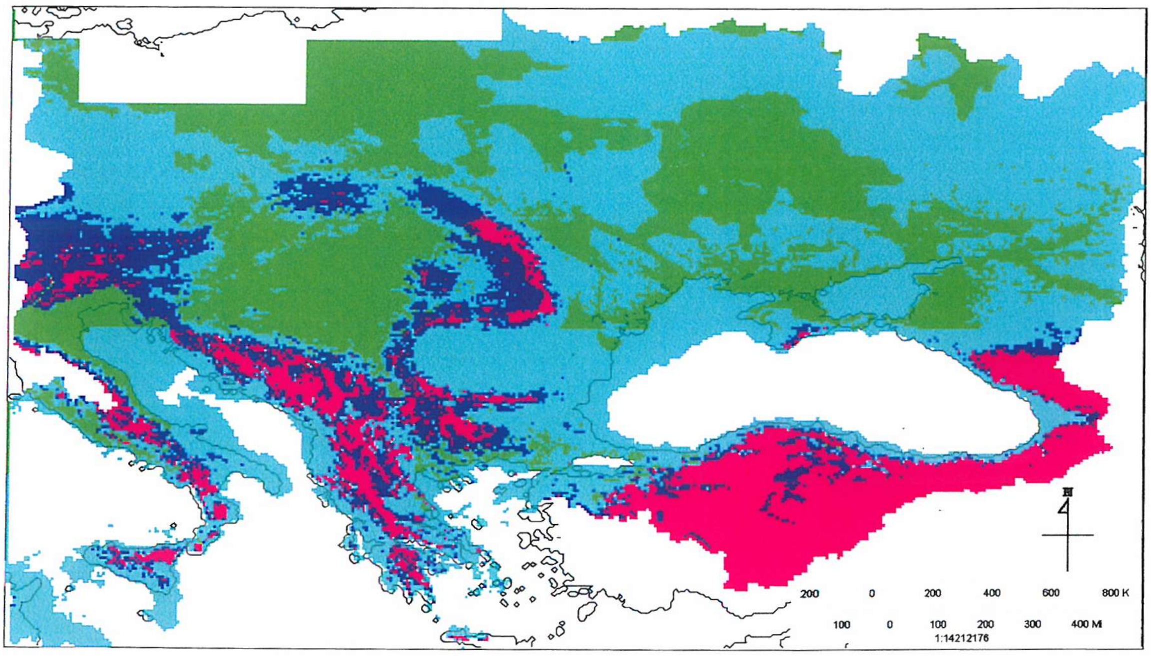
APPENDIX F

Predictive Cost Surface Maps For Each 500-Year Interval From 25000 Cal Bc To 11000 Cal Bc

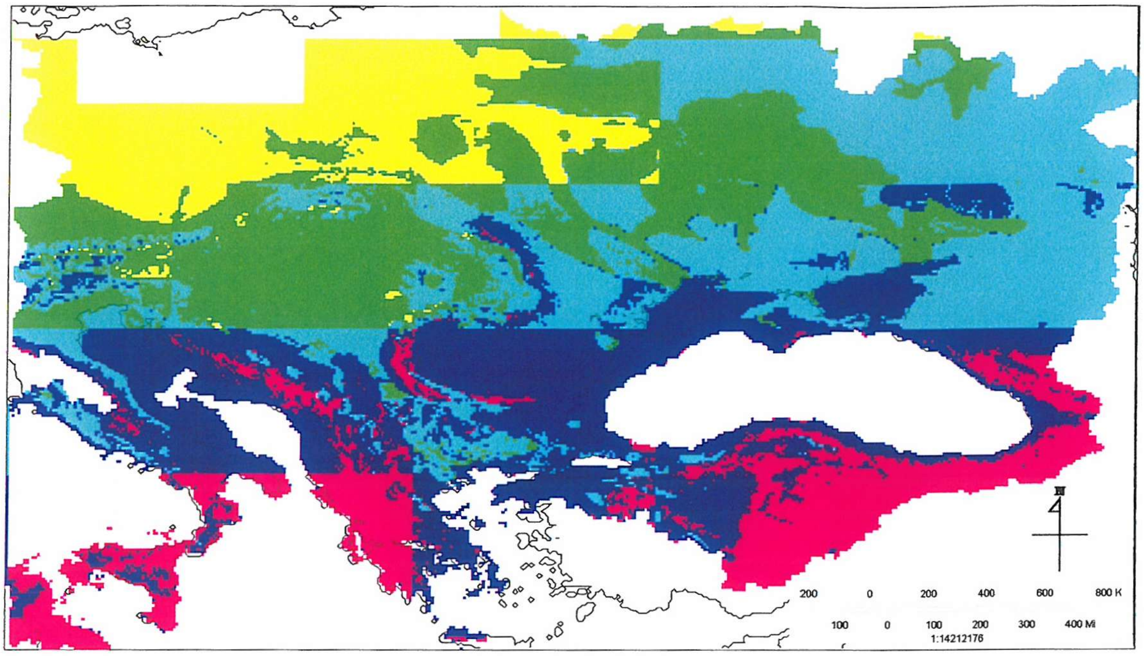
Yellow = very high probability for site location
Green = high probability for site location
Light Blue = average
Dark Blue = low probability for site location
Red = very low probability for site location



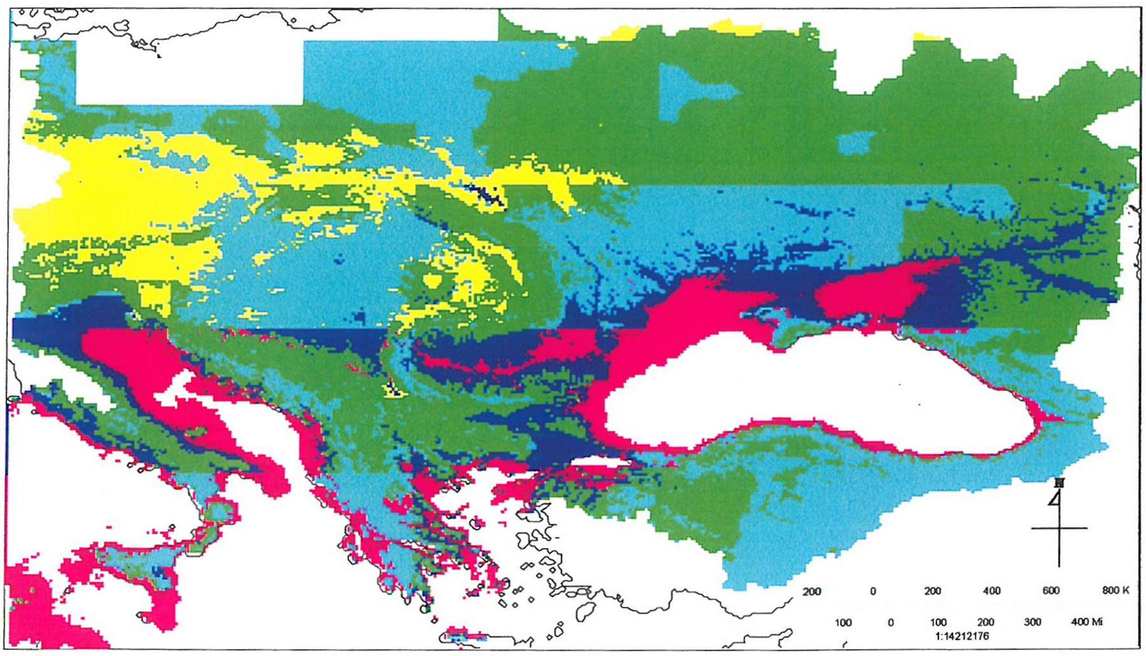
25000 cal BC



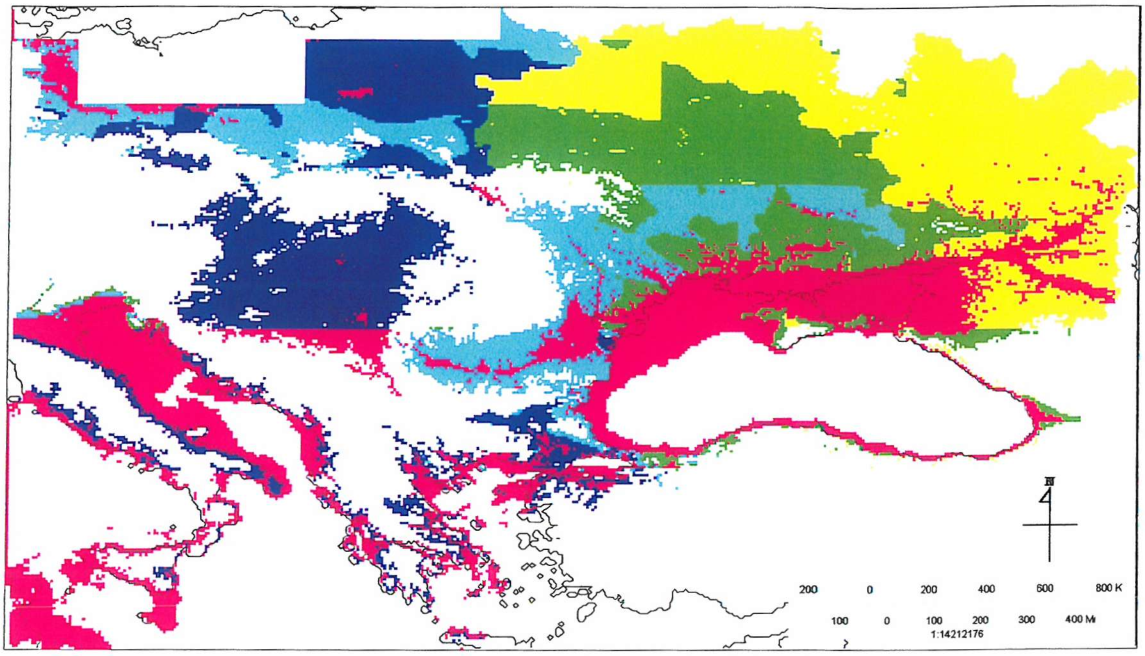
24500 cal BC



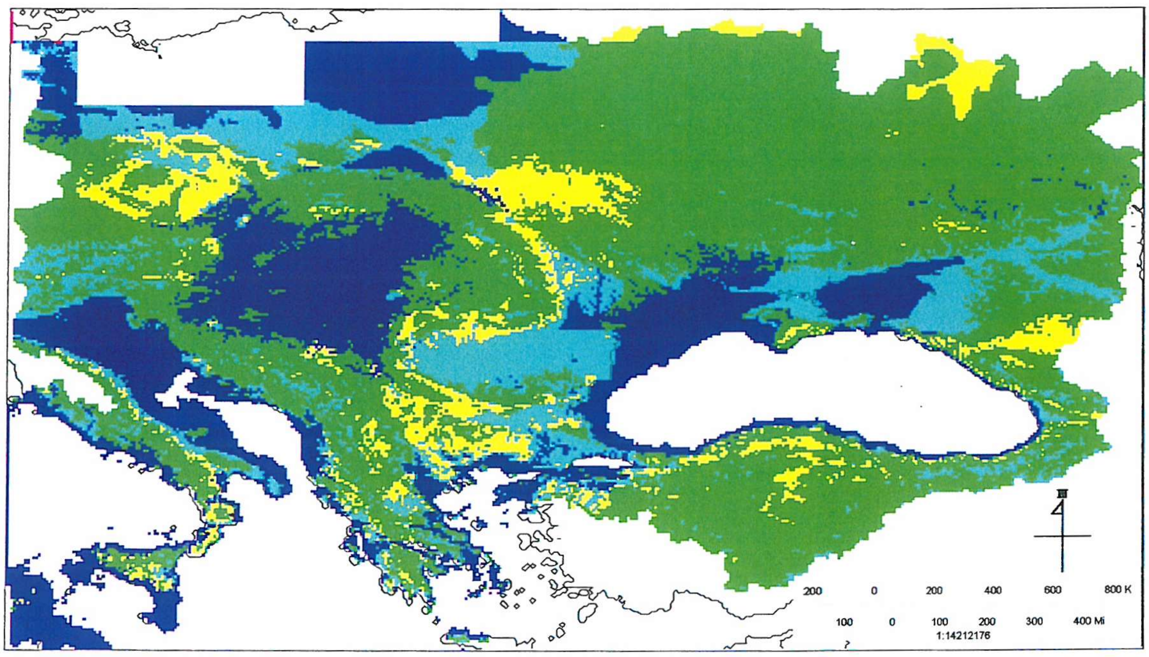
24000 cal BC



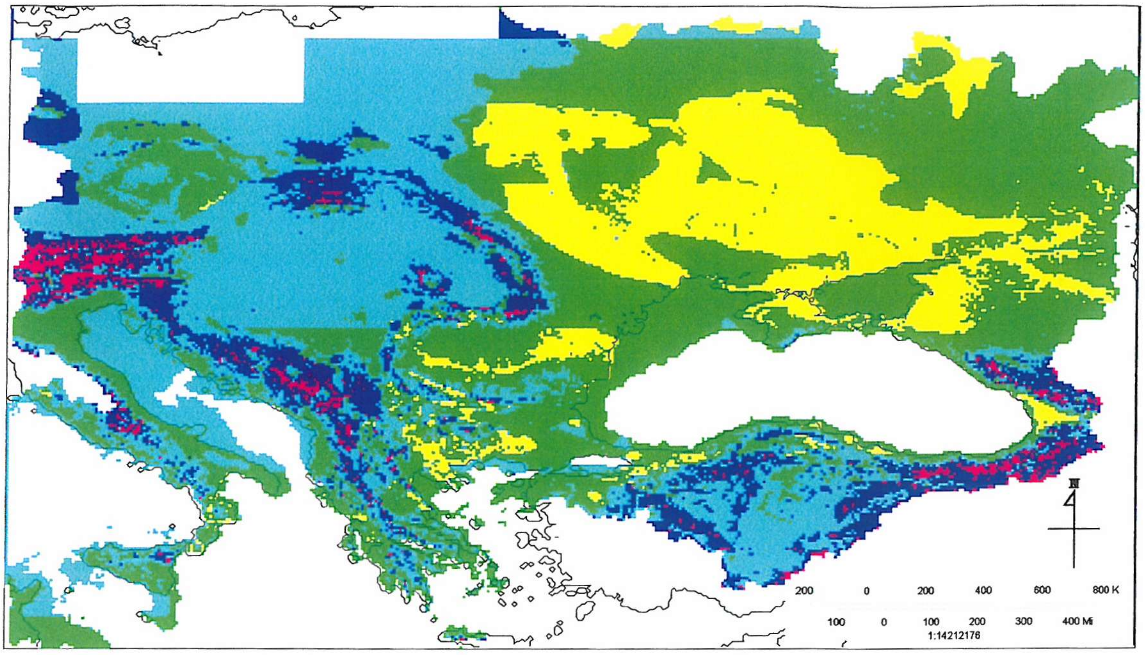
23500 cal BC



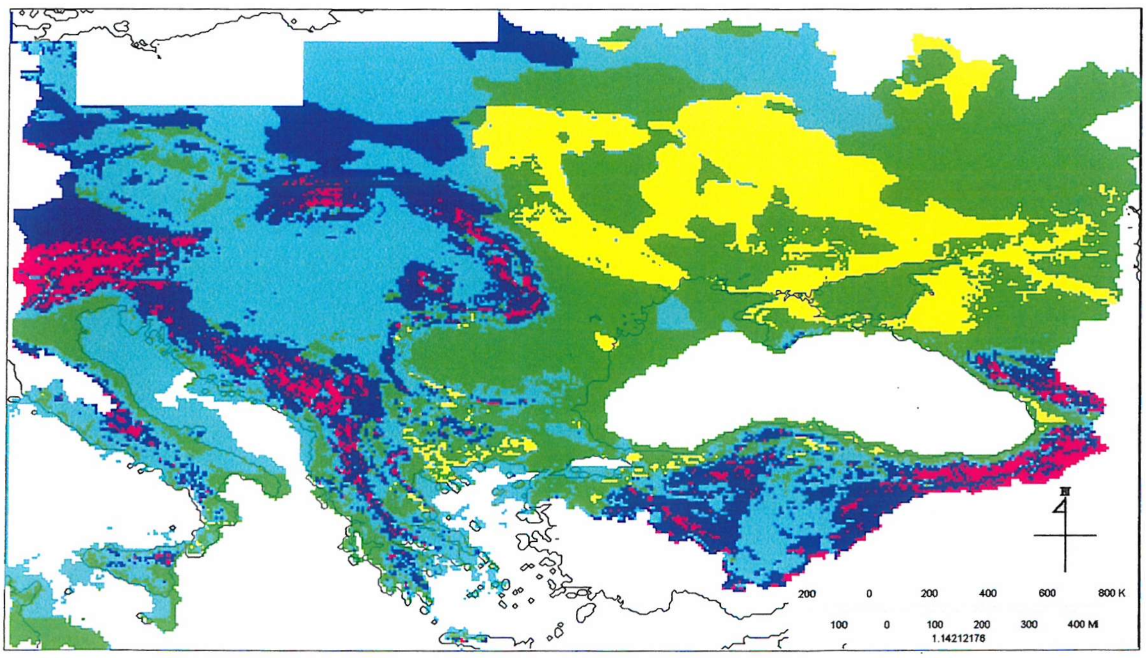
23000 cal BC



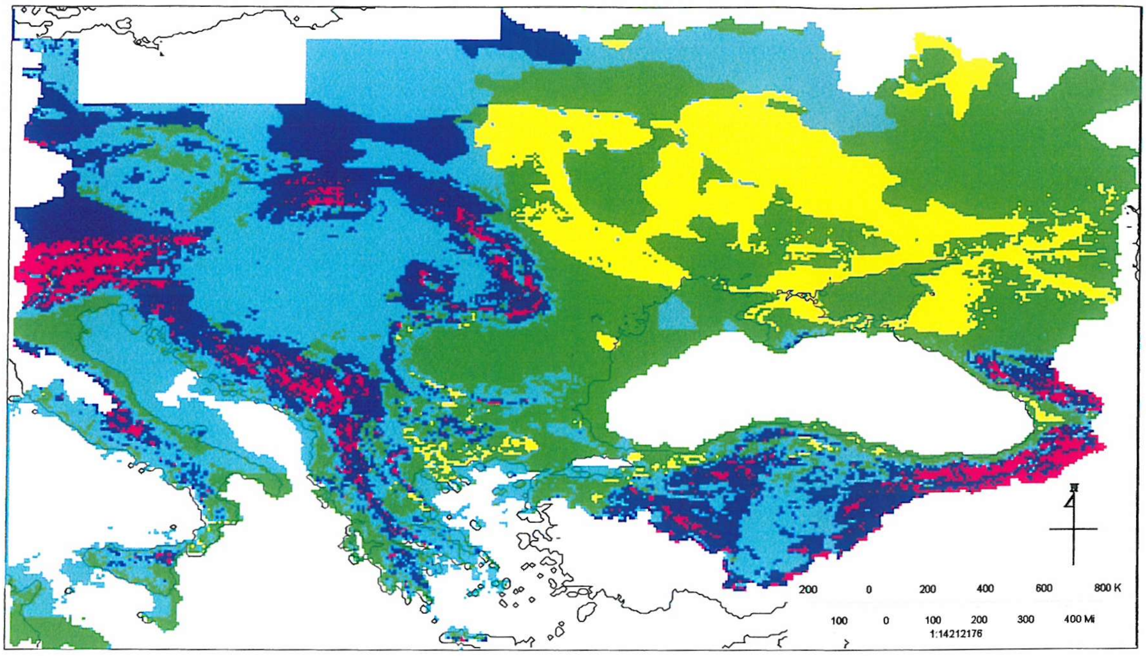
22500 cal BC



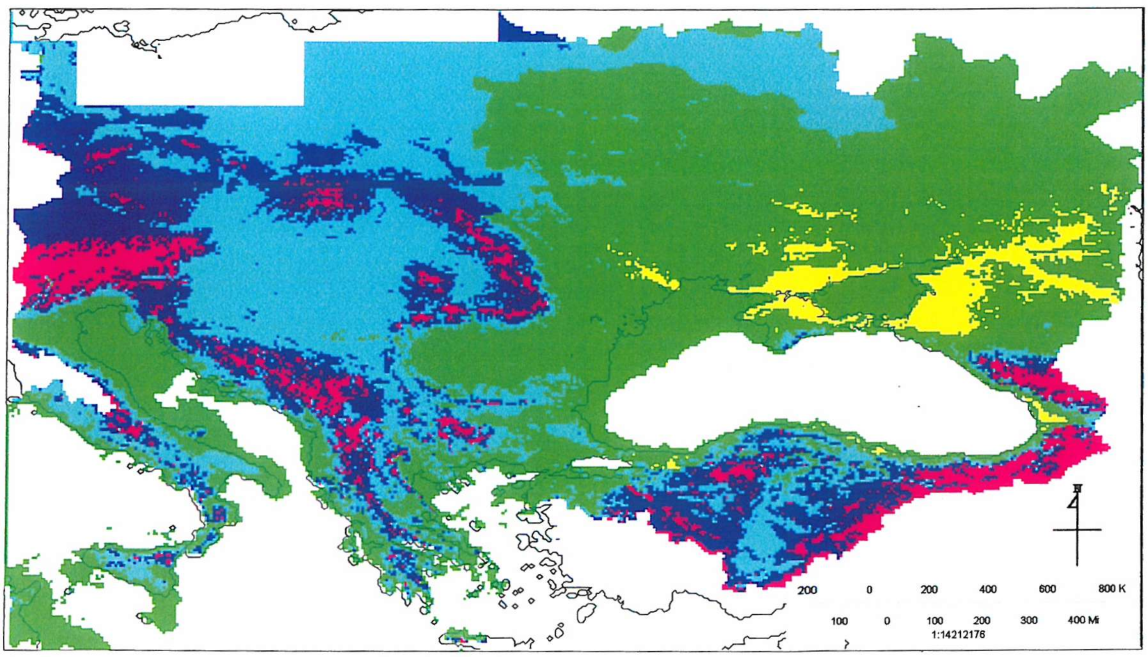
22000 cal BC



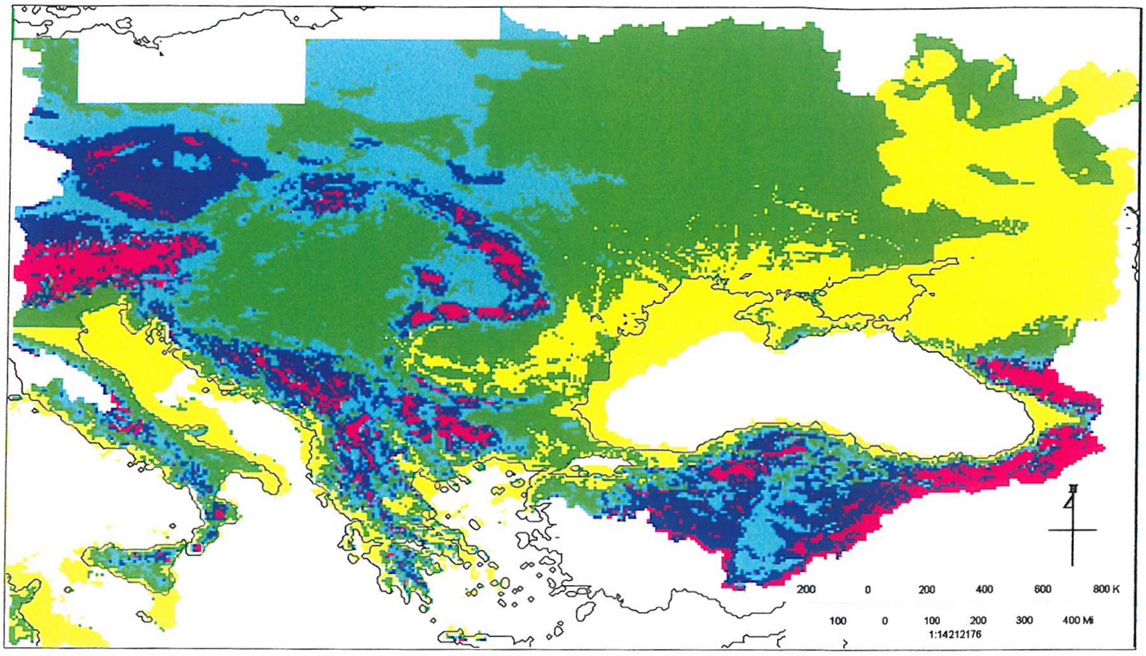
21500 cal BC



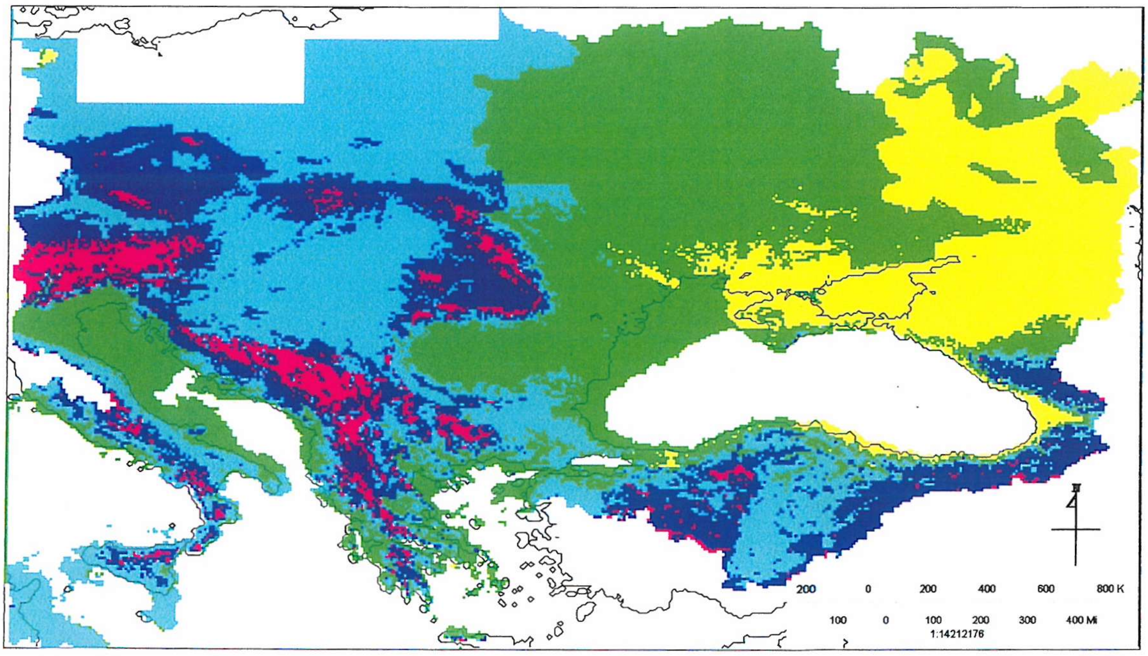
21000 cal BC



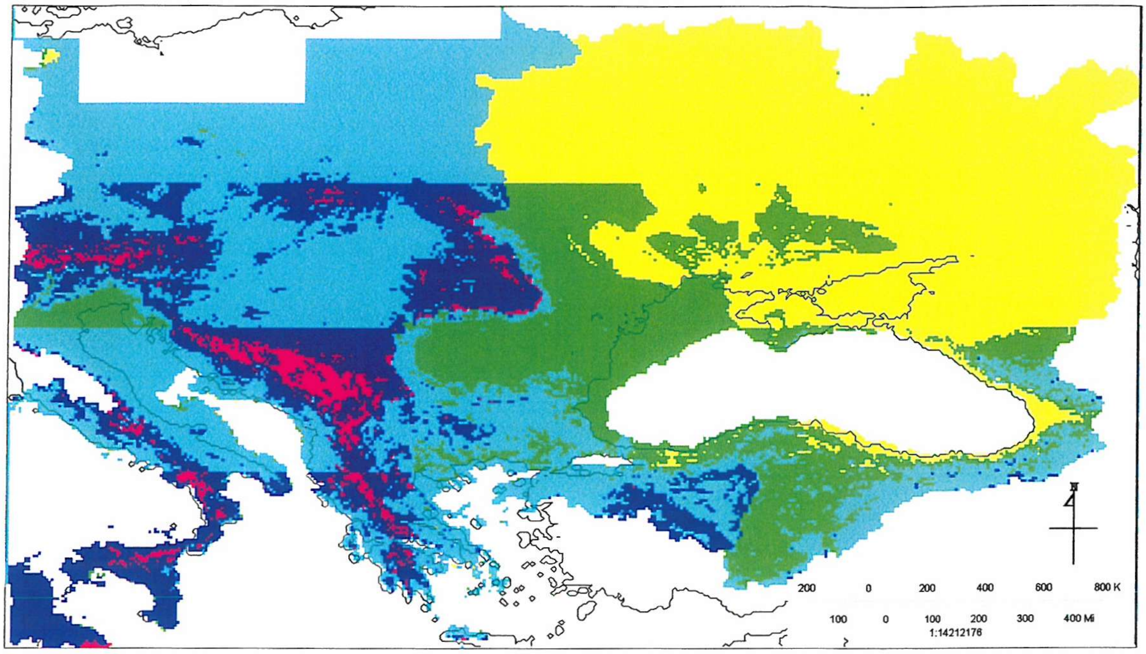
20500 cal BC



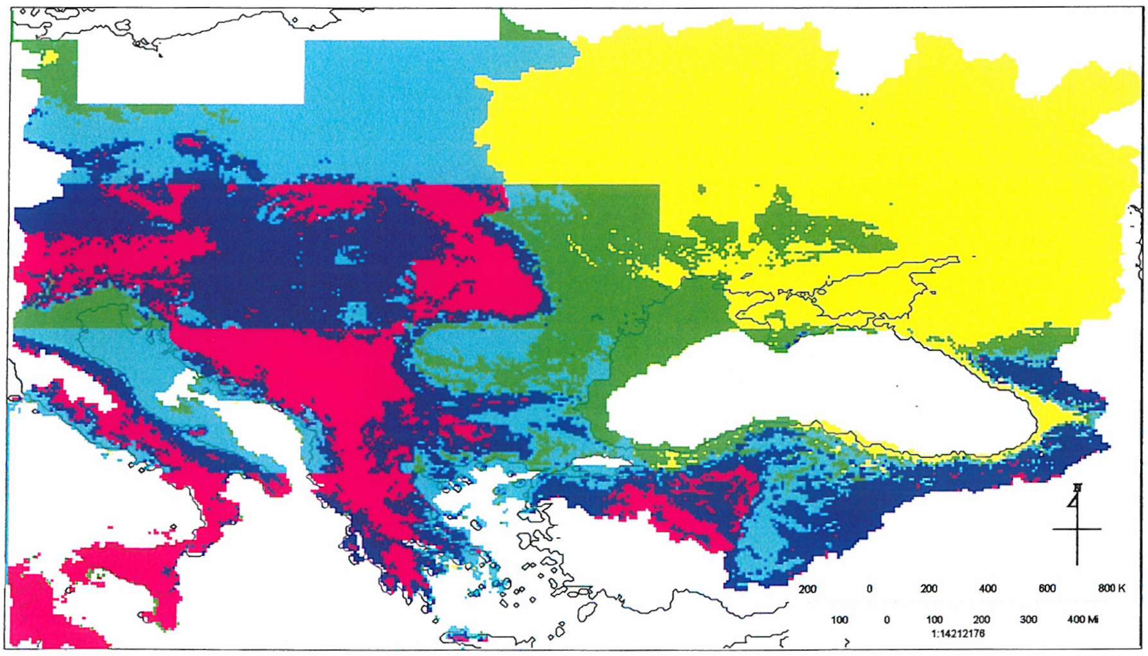
20000 cal BC



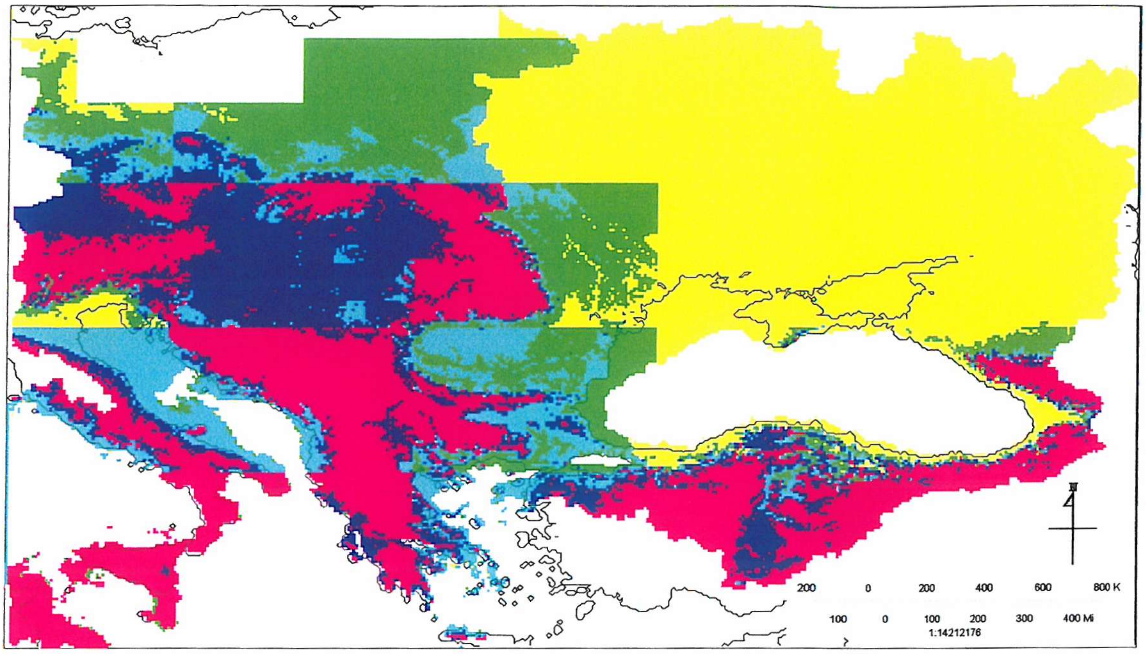
19500 cal BC



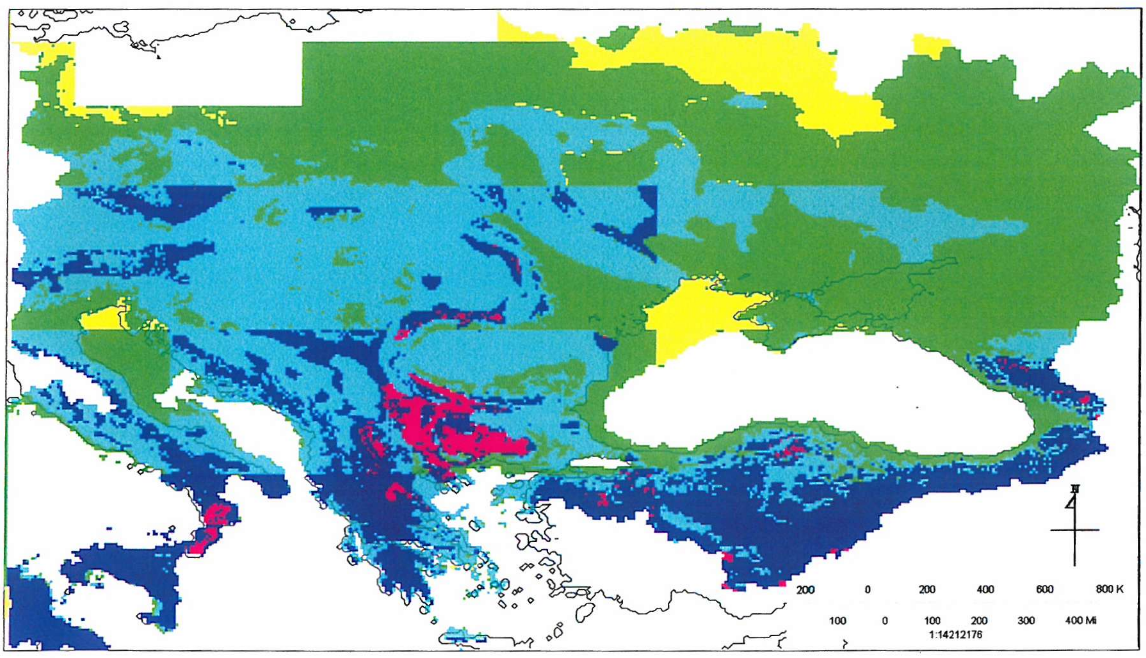
19000 cal BC



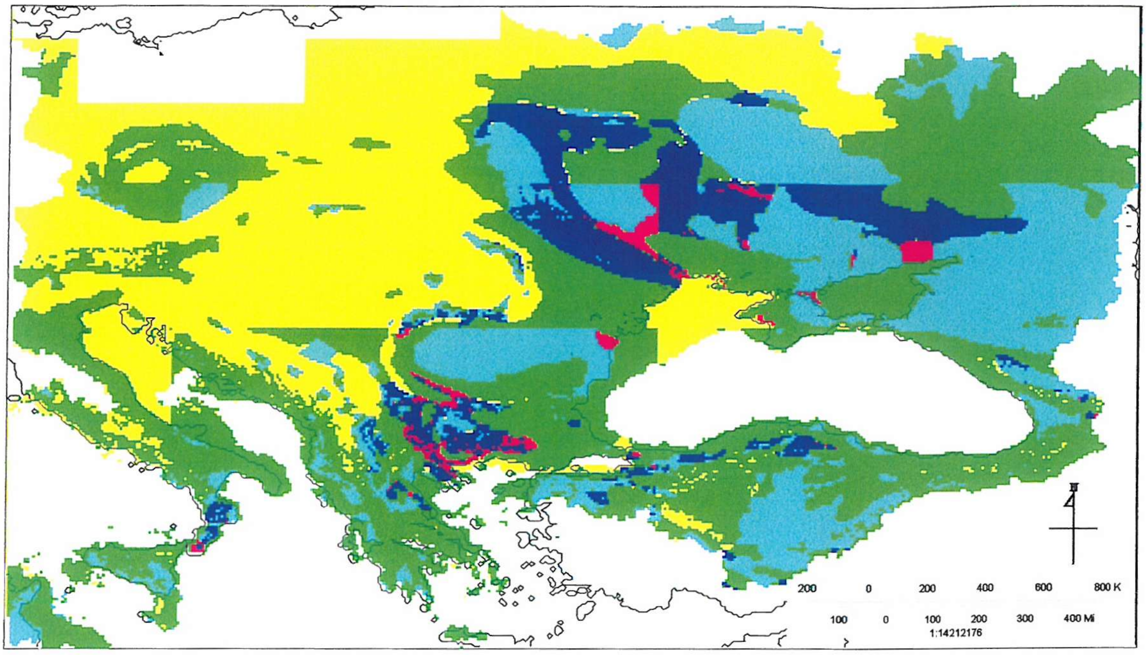
18500 cal BC



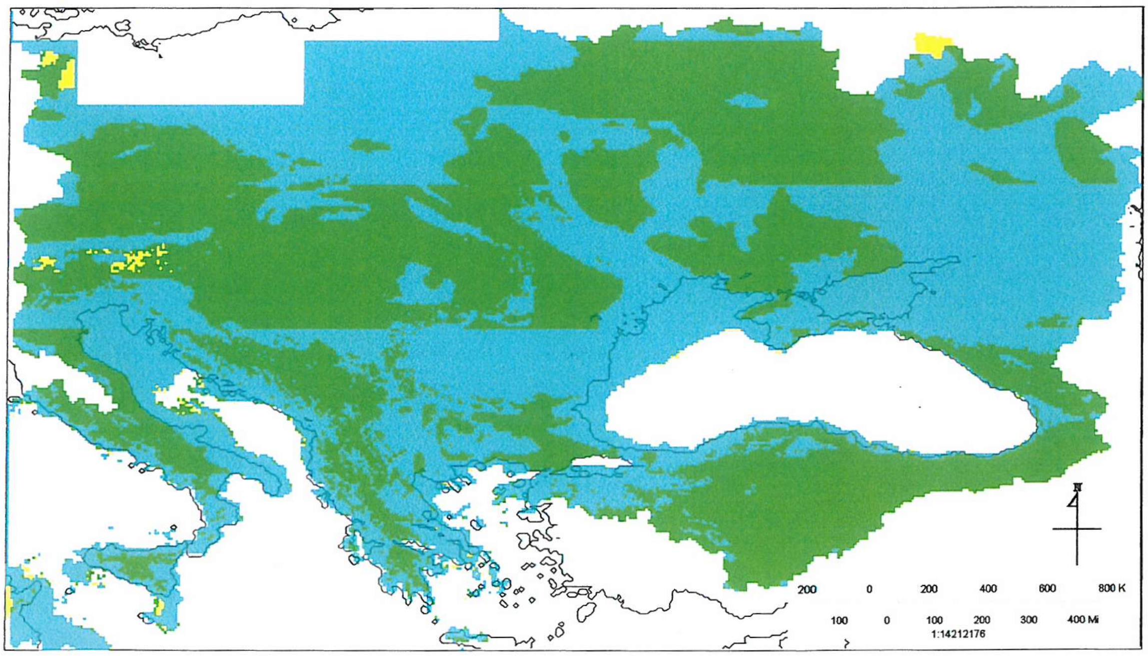
18000 cal BC



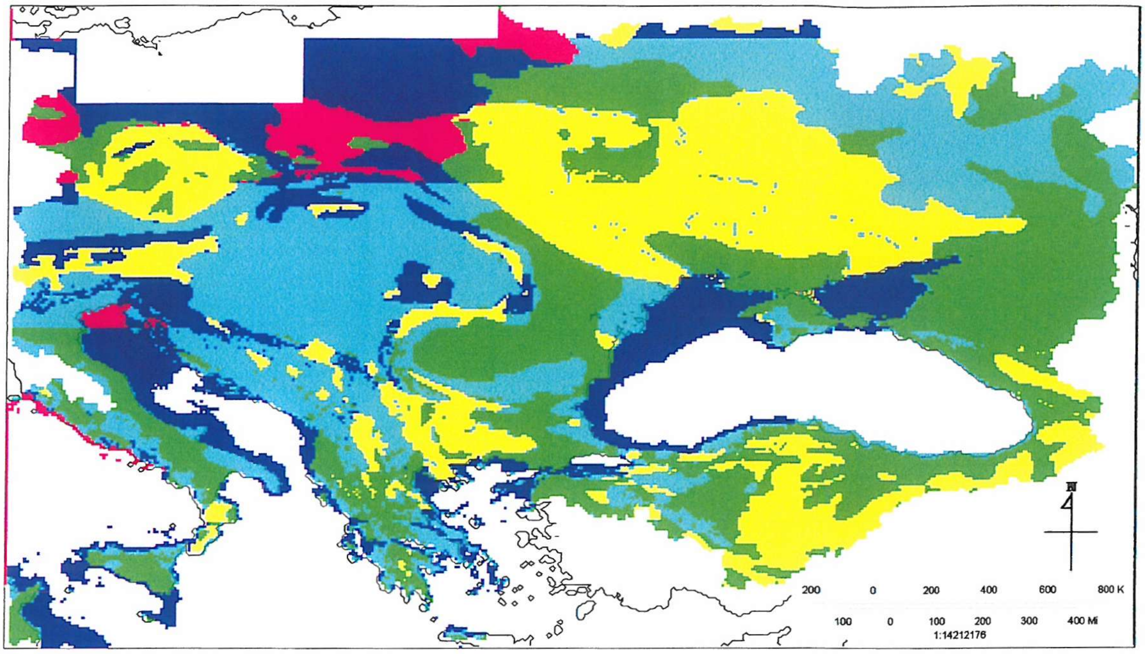
17500 cal BC



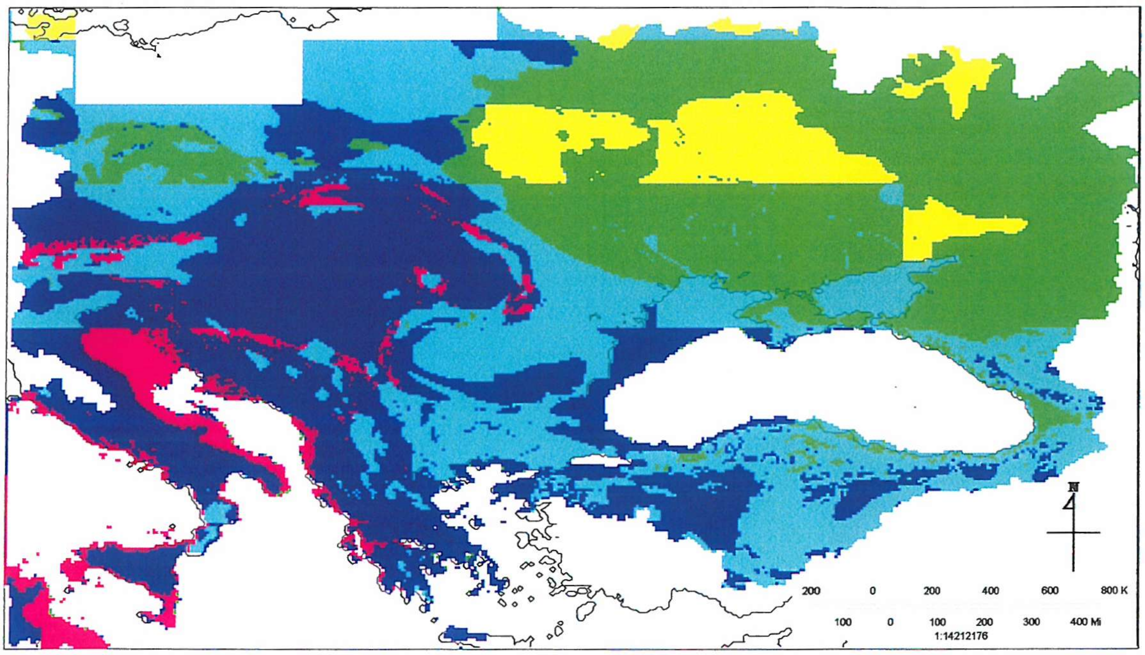
17000 cal BC



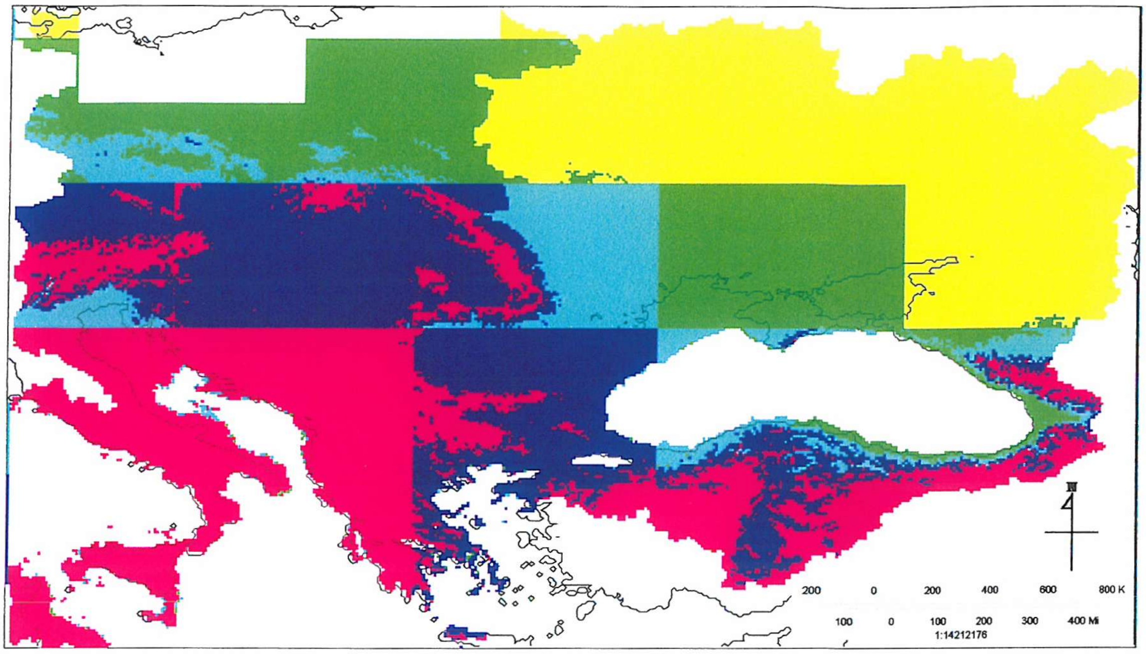
16500 cal BC



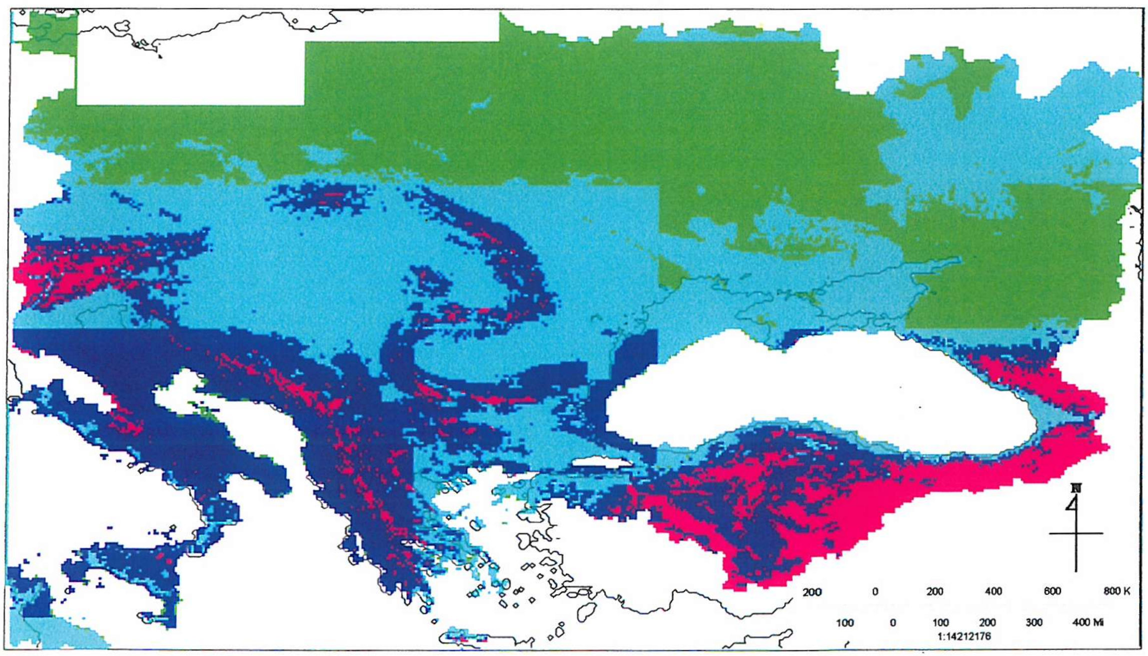
16000 cal BC



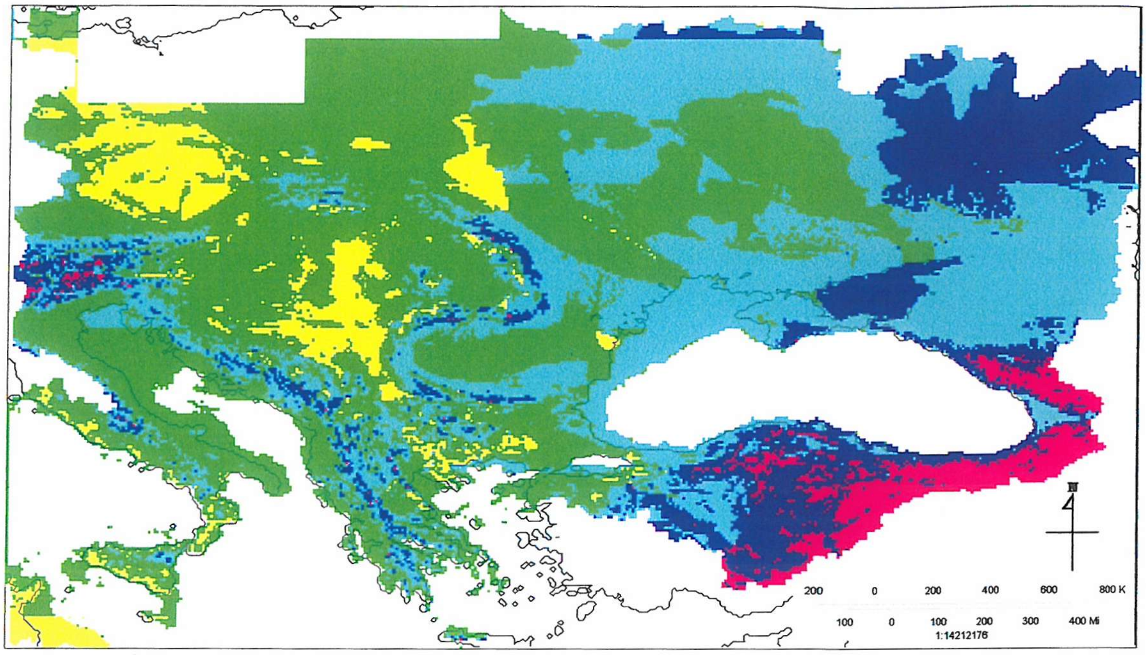
15500 cal BC



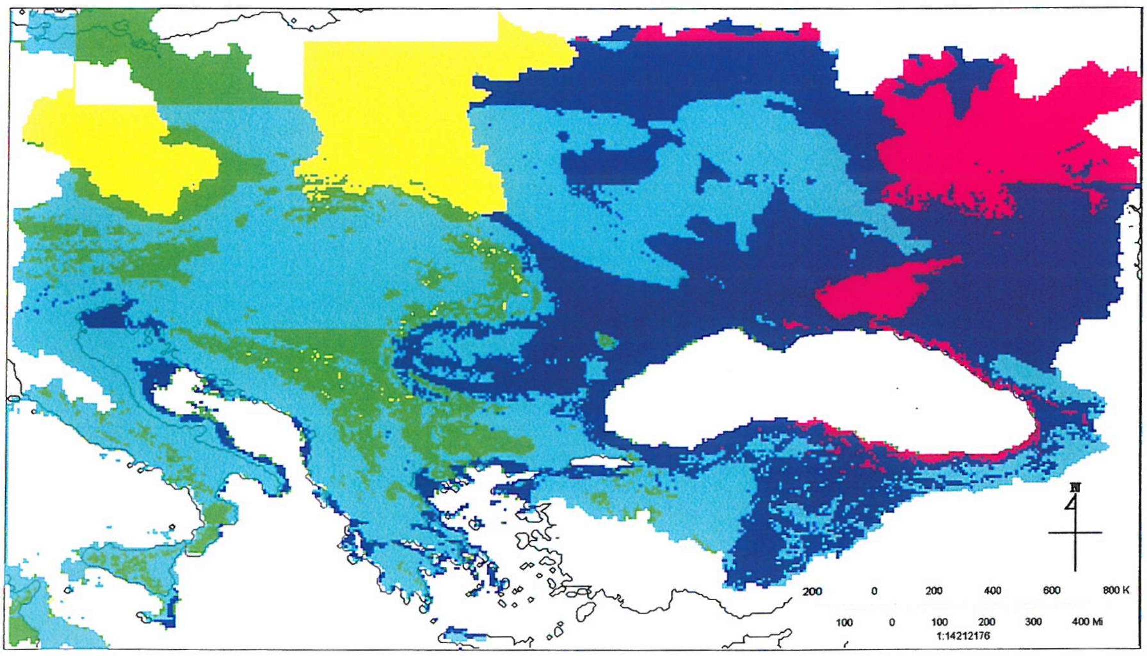
15000 cal BC



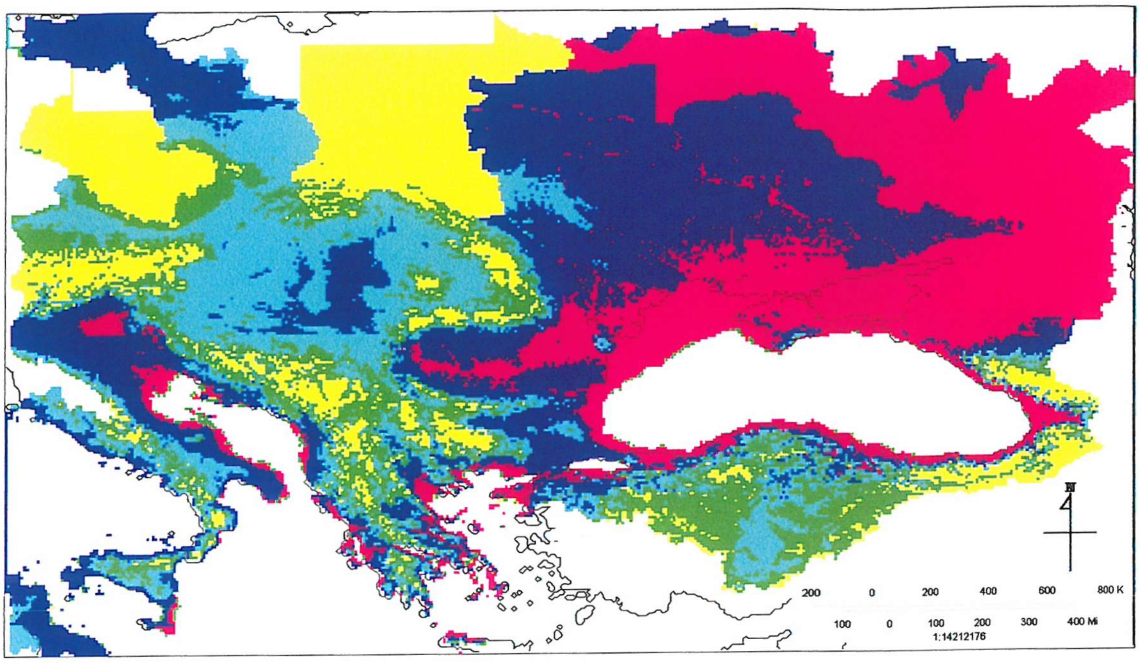
14500 cal BC



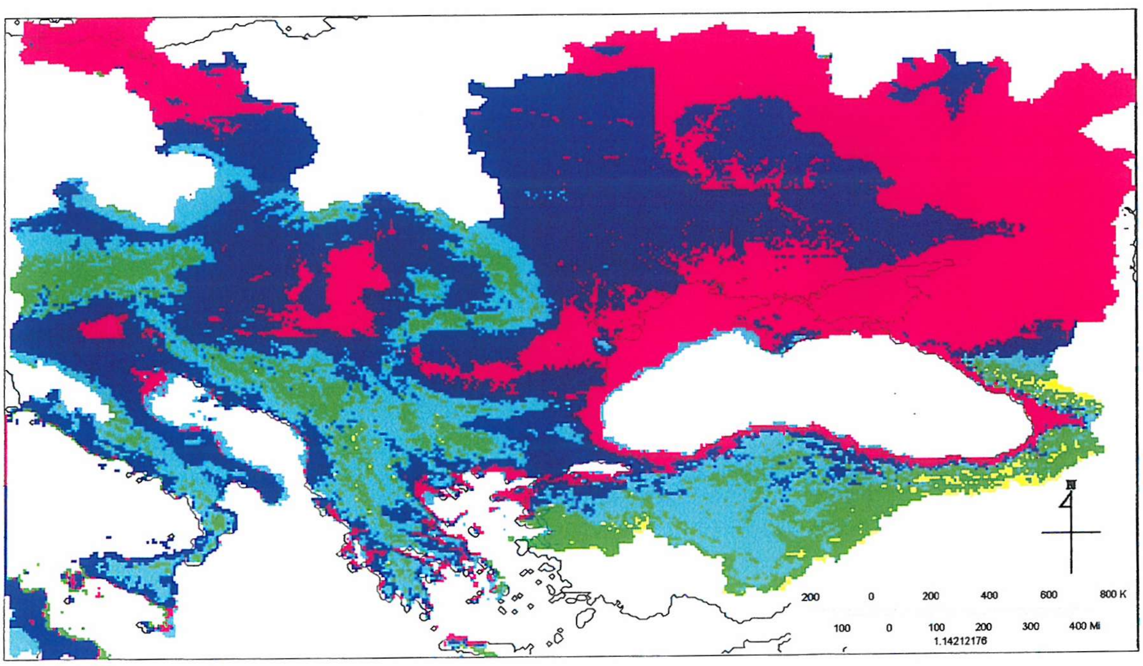
14000 cal BC



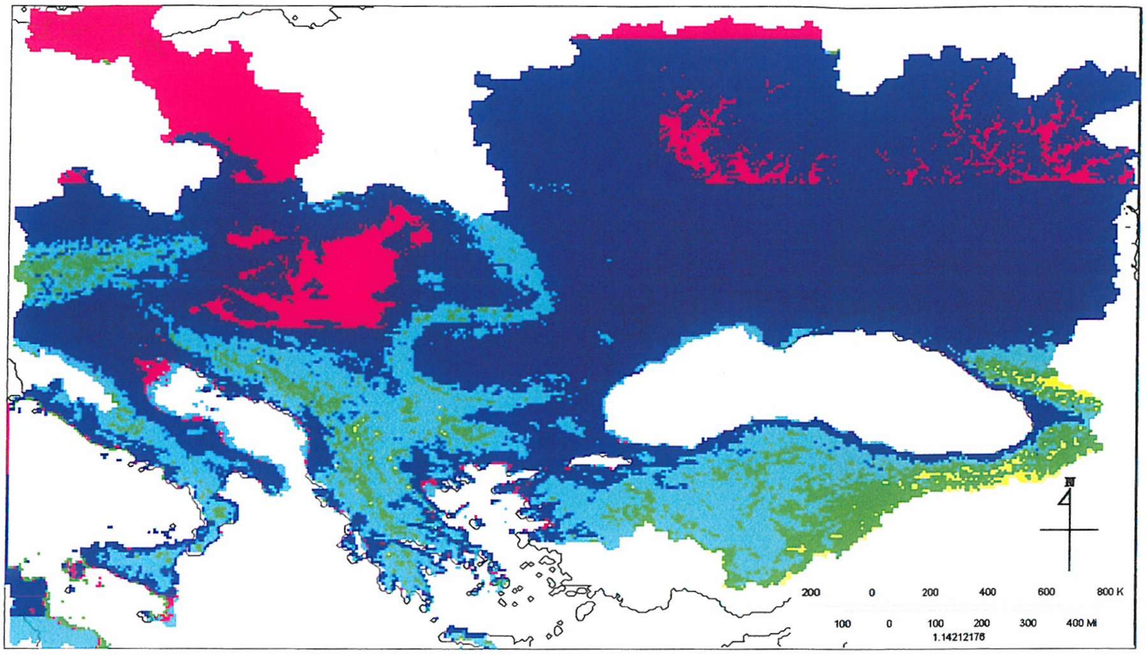
13500 cal BC



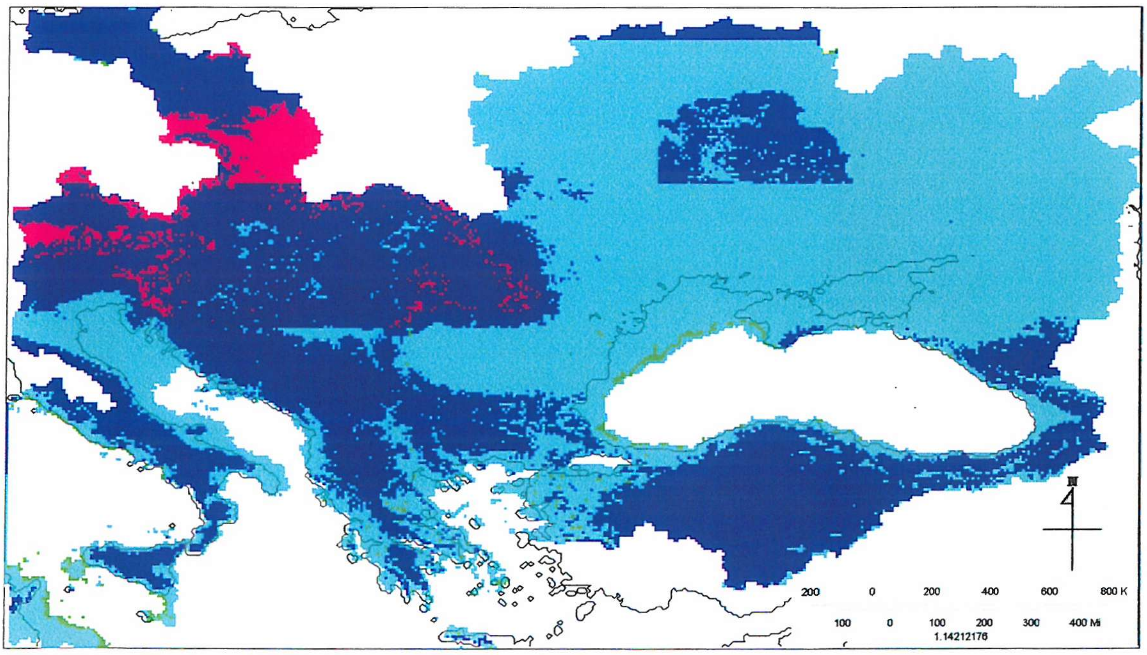
13000 cal BC



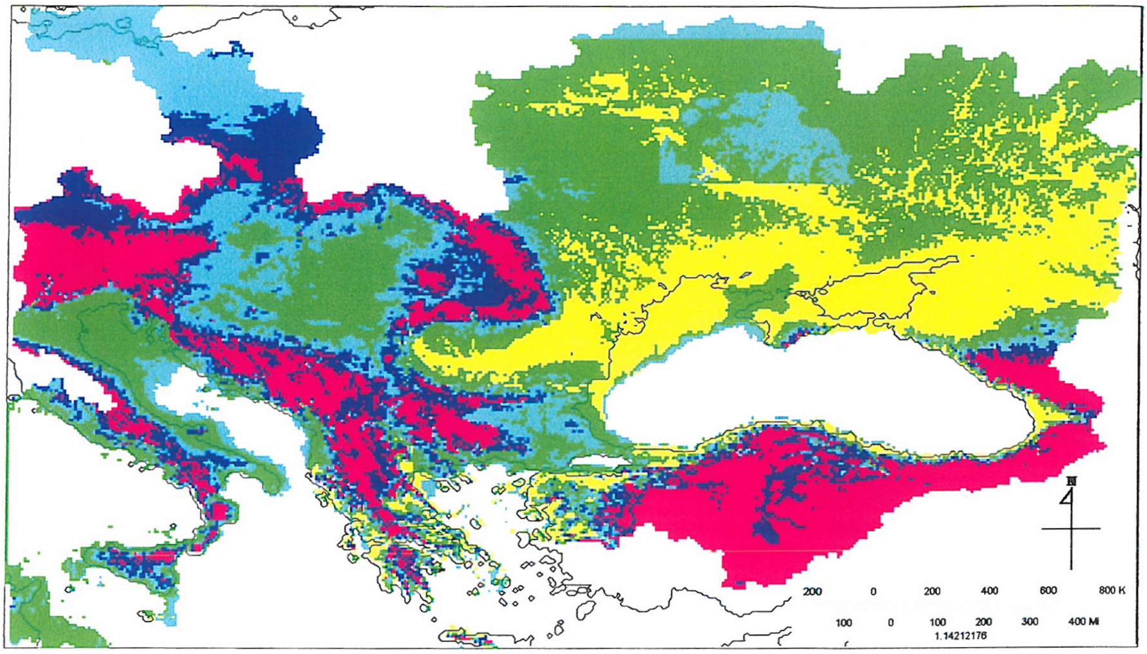
12500 cal BC



12000 cal BC



11500 cal BC

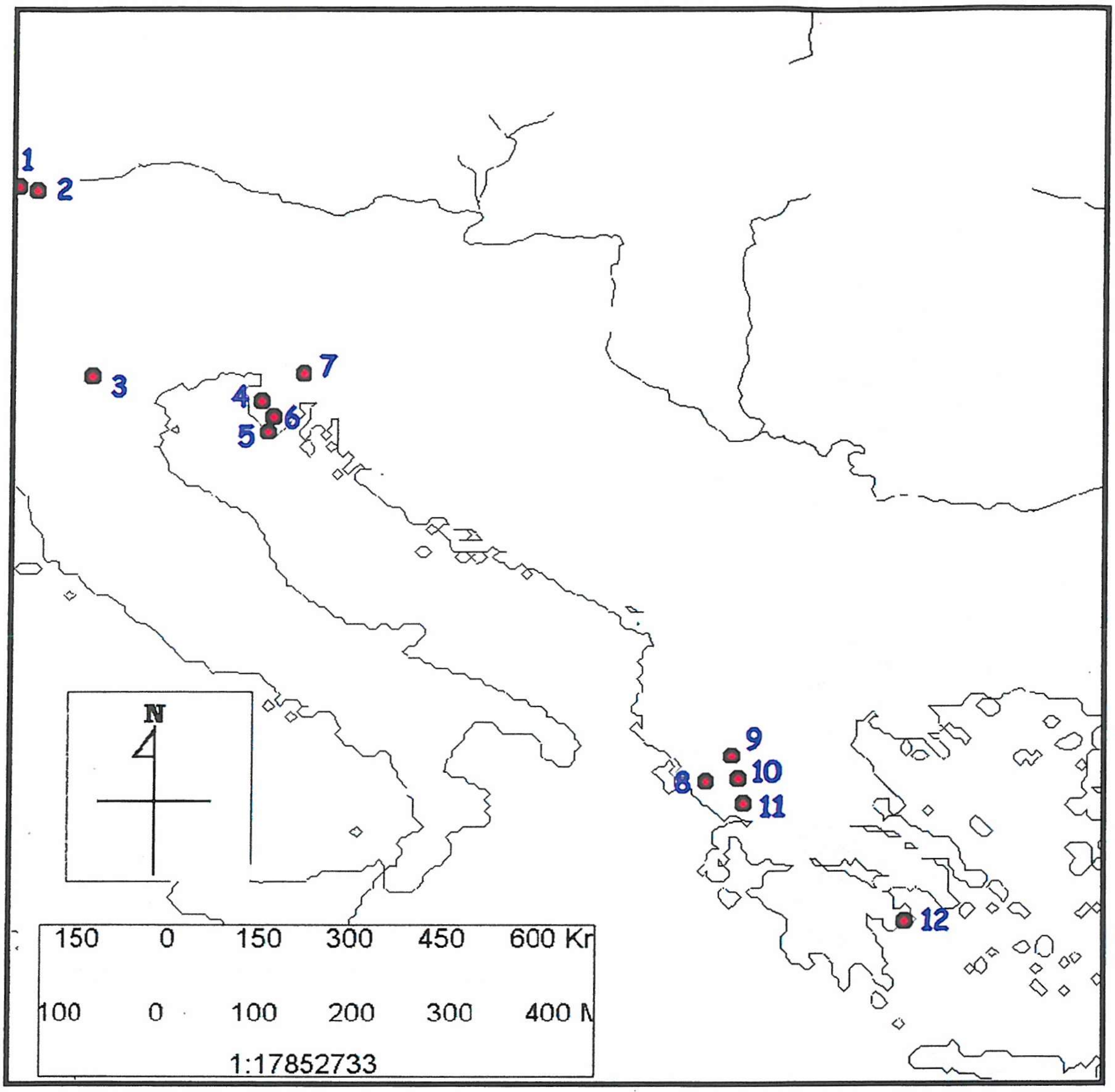


11000 cal BC

APPENDIX G

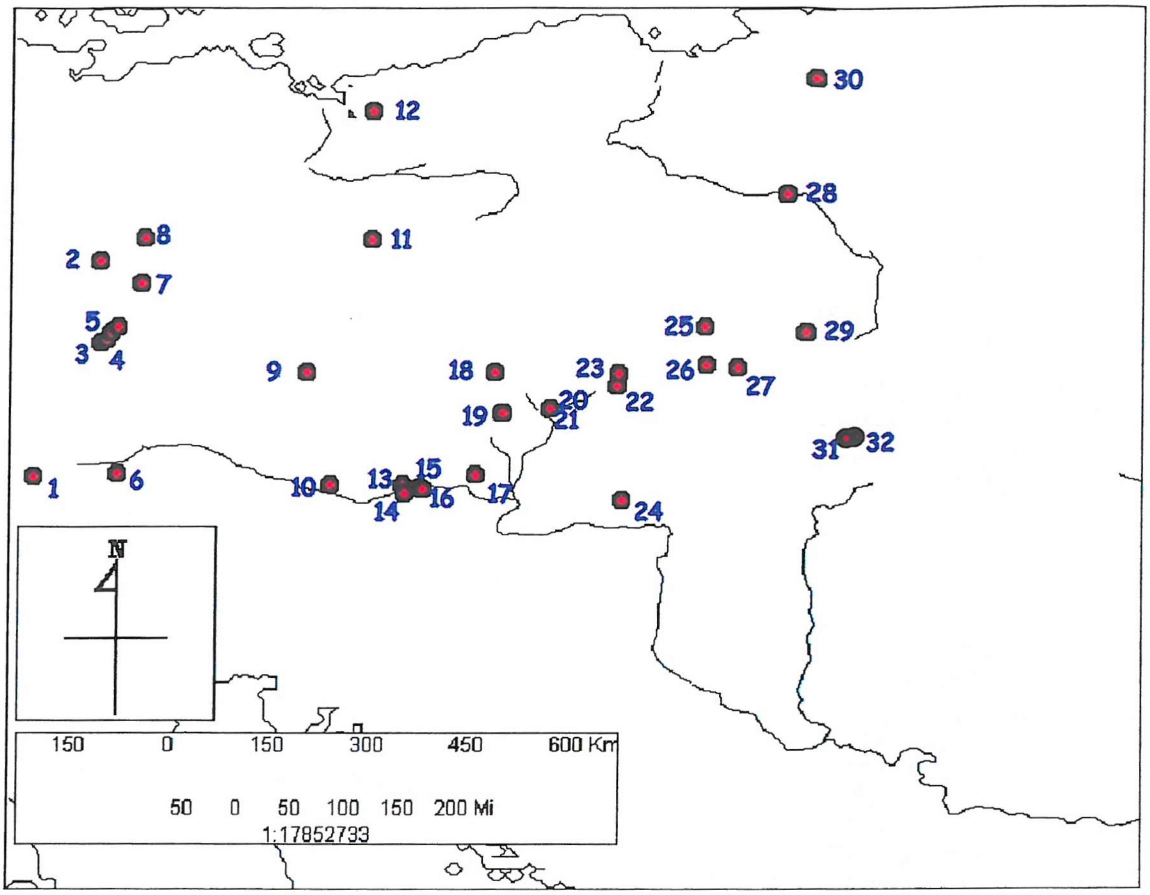
Site Location Maps

Alpine and Mediterranean Regions
North Central Region
North East Eastern Region
North East Western Region
South East Region



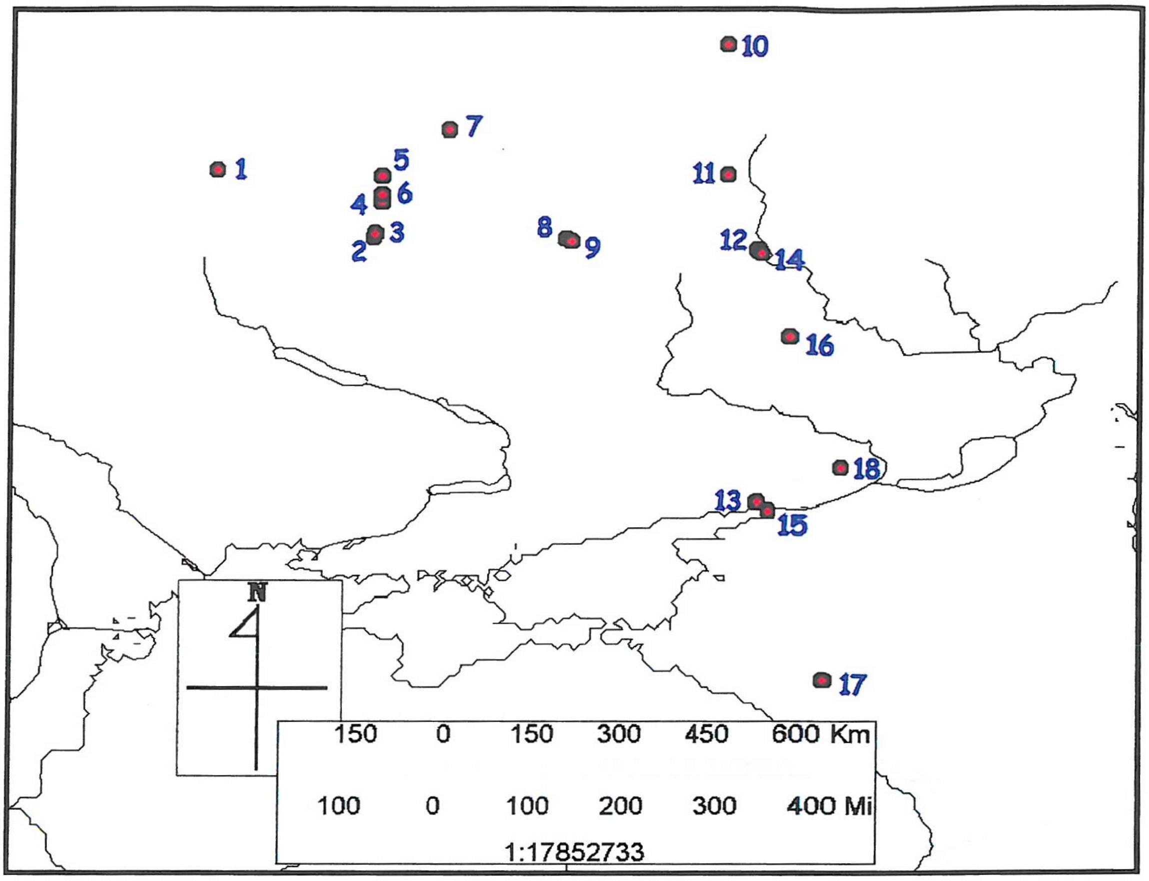
Sites located in the Alpine and Mediterranean Regions.

1	Bockstein-Torle
2	Hohlenstein
3	Abri Tagliente
4	Savudrija
5	Šandalja II
6	Druška peć
7	Ovča Jama, Županov Spodmol
8	Klithi Rockshelter, Megalakkos Rockshelter
9	Boila Rockshelter
10	Kastritsa Rockshelter
11	Asprochaliko Rockshelter
12	Franchthi Cave



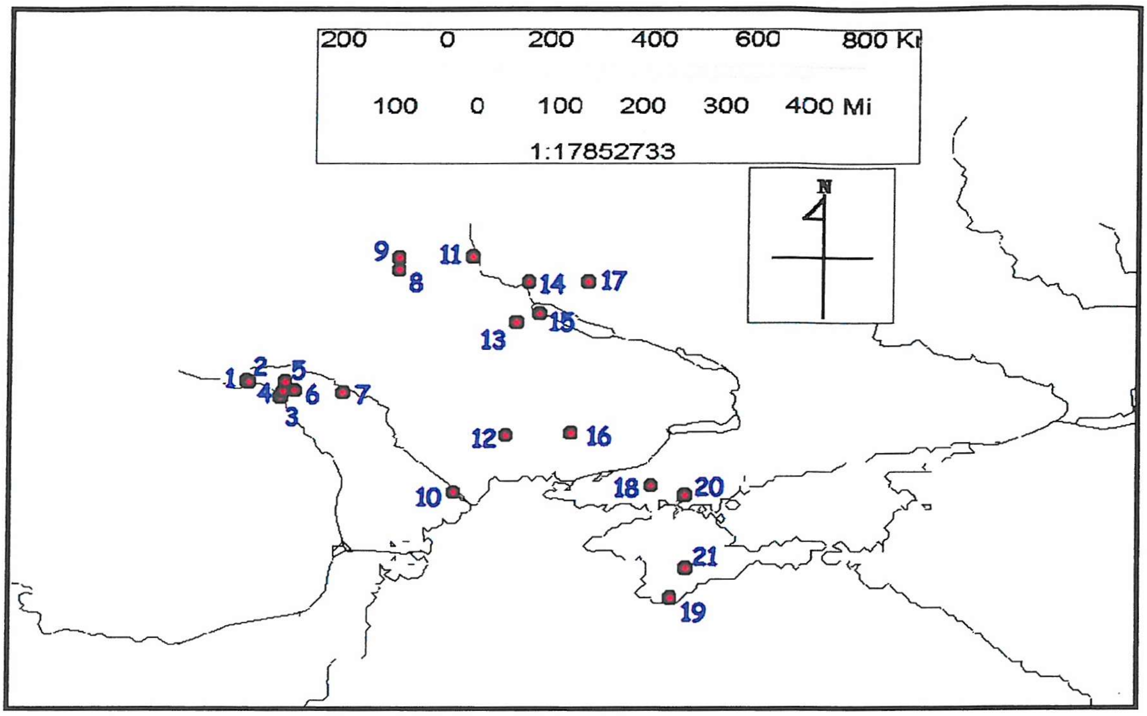
Sites located in the North Central Region.

1	Kaufertserg
2	Königsaue
3	Teufelsbrücke
4	Kniegrotte
5	Oelknitz
6	Bärenkeller
7	Mucheln
8	Krumpa
9	Hostim, Milovice
10	Alberndorf
11	Olbrachcice St 8
12	Mosty
13	Horn
14	Aggsbach
15	Willendorf II
16	Langmanensdorf
17	Dolní Věstonice, Pavlov
18	Brno-Vídenská, Stránská Skála
19	Pekárna Cave
20	Nová Drátenická Cave
21	Predmosti
22	Petrkoviče
23	Krucza Skala
24	Nitra-Čermáň
25	Descrowa Cave
26	Kraków Spadzista
27	Maszycka Cave
28	Calowanie
29	Rydno
30	Dudka
31	Cejkov, Kasov
32	Velke Pavlovice



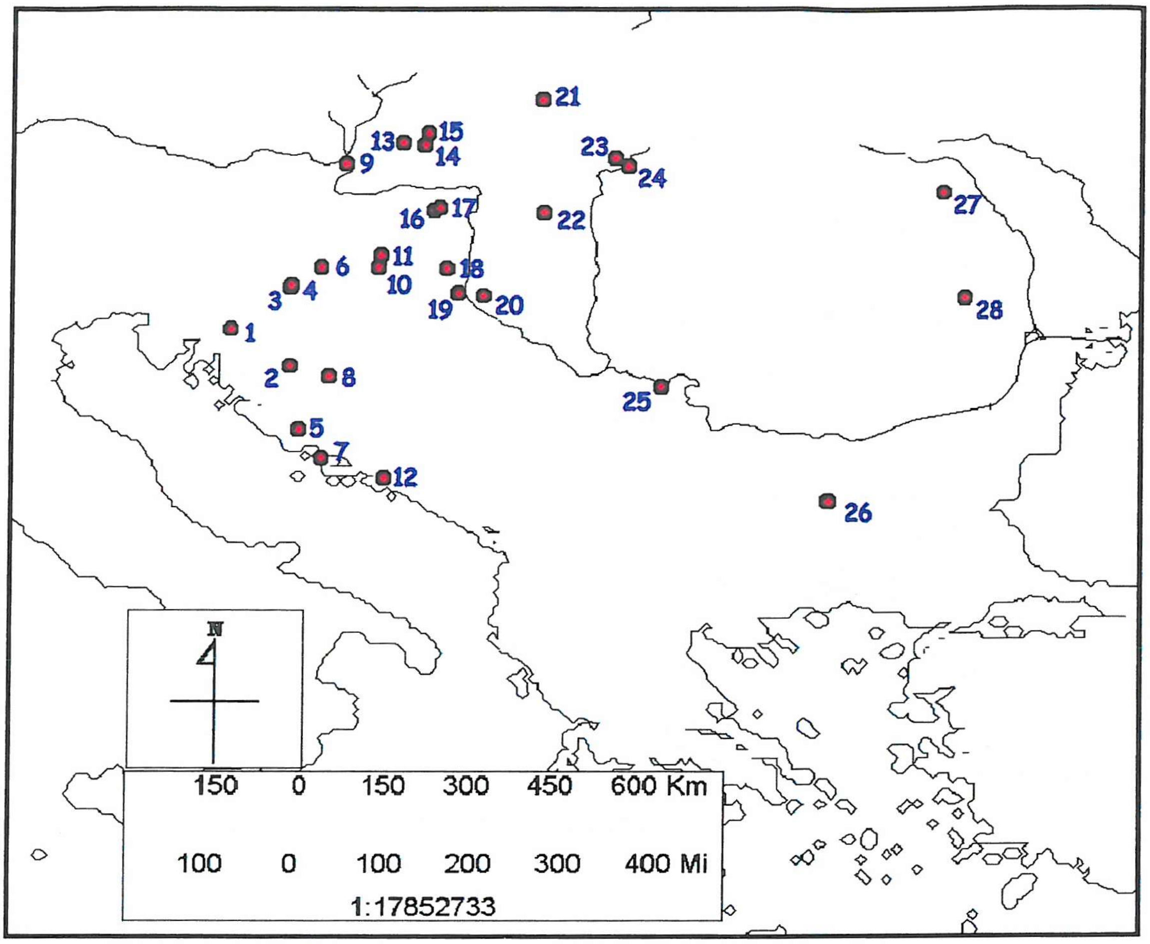
Sites located in the North East Eastern Region.

1	Berdyzh
2	Mezin
3	Tchoulatovo 1
4	Novgorod-Severskii
5	Yudinovo, Soutchkino
6	Pieny, Pogon, Poushkari 1, Sevsk
7	Khotylevo 2, Timonovka
8	Avdeevo
9	Kursk I
10	Zaraisk
11	Gagarino
12	Kostenki
13	Amvrosievka, Muralovka
14	Borshchevo
15	Kamennaya Balka II
16	Leski
17	Kasoznskaya cave
18	Zolotovka I



Sites located in the North East Western Region.

1	Molodova I, V
2	Ataki, Lvov
3	Brînzeni, Tchountou Rockshelter
4	Cuintu
5	Korman 4, Koulytchivka
6	Korpatch
7	Cosaoutsi
8	Korolevo 1
9	Radomyshl'
10	Semonovka
11	Kirillovskaya
12	Anetovka 2
13	Mezhiritch
14	Dobranitchevka
15	Mezhigirtsy 1
16	Sagaidak 1
17	Gontsy
18	Eliseevichi
19	Skalistiy
20	Souponevo
21	Buran-Kaya



Sites located in South East Region.

1	Lukenjska jama
2	Mališina Stijena
3	Velika Pećina
4	Vindija Cave
5	Pecine u Brini
6	Zalaegerszeg, upper
7	Kopacina
8	Hrustovača
9	Kulna
10	Sávgár
11	Balatonszabadi
12	Badanj
13	Moravany-Zakovska
14	Grubgraben
15	Trencianské-Bohuslavice
16	Mogyorósbánya
17	Pilismarót-Palrét, Esztergom-Gyurgyalag
18	Dunaföldvár
19	Dunaszekcsô
20	Madaras
21	Oblazowa Cave
22	Jaszfelsoszent Gyorgy
23	Arka, lower
24	Tokaj
25	Cuina Turcului
26	Temnata Cave
27	Mitoc-Malul Galben, Stanistea
28	Garla Mare

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