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The Obsidian Evidence for the Scale of Social Life during the Palaeolithic

by

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This thesis presents the results of original research undertaken by the author and none of the results, illustrations or text are based on the published or unplublished work of others, except where specified and acknowledged.

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ABSTRACT

The social aspect of modern hominin behaviour is a neglected subject within recent Palaeolithic research. This thesis addresses this issue arguing that modern social behaviour is reflected in the hominin ability to create and maintain extended social networks where relatedness is successfully sustained *in absentia*. Archaeologically, modern social behaviour can be detected through the investigation of raw material movement. This thesis argues that by concentrating on materials that are rare, distinctive and their origins can be securely identified it is possible to reconstruct the dimensions of the exchange networks involved in their circulation. The proposition being tested is that the greater the distances of raw material movement the more advanced the behavioural abilities of the individuals involved in the transfers.

Obsidian provides an opportunity to reconstruct the scale of its movement and to use these data to infer the changing scale of social life during the Palaeolithic. Using the distances of obsidian movement a network model is developed and used in the reconstruction of the Palaeolithic social landscape. This research brings together for the first time all the published instances of obsidian use during the Palaeolithic. Obsidian-bearing sites from the Palaeolithic and located in Africa, Europe and the Near East are analysed with the aim of elucidating the evolution of modern social behaviour. GtJi15 (Kenya) and Bodrogkerestúr (Hungary) serve as the case studies for the exploration of the distance effect on technological and typological issues of the obsidian movement.

The research demonstrated a strong correlation between obsidian use and long distances. The choice of obsidian makes sense within a system of exchange in which hominins chose to obtain their materials from elsewhere in order to maintain social links with other, more distant, groups. I argue that the scale of obsidian movement, although conditioned by a number of climatic, ecological and anatomical constraints, is actually rooted in social grounds. I thereby reject theories that see behavioural modernity as a recent advance in human history and argue for modern behaviour as gradual process that was initiated in East Africa at least as early as the Middle Stone Age.

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«… its thin flakes are effectively transparent; thick flakes can be used as mirrors; it has the sharpest edge of any stone, and can be knapped into intricate forms. It is a truly magical material…»

Mithen 2003: 67

Chapter 1

Introduction: Aims and Questions

1. INTRODUCTION

«I do not doubt that it would be nice to be able to infer that Joe Chevelon made two trips each year to the Flagstaff area to exchange raw materials with Charlie Sinagua to whom he was linked by longstanding ties of reciprocity. Similarly it would be nice to know that site 145 was a location at which Joe and his kinsmen met with Charlie and his kinsmen or with travelling traders from Wupatki. But I believe that our data will not support such inferences...» (Plog 1977: 138).

It would be ideal if archaeological data and the interpretation researchers made of them had the ability to provide such a perfect reconstruction of the past. It is equally true, unfortunately, that the available archaeological data cannot do so. No matter how much evidence is brought to light and irrespective of how well preserved they are, objects cannot tell us anything by themselves. It is the theoretical and interpretative context archaeologists build upon them that give them a voice. This is the reason why the development of appropriate models of analysis is much more than a peripheral need in archaeology. In this thesis a model for the investigation of issues central to Palaeolithic research will be developed with the assistance of a distinctive stone, namely obsidian.

Obsidian as a raw material is characterised by a long lasting and continuous presence as a resource utilised by humans facilitating their control over their physical and social environments. The character of obsidian use and the extent of its utilisation during the late prehistoric, post-classic and modern periods have been the subject of numerous studies (Cann *et al.* 1969, Renfrew & Wagstaff 1982, Drennan 1984, Green 1987, Best 1987, Gratuze *et al.* 1991, Kennedy 1997, Tykot & Chia 1997, Saunders 2001, Summerhayes 2004, Biro 2004). All these studies have invariably shown the great significance attached to obsidian; used for the manufacture of special objects during the Neolithic and Bronze Age, treated as a god in

Mesoamerican times and even included in the group of precious, highly valued materials today.

The high prestige that obsidian has enjoyed throughout later prehistory and the recent past appears in stark contrast with the paucity of obsidian information during pre-Neolithic times. Given that the Palaeolithic is *par excellence* the period of stone exploitation, and the hominins associated with this era the pioneers in the manufacture of lithics, this contrast seems peculiar. The two main features of obsidian, its «knappability» and brilliance, make the rarity of this particular raw material in the Palaeolithic archaeological record a very pronounced phenomenon and called for an investigation to fill this research vacuum. The current thesis aims to fill this gap in archaeological research.

The approach followed in order to deal with this research caveat brings together information from Africa, Europe and the Near East including all the phases of the Palaeolithic. By adopting such a holistic method, this thesis becomes the first project to investigate the use of a particular raw material from a wide chronological and spatial perspective.

The originality of this thesis is further supported by the interpretative framework developed for the explanation of the recorded observations. Contrary to previous raw material studies this thesis is not satisfied in only demonstrating how far obsidian was moving in the Palaeolithic. More importantly, it aims to show the implications this phenomenon had on the social behaviour of the participating hominins and generate a model for the study of hominin behaviour through the most archaeologically visible remains of the past, i.e. stone tools.

2. RESEARCH QUESTIONS

The main shortcoming common in all currently available raw material studies is their focus on local small-scale events which the researchers treat as of purely economic character. It is my conviction that a change in perspective will prove more successful in getting a better insight into the Palaeolithic period. In this thesis I will argue that our concern must be towards the behavioural and social aspects of the seemingly purely economic phenomenon of raw material movement. The emphasis must not be the distances over which the materials and items were transported but what these distances imply for the hominin behavioural abilities and the social processes which the Palaeolithic individual creates and participates in. This connection between raw material movement and hominin social behaviour is the central issue of this thesis. Using obsidian as the bridge between the two interlinked phenomena, this project sets out to provide a satisfactory answer to the following questions:

- How was obsidian used in the Palaeolithic?
- What does the use of obsidian suggest about the formation and organisation of hominin social networks and the scale of their interactions in particular?
- How far back in time can the signs of behavioural modernity be detected according to the obsidian data?

In this project these questions will be respectively approached by:

- Examining the obsidian use and presence in Palaeolithic stratigraphic units
- Examining the distances of obsidian movement
- Synthesising and interpreting the above information from a social behavioural perspective

3. RESEARCH AIMS AND HYPOTHESES

Despite archaeologists' occupation with the subject of raw material movement for several decades, there still is no consensus of what is «local», what may be termed «distant» and what is «exotic». The requirement for a clarification of these terms remains as pronounced as ever since through these concepts the phenomenon of social and behavioural evolution can be fruitfully approached. «How exotic is exotic? How local is local? What do such terms mean when applied to the distribution of stone, stone tools and other Palaeolithic materials?» (Gamble 1993: 35). How can we better explain the fact that what in one case is described as local is seen as distant under different circumstances? And how can we surpass these problems in order to find a model able to satisfy all conditions? Is it fair to exclude information from our analyses, either by denying a high resolution analysis of extremely short distances or ignoring very long distances, when the dataset allows it? And if the answer is «no», how can we manage to generate a methodology that encompasses everything?

It seems that a change in perspective is required. Fixing distances, from ethnographic and archaeological case studies, will probably not bring the solution to the problem archaeologists are facing. Rather, the identification of a common structure in the social behaviour of hominins with regards to space, i.e. networks of interaction, can prove more effective. By this I do not suggest the abandonment of all quantitative information. On the contrary, if properly employed quantitative data can prove of great assistance and is used in this thesis. What is needed is a model that will enable and facilitate comparison among archaeologists. The only way to achieve this is by developing a methodology broad enough to enable the inclusion of any kind of dataset and, at the same time, precise enough as not to result in substantial loss of information. Moreover, any new approach to the archaeological data must be free from ideas regarding the direction the exchange of materials has taken. My proposition is to go beyond cost-benefit models that have been so widely used by archaeologists.

In this thesis,

- I will review and compile all the available information regarding the use of obsidian throughout the Palaeolithic in selected, important in Pleistocene research, areas of the world
- I will detect the patterns of the obsidian movement in terms of the distances over which this raw material travelled on the Palaeolithic landscape
- I will generate a methodological framework for raw material movement analysis that can be used interregionally and diachronically and empirically test it upon selected Middle and Upper Palaeolithic assemblages from two different regions
- I will argue that Pleistocene hominins were not leading an a-social life in a spatially restricted area; on the contrary, the Palaeolithic inhabitants of the world were highly social beings covering long distances on the landscape at a time before the Upper Palaeolithic

The obsidian phenomenon will be addressed through six hypotheses that will be tested in the following chapters. These hypotheses are:

- **HYPOTHESIS 1:** that obsidian was always treated as a special material, i.e. chosen for its aesthetic quality
- **PREDICTION:** obsidian is always found at a maximum distance greater than that of other raw materials found at the same locale

- **HYPOTHESIS 2:** that because of its knapping qualities obsidian is always used when locally available in preference to other raw materials
- **PREDICTION:** obsidian is always the dominant raw material when a source is available less than 0-10 km away

- **HYPOTHESIS 3:** that obsidian, despite its aesthetic distinctiveness, complies with the general patterns of the raw material-distance relationship (expressed through quantity and retouch)
- **PREDICTION:** when the site-to-source distance is over 100 km, obsidian artefacts will be very scarce and fully retouched

- **HYPOTHESIS 4:** that ecology, expressed through the proxy of latitude, will affect the distances over which obsidian is moved
- **PREDICTION:** when obsidian is found in low latitudes (South) it will travel short distances; when it is found in high latitudes (North), it will travel long distances

- **HYPOTHESIS 5:** that climate cycles will affect the distances over which obsidian is moved
- **PREDICTION:** when obsidian is found in cold stages, it will travel long distances; when it is found in warm stages, it will travel short distances

- **HYPOTHESIS 6:** that obsidian has the potential to be used as a marker of change for both the size and complexity of social networks
- **PREDICTION:** network changes will be detected by changes in the distances and frequency of obsidian use during the Palaeolithic

4. RESEARCH OBJECTIVES

The research questions outlined above will be explored through the following research objectives which will examine the role of obsidian:

- Diachronically: the collected data will be used to reconstruct the patterns of obsidian use during the Palaeolithic with the aim to infer whether the particular raw material was differentially exploited among the substages of this period and if certain obsidian sources were preferred over others.
- Interregionally: the collected data will be used to reconstruct the patterns of obsidian use during the Palaeolithic with the aim to infer whether the particular raw material was differentially exploited in the study regions.
- In lithic assemblages: the aim is to determine to what extent was obsidian chosen as a raw material for the production of Palaeolithic tool-kits and the rationale behind this preference; moreover, the extent of variability in the assemblage level among the obsidian collections of the areas under investigation and the possible variation among artefact types and technological characteristics spanning across these assemblages will be addressed.
- In spatial and social networks: mobility range is a key concept in the main research questions that this thesis addresses. I will concentrate on the procurement of obsidian in a number of regions with the aim to establish transportation patterns, mobility strategies and social interactions developed through the acquisition of obsidian. The scale of the spatial and social networks of Pleistocene hominins will be ascertained through the analysis of these concepts in association to obsidian. Characteristic obsidian-bearing archaeological sites will be explored in detail with the aim to generate a theoretical framework for the analysis of these crucial for archaeological thought ideas. With this approach, one that emphasises the differentiated distribution of lithic resources within and between hominin groups, a unique insight into their social organisation, I argue, can be provided.

5. THESIS OUTLINE

The thesis is divided into the following sections:

Chapter 2: this chapter is dedicated to obsidian as a raw material. The significance of the particular stone in answering important archaeological questions is presented. The geological background and its physical and chemical properties are presented here in order to explain the significance of obsidian as a raw material *per se*. Furthermore, certain qualities that the particular raw material exhibits are discussed in depth in order to explain why of all the rocks obsidian is so special.

Chapter 3: in this chapter the theoretical background of this thesis is presented. Initially, a comprehensive literature review focusing on the phenomenon of raw material movement and its importance in reconstructing early human social behaviour is presented. The concepts of raw material movement, social networks and modern behaviour have a central role in this discussion. More importantly, the problems with the current models identified in the respective archaeological thought are addressed. Anatomical and life history hominin parameters are taken into account in order to test their implications on raw material movement. Social networks, a vital concept in this thesis, are introduced emphasising a behavioural explanation of the recorded phenomena and their potential in satisfactorily elucidating past phenomena. In the last section of this chapter I develop my own model of Palaeolithic obsidian use and movement and provide an alternative definition to the concept of modern hominin social behaviour.

Chapter 4: this chapter outlines the methodology that was applied in the recording process and introduces the theoretical framework on which the analysis of the collected data was based. In addition, some comments about the terminology used and the structure of the undertaken analysis are made.

Chapter 5: this chapter sets the framework of the obsidian use throughout the Palaeolithic of Africa, Europe and the Near East. The chapter starts with a discussion of the obsidian sources present in each region, their geology and location. Central in this chapter is the presentation- each region is treated independently for clarity- of the obsidian-bearing Palaeolithic sites collected during this research. A gazetteer of Palaeolithic obsidian is presented, providing information on coordinates, quantities, typological/technological issues (when available) and the main references used for the acquisition of these data.

Chapter 6: this chapter is dedicated to the two obsidian-bearing sites that comprise the two main case studies of this thesis, namely Bodrogkeresztúr (Hungary) and GtJi15 (Kenya). The chapter begins with background information including their location, topography, geological background, history of research and cultural horizons. The discussion continues with the presentation of the data from the lithic analysis conducted on the lithic assemblages from Bodrogkeresztúr and GtJi15. Furthermore, the results of the detailed technological analysis conducted on the obsidian from three additional sites - Subalyuk, Ballavölgyi, and Pilismarót-Diós - are included in this section in order to provide further support to the generated perceptions.

Chapter 7: this chapter is dedicated to the results generated by the analysis of the data collected from the literature. The chapter begins with the analysis of obsidian use by Palaeolithic period and industry. In the following section, distance is included in the analysis and its effect on the formation/distribution of obsidian assemblages is discussed. In the next section two new for this thesis concepts are introduced, climate and ecology, and the ways climate stages and latitude affect obsidian use in the Palaeolithic are discussed. Emphasis is placed upon the changing scales of obsidian movement affected by climate and latitude and evidence for social complexity and modern behaviour is sought through the investigation of obsidian movement and utilisation. In the final section of the chapter, an evaluation of the six hypotheses presented in chapter 1 takes place.

Chapter 8: in this concluding chapter the significance of obsidian in elucidating the social behaviour of the Palaeolithic hominins is briefly overviewed. The implications the obsidian data have on the phenomena of social complexity and the emergence of modern human social behaviour. Moreover, the place and timing of behavioural modernity as revealed by the obsidian data is addressed. The contribution of this thesis to archaeological thought and the potential for future research relating to this project are the final issues to deal with.

6. SUMMARY

The main research questions and aims of this project have been presented and the objectives through which I will approach them described. I will attempt to show that the use of obsidian reflects a conscious decision by the Pleistocene hominins rooted in social and behavioural rather than purely utilitarian grounds. In doing so, I will contribute to a better understanding of Palaeolithic behaviour in association to lithic acquisition and tool production. I regard the long-distance material movement concept as a direct expression of modernity and by examining the diachronic use and transport of obsidian I aim to show that the initial stages of modern behaviour must be sought well before the appearance of anatomically modern humans during the Upper Palaeolithic. This approach will enable me to get a clearer insight of Pleistocene social life, its scale and organisation and the roots to modernity. The synthesis of all this information will assist archaeologists to approach a tantalising question of our field - when did hominin brains become human minds - from a new perspective.

Chapter 2

The Geology and Archaeology of Obsidian

1. INTRODUCTION

The study of obsidian movement is a powerful tool in the investigation of the Palaeolithic archaeological record at an inter-continental scale and across diverse time periods. Based on its unique characteristics, obsidian opens up a wide range of possibilities for successfully dealing with a number of issues and in particular the material evidence of obsidian presence and movement on the Palaeolithic landscape that allows archaeologists to elucidate the social, behavioural and cognitive aspects of Palaeolithic life. The reasons that make obsidian such a useful focus to investigate the Palaeolithic will be specifically addressed in this chapter. Furthermore, the formation processes responsible for the production of volcanic glass and the distinctive properties of obsidian will be presented. Emphasis is placed upon the geological background of the three research regions with particular reference to the tectonic events and the obsidian sources in which those resulted.

2. OBSIDIAN UTILITY IN RAW MATERIAL MOVEMENT STUDIES/OBSIDIAN IN SCIENCE

The potential of raw material movement studies in the reconstruction of past human behaviour is evident in the significant improvement that the results of numerous such studies have brought to archaeological research. Much of the information we now acquire about territorial sizes, group interactions and exchange would not have been available if projects dealing with various raw materials/objects movement had not been undertaken (Montet-White & Holen 1991, Féblot-Augustins 1993, Fisher & Eriksen 2002). Despite the significance such investigations could have in Palaeolithic archaeology and specifically in the behavioural/social issues associated with the field, there are several shortcomings in using the current models of raw material movements as a means to understand past phenomena on a world-wide scale (see next chapter for a detailed discussion).

Obsidian constitutes an excellent means of approaching the subject of raw material movement from a world-wide perspective enabling archaeologists to make useful and comparable inferences of the same phenomena on a large scale. Such a scenario was not possible in previous work. On the one hand, there are studies where the raw material under investigation (e.g. flint) is too common and its geological sources too numerous to be accurately distinguished. On the other hand, there are studies where the raw material under investigation (e.g. chocolate-coloured flint, Schild & Wendorf 1976) is unique with only single or too regionally restricted sources to allow for large scale interpretations. Obsidian surmounts both these problems as it is rare enough to permit the exact identification and location of its primary sources but not too rare to be found in more than one places in the world. By being present in several, but not too many, areas around the world, obsidian allows archaeologists to overcome the caveats of small-scale explanations and approach the past from a new angle.

I argue that obsidian can satisfactorily overcome the shortcomings of these models and in this thesis I will attempt to prove its potential in reconstructing Palaeolithic life and hominin behaviour. Its rareness and distinctive physical and chemical properties, as they will be described in the following sections, make it an excellent candidate in successfully approaching these issues. Obsidian can be securely attributed to specific geological sources and, thus, the spatial scale of its movement can be reconstructed with great precision and certainty. It is this special characteristic that distinguishes obsidian from all (with few exceptions) other lithic raw materials whose provenance cannot be accurately fingerprinted, providing a level of interpretative certainty missing from most raw material studies.

In archaeology, obsidian has been most widely associated with technical aspects of the field where a plethora of scientific techniques have shown the material's efficacy in dating and chemical fingerprinting. Neutron Activation Analysis (NAA, Ammerman *et al.* 1990), Instrumental Neutron Activation Analysis (INAA, Randle *et al.* 1993), Mossbauer spectroscopy (Scorzelli *et al.* 2001), Electron Paramagnetic Resonance (EPR, Scorzelli *et al.* 2001), XR-Fluorescence Analysis (XRF, De Francesco *et al.* 2002), Electron Microprobe Analysis (EMPA, Merrick & Brown 1984), Back-Scattered Electron Petrography (BSE, Kayani & McDonnell 1996), strontium isotope analysis (Gale 1981), magnetic sourcing (McDougall *et al.* 1983), Optical Emission Spectroscopy (OES), Atomic Absorption Spectrography (AAS), electron spin resonance of Fe 3+ ions (ESR, Duttine *et al.* 2003), Fission-Track dating (Bellot-Gurlet *et al.* 1999), Proton Induced X-ray Emission (PIXE, Bellot-Gurlet *et al.* 2005), Proton Induced Gamma Ray Emission (PIGME/PIGE, Elekes *et al.*, nd, Le Bourdonnec *et al.* 2005), Inductively Coupled Plasma Emission Spectrometry (ICP-AES, Bellot-Gurlet *et al.* 2005), Inductively Coupled Plasma Mass Spectrometry (ICP-MS, Bellot-Gurlet *et al.* 2005), Laser Ablation ICP-MS (LA-ICP-MS, Elekes *et al.*, nd), and Scanning Electron Microscope using Energy Dispersive Spectrometer (SEM-EDS, Acquafredda *et al.* 1999) are the most recent scientific developments in the provenance/source characterisation of obsidian that I have encountered in the literature research while working on this project. Less numerous are the scientific, technological developments with regards to obsidian dating: Obsidian Hydration Dating (OHD, Friedman *et al.* 1969, Taylor 1976, Goffer 1980, Aitken 1990), more recently developed with the utilization of nuclear resonance reactions (Leach & Naylor 1981), Sputter Induced Optical Spectrometry (SIPS, Leach & Hamel 1984). Fission-Track dating (Wagner & Van den Haute 1992) and Potassium-Argon dating have also been applied but never got widely accepted. The potential of obsidian in widely assisting archaeologists in their efforts to understand the past is clearly stated by the long list mentioned above. All these technological advances are not restricted to obsidian; they use obsidian but the results they provide help answer questions from a wider scientific context.

Despite its potential in satisfactorily dealing with the more theoretical aspects of archaeological research, obsidian's association to such issues has generally been restricted to the discussion of trade and economic phenomena. It has been particularly important in the study of late prehistory, especially from the advent of the Neolithic period onwards, as numerous studies of the period clearly indicate (Renfrew *et al.* 1965, Ammerman 1985, Gratuze *et al.* 1991, Nishiaki 1993). However, its significance with regards to phenomena that fall within the territory of Palaeolithic archaeology remains unexplored. Issues of mobility, territoriality, social evolution and the origins of modern human behaviour are topics that can also be fruitfully approached through the study of obsidian. Obsidian is the bridge between material culture (expressed in raw material movement) and Palaeolithic hominin social behaviour.

3. WHAT IS OBSIDIAN?

3.1. Chemical Properties

Obsidian is produced by lavas with very high silica (SiO_2) content, more than 66% of the overall chemical composition, and according to the proportions of the various chemical elements different categories of obsidian can be identified. Usually the obsidians have a rhyolitic composition due to the high silica content, and are therefore classified as acid rocks. Chemically, obsidians can be defined according to the balance of alkalis (soda and potassium oxide), silica, aluminium and calcium oxide; for example, the ratio of alkalis to aluminium is used for the distinction between «peralkaline» and «sub-alkaline» obsidians. One of the main characteristics in the composition of the obsidian is the very high level of aluminium, usually more than 10%, and the extremely low levels of calcium oxide, generally less than 2%, which is the reason for the very high melting temperature of this particular rock (Brothwell & Pollard 2001).

The chemical composition of most volcanic obsidian (figure 2.1) ranges from about 70-75% SiO_2, 10-15% Al_2O_3, 3-5% Na_2O, 2-5% K_2O and 1-5% total Fe_2O_3+ FeO, according to Glascock *et al.* (1998), while for Constantinescu *et al.* (2002) the typical composition of an obsidian sample is: 35% Si, 47% O, 8% Al, 4% K, 3% Na, 1% Fe, 1% Ca, 0.3% Ti, 0.3% Mg. Peralkaline obsidians are typically higher in Fe composition than rhyolitic obsidians. As far as the intrinsic water content of obsidian is concerned, it is present in a range of 0.1-0.5% and it increases to about 3.5% by weight as rhyolitic obsidian gradually transforms into perlite. Other elements are also present in obsidian but in such concentrations (much less than 1%) that are referred to as trace elements. Despite the fact that they differ, usually by one or two orders of magnitude, between sources and even sub-sources it is possible to correlate between certain elements with great certainty. This phenomenon allows for the identification and distinction among various sources and, most importantly, the assignment of artefacts to their specific sources/sub-sources even when the flow is not entirely homogeneous (Glascock *et al.* 1998).

GENERAL

Category: volcanic glass

Chemical formula: 70-75% SiO_2, MgO, Fe_3O_4

IDENTIFICATION

Colour: black, grey, dark green, red

Fracture: conchoidal

Hardness (Mohs scale): ~5 to 5.5

Luster: vitreous

Specific gravity: ~2.6

Optical properties: translucent

Figure 2.1. Characteristics of obsidian.

3.2. Physical Properties

Obsidian, with its highly lustrous and homogeneous texture, is the most typical of the naturally occurring volcanic glasses (igneous family of rocks). As such it yields sharp-edged, conchoidal-shaped fractures better, in general, than any other type of tool-making stones (Glascock *et al.* 1998). It is normally translucent, especially on the edges of the flakes, but there are instances when it is opaque. Most of the time it has a black or smoky colour, caused by the presence of finely disseminated magnetite, but other varieties have also been found. Red obsidian, resulting by the oxidisation of magnetite to hematite, greenish and sometimes nearly colourless obsidians are also found (figure 2.2). The colour is not always regularly distributed and sometimes flow structures may be seen, especially when the obsidian contains inclusions that become drawn out into bands. Finally, many types of obsidian have been found to contain bubbles of gas or inclusions of crystallised minerals, particularly feldspars, which grow into small globular clusters of needle shaped crystals (Rosenfeld 1965).

It is worth mentioning that obsidian is not the only natural glass and not the only material of this category that was being used during prehistory. Other rocks, that also appear in archaeological assemblages, such as rhyolite, andesite, trachyte and phonolite, are members of this class of rocks and are usually referred to as types of obsidian (Green 1998). Tektites and pitchstone are natural glasses as well (Wondraczek *et al*. 2003). Additionally, a more detailed analysis would distinguish among several types of obsidian itself: rhyolitic obsidians, trachytic cone and dome obsidians, ignimbrite or welded tuff obsidians and marekenites. In this research such a distinction is not taken into consideration as it mainly applies to chemical studies. Furthermore, a distinction on the sub-source level among obsidian flows and sources (practised in geological research) is not useful for the purposes of this study (Eerkens & Rosenthal 2004). Such a separation is undoubtedly valid in geological terms but it has little value in archaeology as it is basically a chemical differentiation not affecting the appearance of the raw material.

Figure 2.2. Various types of obsidian: green (upper left corner), mahogany (upper right corner), banded (lower left corner) and snowflake (lower right corner).

4. WHAT IS SPECIAL ABOUT OBSIDIAN?

Obsidian provides the first evidence for truly long-distance raw material transports from a very early stage in the Palaeolithic. Distances of the order of 100 km, figures not easily reached even by the standards of modern hunter-gatherers (Binford 2001), have occasionally been recorded from Earlier Stone Age/Lower Palaeolithic layers and they reach far greater values in the Middle and Upper Palaeolithic/Middle and Later Stone Age. The results of previous research (Féblot-Augustins 1997; 1999) dedicated to the circulation of raw materials in the Palaeolithic very rarely connect other materials, and then usually not lithics, with such a spatial range (table 2.1 and figure 2.3).

Items such as ochre, shells or figurines have been recorded from distances resembling those of obsidian on the Palaeolithic landscape (Rensink *et al.* 1991, Féblot-Augustins 1997). Traditionally, such objects are denoted a «special» character exactly due to their transportation distances. Despite the fact that ochre is a naturally occurring substance and shells a foodstuff at some point in their lives, their great spatial coverage and small numbers change them from mundane to special. I argue that obsidian should have the same treatment too. In several instances where it has been stratigraphically associated with ochre or shells (table 2.2), obsidian circulation ranges are the same or exceed those of the above materials.

When compared to other lithic resources, obsidian again exhibits ranges that are similar or greater than those of other stones. It must be bore in mind that the distances recorded for those materials, for example the chocolate-coloured flint of Central Poland (Schild 1971; 1976), are absolute whereas for obsidian they are only a minimum. This indicates that the obsidian ranges and, subsequently, the difference between obsidian and other resources, could potentially prove to be even greater than currently estimated.

A final point that must be considered is the temporal differences between long distance movement of obsidian and other materials. As it is shown in table 2.3 all long distance transports occur from the Late Middle Palaeolithic onwards with the majority of instances dating well into the Upper Palaeolithic; the Lower Palaeolithic record is completely void of any long transfers either in Europe of Africa. Contrary to that, distant circulation of obsidian has been established both in Earlier Stone Age Africa and Lower Palaeolithic Near East.

name	**age**	**material**	**km**	**Source**
Central Europe general	Aurignacian & Gravettian	molluscs	750	Rensink *et al.* 1991
Central European Plain general	UP	fossil marine shells	300-650	Soffer 1991
Kostenki I (Ukraine)	UP	shells	600-800	Soffer 1991
Castanet (France)	Aurignacian	shells	120-280	Féblot- Augustins 1997
Lartet (France)	Aurignacian	shells	130	Féblot- Augustins 1997
Poisson (France)	Aurignacian	shells	120-200	Féblot- Augustins 1997
Cellier (France)	Aurignacian	shells	130-200	Féblot- Augustins 1997
Spy (Belgium)	Aurignacian	18 perles	190	Féblot- Augustins 1997
Spy (Belgium)	Aurignacian	shells	250-300	Féblot- Augustins 1997
Vogelherd V-IV (Germany)	Aurignacian	ammonite	100	Féblot- Augustins 1997
Krems- Hundssteig (Austria)	Aurignacian	*shells*	*60-320*	Féblot- Augustins 1997
Senftenberg (Austria)	Aurignacian	*shells*	*60*	Féblot- Augustins 1997
La Roque (France)	Gravettian	shells	200	Féblot- Augustins 1997
Pataud (France)	Gravettian	shells	200-280	Féblot- Augustins 1997
Gavaudun (France)	Gravettian	shells	200-250	Féblot- Augustins 1997
La Ferrassie (France)	Gravettian	shells	120-220	Féblot- Augustins 1997
Le Ruth (France)	Gravettian	shells	200	Féblot- Augustins 1997
Le Flageolet (France)	Gravettian	shells	200	Féblot- Augustins 1997
Spy (Belgium)	Gravettian	shells	250-290	Féblot- Augustins 1997
Geissenklosterle (Germany)	Gravettian	ammonite	20-40	Féblot- Augustins 1997
Hohler Fels (Germany)	Gravettian	ammonite	20-50	Féblot- Augustins 1997
Hohler Fels (Germany)	Gravettian	shells	20-50	Féblot- Augustins 1997
Sprendlingen (Germany)	Gravettian	shells	800	Féblot- Augustins 1997
Mainz- Linzenberg (Germany)	Gravettian	shells	800	Féblot- Augustins 1997
Certova Pec (Slovakia)	Gravettian	shells	80	Féblot- Augustins 1997
Aggsbach (Austria)	Gravettian	*shells*	*270*	Féblot- Augustins 1997
Dolni Vestonice (Czech Rep.)	Gravettian	*shells*	*40-80*	Féblot- Augustins 1997
Dolni Vestonice (Czech Republic)	Gravettian	*ochre*	*110*	Féblot- Augustins 1997
Pavlov (Czech Republic)	Gravettian	*shells*	*400*	Féblot- Augustins 1997

Podkovica (Slovakia)	Gravettian	shells	450	Féblot- Augustins 1997
Abri Fritsch (France)	Solutrean	shells	100	Féblot- Augustins 1997
Le Placard (France)	Solutrean	shells	180-380	Féblot- Augustins 1997
Fourneau du Diable (France)	Solutrean	shells	100-350	Féblot- Augustins 1997
Badegoule (France)	Solutrean	shells	130-280	Féblot- Augustins 1997
P. de la Boissiere (France)	Solutrean	shells	90-250	Féblot- Augustins 1997
Jean- Blancs (France)	Solutrean	shells	150-300	Féblot- Augustins 1997
Laugerie-Haute (France)	Magdalenian	shells	120-200	Féblot- Augustins 1997
Jean- Blancs (France)	Magdalenian	shells	100	Féblot- Augustins 1997
La Bergerie (France)	Magdalenian	shells	200-250	Féblot- Augustins 1997
Roc la Tour (France)	Magdalenian	shells	50-65	Féblot- Augustins 1997
Roc la Tour (France)	Magdalenian	perles on jayet	50-65	Féblot- Augustins 1997
Pincevent (France)	Magdalenian	shells	60	Féblot- Augustins 1997
Monruz (Switzerland)	Magdalenian	shells	330-380	Féblot- Augustins 1997
Kesslerloch (Switzerland)	Magdalenian	shells	250-600	Féblot- Augustins 1997
Schweizerbild (Switzerland)	Magdalenian	shells	250	Féblot- Augustins 1997
Petersfels (Germany)	Magdalenian	shells	220-800	Féblot- Augustins 1997
Hohler Fels (Germany)	Magdalenian	shells	200-850	Féblot- Augustins 1997
Napoleonskopf (Germany)	Magdalenian	shells	180	Féblot- Augustins 1997
Munzingen (Germany)	Magdalenian	shells	220-750	Féblot- Augustins 1997
Andernach (Germany)	Magdalenian	shells	800	Féblot- Augustins 1997
Gonnersdorf (Germany)	Magdalenian	shells	70-800	Féblot- Augustins 1997
Kniegrotte (Germany)	Magdalenian	shells	250	Féblot- Augustins 1997
Grotte Maszycka (Poland)	Magdalenian	shells	1400	Féblot- Augustins 1997
Grotte Maszycka (Poland)	Magdalenian	ochre	70	Féblot- Augustins 1997
Kulna (Czech Republic)	Magdalenian	*amber*	*400*	Féblot- Augustins 1997
Zitneho (Czech Republic)	Magdalenian	amber	400	Féblot- Augustins 1997
Pekarna (Czech Republic)	Magdalenian	amber	400	Féblot- Augustins 1997

Figure 2.3. Raw materials other than stone that exhibit long-distance movement on the European Palaeolithic landscape. Names in italics indicate sites where obsidian has also been recovered.

name	**age**	**material**	**km**	**source**
Ardennes (Belgium)	LMP	phtanite/quartzite	10-80	Rensink *et al.* 1991
Ardennes (Belgium)	LMP	flint	>30	Rensink *et al.* 1991
Neuwied Basin (Rhine)	LMP	flint	>100	Rensink *et al.* 1991
Kůlna (Poland)	LMP	flint	200	Rensink *et al.* 1991
Solyomkut (Hungary)	LMP	flint	300	Rensink *et al.* 1991
Ondratice (Czech Republic)	LMP	1 piece Bükk quartzoporphyry	>250	Rensink *et al.* 1991
Oelknitz (Germany)	Magdalenian	1 piece Swieciechow flint	350-600	Rensink *et al.* 1991
Maszycka (Poland)	Magdalenian	Alpine radiolarite	350-600	Rensink *et al.* 1991
Podranska (Czech Rep.)	EUP (Bohunician)	radiolarite	>130	Kozlowski 1991
Lisen (Czech Republic)	EUP (Bohunician)	radiolarite	>130	Kozlowski 1991
Brno-Bohunice (Czech Republic)	EUP (Bohunician)	radiolarite	>130	Kozlowski 1991
Lovas (Hungary)	MP	radiolarite	120	Simán 1991
Mezhirich (Ukraine)	UP	mountain crystal	150-450	Soffer 1993
Gontsy (Ukraine)	UP	mountain crystal	150-450	Soffer 1993
Dobranichevka (Ukraine)	UP	mountain crystal	150-450	Soffer 1993
Kostenki-Borschevo sites (Ukraine)	UP	flint	130- 300	Soffer 1993
Gagarino (Ukraine)	UP	flint	300-450?	Soffer 1993
Avdeevo (Russia)	UP	flint	200	Soffer 1993
Kursk (Russia)	UP	flint	200	Soffer 1993
Grubgraben (Austria)	UP	radiolarite	80	Montet-

				White 1991
Tarnowa (Poland)	Final Magdalenian	chocolate-coloured flint	225	Schild 1976
Calowanie (Poland)	Final Magdalenian	chocolate-coloured flint	>100	Schild 1976
Swidry Male III (Poland)	Final Magdalenian	chocolate-coloured flint	>100	Schild 1976
Kaszety (Lithuania)	UP	chocolate-coloured flint	400	Schild 1976
Duba (Lithuania)	UP	chocolate-coloured flint	400	Schild 1976
Wojcice I (Silesia)	UP	chocolate-coloured flint	290	Schild 1976
Dobiegniewo (Poland)	UP	chocolate-coloured flint	200	Schild 1976
Schweinskopf (Germany)	MP	Maas flint	>100	Roebroeks 1988
Plaidt-Hummerich (Germany)	MP	flint	>100	Roebroeks 1988
Trou Magrite (Belgium)	MP	phtanite	50-60	Roebroeks 1988
Trou du Diable (Belgium)	MP	phtanite	50-60	Roebroeks 1988
Zwolen (Poland)	MP	chocolate-coloured flint	40	Roebroeks 1988
Laugerie-Haute (France)	MP	flint	<50	Roebroeks 1988
St Jean de Verges (France)	Aurignacian	flint	70	Fèblot-Augustins 1997
Plasenn-al-Lomm (France)	UP	flint	75	Fèblot-Augustins 1997
Roc la Tour (France)	Magdalenian	quartzite, phtanite	90	Fèblot-Augustins 1997
Sweikhuisen-Groene Pal	Magdalenian	quartzite, lydienne	110	Fèblot-Augustins

(Netherlands)				1997
Pekarna (Czech Republic)	Magdalenian	Turonian flint	200-250	Fisher & Eriksen 2002
Pekarna (Czech Republic	Magdalenian	chocolate-coloured flint	200-650	Fisher & Eriksen 2002
Pekarna (Czech Republic	Magdalenian	radiolarite	50-240	Fisher & Eriksen 2002
Pekarna (Czech Republic	Magdalenian	Bavarian tabular chert	>120	Fisher & Eriksen 2002
Pekarna (Czech Republic	Magdalenian	Maas flint, molluscs	>100, >800	Fisher & Eriksen 2002
Pekarna (Czech Republic	Magdalenian	Bavarian tabular chert	>50-200	Fisher & Eriksen 2002
Pekarna (Czech Republic	Magdalenian	1 quartzite tool	110	Fisher & Eriksen 2002
Pekarna (Czech Republic	Magdalenian	Maas flint	100	Fisher & Eriksen 2002
Pekarna (Czech Republic	Magdalenian	flint	80	Fisher & Eriksen 2002
Pekarna (Czech Republic	Magdalenian	phtanite	60	Fisher & Eriksen 2002

Table 2.1. Other lithic raw materials that travel long distances on the European Palaeolithic landscape.

archaeological site	distance (km)	
	obsidian	other «exotics»
Kůlna	386	400
Pavlov	382	400
Dolní Věstonice	385	40-80
Dolní Věstonice	385	110
Aggsbach	484	270
Senftenberg	471	60
Krems-Hundssteig	467	60-320

Table 2.2. Palaeolithic sites exhibiting a combined presence of obsidian and other exotic/special objects. Notice that in every single case obsidian either outnumbers or is of the same range (2 instances) to the distance of the shells/ochre movement.

The circulation of obsidian during the Palaeolithic does not comply with the general patterns underlying the movement of raw materials at the time. Indeed, the scale of Palaeolithic obsidian movement shows a better correspondence with obsidian transports during the late prehistoric or early historic periods.

A compilation of obsidian movement data from various regions and a temporal framework ranging from the Neolithic to Early Agricultural times (table 2.3) shows the similarities between Palaeolithic and more recent obsidian transfers. If the use of the estimated maximum obsidian distances for the Palaeolithic was not a risky research practice it would be possible to discern an even greater resemblance between the two sets of data.

Obsidian movement regularly exceeds 200-400 km in continental regions during the Neolithic and Bronze Age. For example, in Early Bronze Age Mandalo, Greece (Kilikoglou *et al.* 1996), Carpathian obsidian coming from 400 km has been identified. The circulation of obsidian reaches impressive ranges in island regions as data from Fiji, for example, indicate. There obsidian transfers over 1000 km and often up to 3500 km have been recorded (Tykot & Chia 1997). Although it is hard to argue for obsidian transfers of such a scale in the

Palaeolithic, the point still remains that Palaeolithic obsidian ranges more closely resemble these of late prehistoric times than the distribution ranges of other materials of the same time.

name	**age**	**material**	**km**	**source**
Primorye region (Russian Far East)	Neolithic	obsidian	200-700	Kuzmin *et al.* 2002
Korean Peninsula	Neolithic	obsidian	400	Kuzmin *et al.* 2002
Tucson Basin (Arizona)	Archaic	obsidian	200	Roth 2000
Bukit Tengkorak (Borneo, Malaysia)	Neolithic	obsidian	3500	Vandiver *et al.* 1996
Fiji	Neolithic	obsidian	3300	Vandiver *et al.* 1996
Cluj (Transylvania)	Neolithic	obsidian	>1500	Constantinescu *et al.* 2002
Nahal Lavan (Israel)	Neolithic	obsidian	800	Cauvin & Chataigner 1998
Ali Kosh (Iran)	Neolithic	obsidian	900	Cauvin & Chataigner 1998, Renfrew *et al.* 1966
Catal Huyuk (Turkey)	Neolithic	obsidian	200	Renfrew *et al.* 1966
Beidha (Turkey)	Neolithic	obsidian	900	Renfrew *et al.* 1966
Ganja- Kazakh (Caucasus)	Neolithic	obsidian	150	Kushnareva 1997
Ilanly- Tepe (Caucasus)	Neolithic	obsidian	100	Kushnareva 1997
Alikemek-Tepesi (Caucasus)	Neolithic	obsidian	200	Kushnareva 1997
Meshoko (Caucasus)	Eneolithic	obsidian	450	Kushnareva 1997
Veselyy (Caucasus)	Eneolithic	obsidian	600	Kushnareva 1997
Mandalo (Greece)	Late Neolithic	obsidian	400	Kilikoglou *et al.* 1996
Tal-e Malyan (Iran)	2100-1800BC	obsidian	1300	Keller *et al.* 1994

Table 2.3. Some instances of obsidian movement in various periods of late prehistory. Note that in many cases obsidian transports far exceed 1000 km.

The question that these findings pose is why obsidian of all the lithic materials was consistently treated so differently? In other words, what is special about obsidian?

4.1. Scarcity/ Distance

A first step in answering this question is provided by the obsidian distances themselves. The long scales obsidian was covering on the Pleistocene landscape denote a special character to the material. As a material category and with special reference to the Palaeolithic, stone tools carry and signal sensory patterns both to their makers and users (Berleant 2007). Tools made of raw materials with distinctive physical properties will be more effective in the creation and maintenance of social relations. The extent those interactions acquire will similarly be affected by the use-value of the exchanged materials.

The availability of obsidian sources in only a limited number of locations added to its attractiveness as a material for social bonding. The fact that obsidian could not be found everywhere, but special strategies had to be devised for its acquisition, denoted obsidian with a quality that increased its value above that of an ordinary material. Within this framework, obsidian became a material with social value, based on its aesthetic properties and the distances of its circulation. This value, reflected in its rarity, expresses distinctive social relations associated with exotic networks. In terms of its use as a social communicator, it is exactly its rarity that turned obsidian into an effective medium of social relatedness. More importantly, obsidian's distinctive visibility enabled communication to a scale that extended beyond the local environment. Interaction was in this sense based entirely on obsidian's ability to convey social messages and effectively transfer them among hominin groups. A feeling of relatedness *in absentia* (to be discussed in a later chapter) was subsequently achieved resulting in the stretching of social networking beyond one's immediate environment. The increasing distances obsidian movement covered on the Pleistocene landscape was adding to its rarity and significance as a social medium bringing distant groups together.

4.2. Knapping Quality/ Function

A second parameter to be taken into account when discussing the special character of obsidian is the quality of the raw material. The chemical and physical properties that result from the special conditions under which obsidian is formed make this volcanic rock an excellent material for the manufacture of tools. Its chemical homogeneity enables modification with great precision whilst its glassy appearance allows the formation of extremely sharp edges, a particularly useful feature for certain tasks. Experimental knapping of a variety of rocks that was undertaken alongside this project has provided evidence supporting the versatility of obsidian as a raw material for tool-making. Functionally, obsidian is also very satisfactory especially when precision is required. The sharp edges that it produces make obsidian highly useful for tasks that involve thin and small cuts. The contemporary world provides the best example supporting this argument: obsidian blades are often preferred over steel in cardiac surgery as their extremely sharp edges result in very precise and thin cuts that heal faster and easier (Buck 1982, Disa *et al.* 1993).

With regards to the Palaeolithic, when Pleistocene hominins were highly mobile, the procurement of high quality raw materials was essential for the maintenance of a reliable toolkit (Torrence 1989). Choosing the right materials for their tools was critical if optimal survival was to be achieved. High quality raw materials whose use life can easily be extended through repair or further modification successfully meet the criteria of maintainability and reliability that were crucial for the successful accomplishment of subsistence tasks.

According to the model of cost-effective behaviour a rock of relatively good quality but very close to a home base should be the preferred choice compared to an excellent but too costly to get to rock. Applied to obsidian this model implies that the specific rock should be in use only when camps are located in the vicinity of an obsidian source. Obsidian is an excellent raw material for the production of lithic tools but it is not the only stone producing nice, workable edges. Travelling hundreds of kilometres or extending one's social network for its acquisition is not a particularly efficient strategy based on a cost-effective system. However, the picture that emerges from the obsidian data shows that the Palaeolithic hominins were indeed willing to ignore such a system when obsidian was sought. They made every effort to get to its sources, even when obsidian was not readily available; they were not satisfied with using just what was exposed in the area where they made their homes. In certain occasions they were not even pleased with the obsidian from their nearest sources; on the contrary, they would acquire material from a source located further than their closest ones.

Thus I propose that although function expressed in obsidian's «knappability» had an effect in hominins decision to pursue obsidian the main reason for its exploitation was aesthetic, i.e. its brilliance (see below). I argue that hominins' behaviour towards obsidian was not controlled by functional criteria but rather linked to the attractive appearance of obsidian that distinguishes it from the majority of the available lithic resources.

4.3. Aesthetic Quality/ Brilliance

«May he savor the fragrance, the sweetness of death by the obsidian knife...May he desire...the flowery death by the obsidian knife. May he savor the scent, the sweetness of the darkness, the din of battle» [Sahagún 1950-78, book 6: 14 (Aztec prayer)]

Apart from its distinctive flaking properties, obsidian has another special attribute that differentiates it from the rest of the lithic resources available for exploitation; brilliance. Unlike most rocks, obsidian exhibits extremely shiny surfaces resulting in an overall lustrous appearance of the material.

Gosden (2001) has addressed the issue of the aesthetic appeal of objects to people and concluded that some objects or classes of objects attract a lot more attention and respect than others. Iridescence, the ability to reflect light and brightness are all qualities that are aesthetically satisfying and spiritually charged with power (Berleant 2007) in all human societies. Although the various human populations live and perceive in different cultural and perceptual worlds they all adhere to a system of aesthetics in which brilliance holds a central role.

The visual appearance of objects affects the way they are perceived by the hominin brain. Vision is the sense the western world places most emphasis to (Gosden 2001) but it is not unreasonable to expect a similar reaction by other populations from the recent and/or distant past, Pleistocene hominins included. As a matter of fact, evidence for visual specialisation occurs from very early in the time frame of human evolution. Anatomical data support the importance of the sense of vision in human evolution. A strong connection between neocortical evolution, and indeed the whole encephalisation process, and visual specialisation, exists. According to Barton (1998; 2000) a large part of the neocortex (a part of the brain that plays a key role in consciousness, awareness and thought) in monkeys and apes is dedicated to visual processing. The variation in neocortex size observed among hominin species is at least partly a product of selection on specific visual mechanisms, such as colour vision. Despite the fact that other aspects of parvocellular function are involved in the evolution of primate brain, colour vision and the visual apparatus has been more intensively selected for.

Allman (1987: 639) confirms the link between vision and behaviour, as identified in haplorhine primates, with the following statement: «as complex systems of social organisation evolved in haplorhine primates, social communication was increasingly mediated by the visual channel». What this implies is that primate and hominin, it is argued here, social interactions were facilitated through vision. The importance of vision in social communication is not restricted to face-to-face interactions. Its most significant contribution is its ability to bring individuals together even from a distance and through items that are more visible than others. The increasing complexity of social communication necessitated an increasingly elaborate basis for the processing of social information and vision was a very satisfactory means towards this end. Subsequently, in highly complex societies communication and interaction among its members is progressively more mediated through the visual channel.

The significance of this aesthetic characteristic of obsidian can be fully appreciated in association with the following observations. Anthropological studies on aesthetics examining the ways objects appeal to the senses, have found that «brightness» takes evolutionary precedence over hue-orientated classification schemes (MacLaury 1992, Watts 1999). Morphy's (1989) research on the Yolngu of Eastern Arnhem Land is particularly informative to this account. Using the art of this population, Morphy shows that spiritual power is heightened through brilliance. In addition, studies on human cognition and the ways the brain receives various stimuli have shown that a special interest is attached to objects with «brilliant» qualities (from unpublished «Lucy to Language» workshop discussions). In this context, brilliance is perceived as a cross-culturally effective sensory stimulus strongly affecting the hominin brain. Subsequently, objects brimming with brilliance are perceived as having an enhanced aesthetic quality which makes them not only visually pleasing but also desirable.

Archaeological examples from the Palaeolithic record supporting the above argument exist both in Europe and Africa. The Mousterian rock crystal tools from Les Merveilles, the swirling jasper handaxes from Fontmaure-en Vellèches (cited in Gamble 1999) are two characteristic examples from the European territory. In Africa, evidence for Middle Stone Age mining of glittery specularite at Lion Cavern and caching of specularite at Olieboompoort (Watts 1999) constitute two early examples of the effect of brilliance on hominins' mind. Obsidian's lustrous appearance undoubtedly had a strong aesthetic power over the hominins encountering it. This would have resulted in a desire for its acquisition and use. The cases where far-travelled obsidian is preferred over other locally available good quality lithic resources are a clear indication of the power obsidian had on the hominin brain. In these instances, obsidian is not simply exploited as an affordance within the landscape, (see Gamble 1999: 330), but it is rather a consciously chosen material, desired for its unique functional and aesthetic qualities.

The dual character of obsidian, i.e. the fact that it combines the attributes of high technical performance and aesthetic attraction, resulted in its worldwide dominance. Obsidian was similarly used and valued in several quite distinct societies in different parts of the world and in different cultures widely separated in time and space. This popularity obsidian was enjoying across time and space suggests that all the people involved in those cultures had a basic common human aesthetic sense to which obsidian was appealing (Barfield 2003).

The aesthetic value that obsidian enjoyed in the past reached its apotheosis in the Mesoamerican cultures whose economic and symbolic life it underwrote for ~3000 years. In the multi-sensorial world-view of the Mesoamerican peoples obsidian possessed polysemic qualities that distinguished it from all other materials. The symbolic importance of obsidian (Heyden 1988) was particularly prevalent by the Aztecs who considered the specific volcanic glass as a divine stone with metaphysical powers (Saunders 1994; 2001). Blades for bloodletting and human sacrifice made of obsidian acquired powerful symbolic connotations in the Aztec societies. The aesthetic engagement with obsidian bequeathed distinctive kinds of agency on artefacts made from this dark volcanic glass. The authority obsidian was attaining throughout that period is exemplified by the Aztecs' respect towards Tezcatlipoca, Lord of the Smoking Mirror (Miller & Taube 1993, Olivier 2003). Tezcatlipoca was not only the patron god of Aztec royalty but his diagnostic and eponymous possession, the obsidian mirror, was a metaphor for rulership and power as the quoted prayer indicates. In other words, obsidian was not only adored as a pretty stone but its excellent aesthetic properties were recognised as so unique as to grand obsidian human worship. Obsidian's unequalled utility generated an enduring Mesoamerican aesthetic, unique in its capacity to create social relationships and stimulate symbolic connections. The significance of shiny raw materials and objects resulted in the development of an aesthetic of brilliance which underwrote all the Mesoamerican cultures as a pan-Amerindian phenomenon (Saunders 2001). This power obsidian possessed in the Mesoamerican cultures was even recognised by the first Catholic priests who stepped onto the newly discovered continent. Although they did not share the same beliefs with the conquered nations, the priests did use obsidian to decorate early Christian atrial crosses recognising not only the authority of obsidian on those people but also its decorative value (Saunders 2001).

In addition, Australian Aborigines and Melanesian populations (Taçon 1991, Summerhayes 2004, Harrison 2006), Neolithic and Bronze Age Greek, Pre-pottery Neolithic Turkish cultures (Renfrew *et al.* 1966; 1968) placed a particularly high value on obsidian both as a raw material and finished objects. For Australian Aborigines stone in general and obsidian in particular is associated with landscape features that themselves carry powerful sensory and cultural meanings (Gould 1968). All along the long tradition of its use, obsidian was popular not only for its utilitarian properties but also a very attractive stone. In later prehistory, this quality made obsidian a highly preferable material for the production of objects offered as gifts to important members of the respective societies. Even in the contemporary world obsidian attains its high prestige associated either with spiritual powers or more practical purposes. For example, obsidian is popular in new age mysticism where the owning and touching of crystals and semi-precious stones as a way of getting in touch with human emotions and past spiritualities (Saunders 2001).

The anatomical and ethnographic information discussed above provides strong evidence supporting the central role of vision in hominin life. The identification of a sense of aesthetics archaeologically, especially in the distant Palaeolithic period, is undoubtedly difficult. Nevertheless, it is also hard to disagree that our prehistoric ancestors would have had a «sensory system» too. The way objects look and the mental reactions they cause control the social behaviour of the interacting individuals. Social relations are created and shaped through the aesthetic properties of objects. The sensory responses of those objects to the subjects handling them are socially important. Following Gell's approach (1992) not all objects are equal in their effectiveness and not all objects attract social relations at the same rate or degree of importance. Within this context, items exhibiting attractive qualities to a greater extent than others will be dominant in the creation and maintenance of social networks.

In all the areas under examination obsidian is not the only usable rock (as the presence of lithics on other stones in the assemblages under investigation has shown). Still those hominins chose not to use their nearest sources and, instead, travel long distances for that specific stone, as a few characteristic examples in the previous sections indicated. Raw material circulation ranges that far exceed the radii of daily subsistence movements suggest sophisticated behaviour as they involve the choice of materials whose cost of acquisition is far greater than what would normally be expected for covering someone's basic needs. Instead of using what is readily available, a group consciously decides to undertake a long trip in search of a particular material. In the previous section an attempt was made to explain the reasons that made such a choice necessary. The Palaeolithic choice to use obsidian irrespective of distance seems to have implications that rather than being economic or functional appear to be strongly social.

5. BRINGING OBSIDIAN AND PALAEOLITHIC SOCIETY TOGETHER

Distances of the order discussed so far have implications for the social skills of the hominins involved in the circulation of obsidian. Following from the proposition that lithics are an independent means to observe how hominins moved around the Palaeolithic landscape, obsidian allows us to investigate how the Palaeolithic hominins created their social environment by engaging in its distribution. Moreover, I argue, obsidian permits inferences with regards to the creation, organisation and scale of the Palaeolithic social environment.

Artefacts, and especially stone tools, have always been a big part of the performance of social life as they facilitated structuring hominin interactions. Similarly, obsidian was part of the routines by which hominins were known and responded to in the social context of its circulation. Throughout its long history of use, obsidian has been instrumental in the creation and maintenance of the social environment within which its transportation occurred. Obsidian exchange facilitated communication locally and, especially, over long distances as the analysed data suggest.

The economic rationalist approach dominating raw material studies does not always recognise that different types of social information are transmitted during raw material exchange. Artefacts, even the most mundane ones, are embedded with meanings and knowledge that are communicated through their exchange. They are items displaying meanings and they can even be recognised as symbolic markers on the environment. Paton (1994) identifies the value of artefacts as communicators of coded information associated with survival purposes in times of stress. The type of communicated knowledge is not investigated here; what is of importance is the hominin ability to build and maintain social links by making use of material culture. In traditional Aboriginal populations (Paton 1994), quartzite blades were instrumental in the transmission of an extensive amount of knowledge regarding social mores such as ownership rights and, perhaps most importantly, they were regarded as symbols of vital information about creation myths. Similarly, it is argued here, obsidian played a protagonistic role in the communication between individuals and groups participating in its exchange throughout the Palaeolithic.

Paton (1994) has argued that the real value of artefacts lies in the socially indispensable messages they help communicate rather than their utilitarian capacities. Indeed, sophisticated information crucial to the operation of a society can be conveyed even through the distribution of seemingly mundane artefacts. If there is one parameter that is potentially affected by the quality (mundane *versus* special) of the distributed items that is the scale this communication of information can reach. Obsidian is but another stone; however, by being rare enables its embedded meanings to reach across distances far greater than those of other rocks. All artefacts carry meanings; nonetheless, a distinctive item, e.g. obsidian, can communicate messages easier. Its scarcity makes obsidian more visible than other commoner materials. Even if it is hard to prove that its scarcity denotes it value by default, it is, however, unarguable that its rareness denotes it extra visibility making communication and social links easier and, thus, obsidian a valuable material in the social life of hominins.

The use-value in social transactions of portable resources is closely connected to their association with the individuals that performed those social ties. Following Leroi-Gourhan's (1993) argument that «materials associated with gatherings are best regarded as an extension of the social actor» (Gamble 1999: 74), obsidian had a crucial contribution in the social experience of the hominins participating in its exchange. Along the process of manufacturing, handling and transporting obsidian, artefacts were taking on the properties of the involved individuals as social actors. Therefore the scale of exchange actively controls the potential value of a distributed artefact. The more hands/individuals an object goes through during its exchange history the more valuable it becomes as it encompasses all those persons. Gould (1980: 142-3) provides further support to the link between value and distance in his argument that by travelling far an exchange item is automatically transformed from being mundane to being special.

The real value of artefacts, however, is their control over the global social landscape. All objects are important connectors bringing individuals and groups together; nevertheless, the social value of artefacts increases according to their distribution ranges. In the instances where objects are used as a means for negotiation and affiliation of otherwise completely independent individuals/groups, an added value of those items must be accepted. Artefacts are essential in the performing of social structure (Gosden 1994) but some of them have the ability to do so from a great distance. Although materials offer affordances (Ingold 1992) or use-values both in short (regional) and long (global) distances, that value will be higher in the second case. It is argued that the way an object is perceived is directly affected by the scale of its movement; the same artefacts can change from being commodities to being gifts/symbols depending on the distance of their circulation.

Palaeolithic hominins formed intimate relations with and through artefacts and when the ability to stretch those relations beyond a local scale was achieved a major behavioural development had been accomplished (Rodseth *et al.* 1991). The changing patterns in raw material transfers provide an excellent means to trace these behavioural developments in the archaeological record of the Palaeolithic. Obsidian in particular offers a great opportunity to this direction as its rarity and chemical distinctiveness permit to undertake this task with a great degree of security. The link between raw material movement and social behaviour is unbreakable; this connection provides an excellent opportunity to investigate hominin behaviour through raw material transfers in terms of social networks.

Chapter 3

A Model of Obsidian Raw Material Movement

1. INTRODUCTION

This chapter addresses two topics that are brought into focus through the study of obsidian: raw material movement and its contribution to the study of the appearance of modern social behaviour. The established theories in each of these are central to archaeological research issues and are discussed here. My aim is to present a theoretical framework to investigate the Palaeolithic use of obsidian. The patterns in obsidian exploitation, movement and use will then form the basis for examining which of the above models best reflects the social and behavioural phenomena of the Palaeolithic.

2. MODELS OF LITHIC RAW MATERIAL PROCUREMENT AND MOVEMENT

The study of the distribution of obsidian during the Palaeolithic has rendered the need for a coherent methodology for the analysis of Palaeolithic raw material movement imperative. A number of scholars (Féblot-Augustins 1993, Fisher & Eriksen 2002) have already turned their attention towards this goal but how coherent are their methodologies for a wide range of data? A discussion of the best known models will attempt to show the validity of my scepticism towards the application of the existing theories of raw material transport in explaining large scale events.

Renfrew (1966; 1968; 1969) inaugurated a systematic approach to the subject of raw material movement. Although his interest was mainly towards Neolithic trade and cultural contact, the analytical system he developed was innovative and has had an immense influence on archaeology. Specifically, he introduced the concepts of down-the-line exchange and prestige-chain exchange where objects move complying with the law of monotonic decrement and fall within two spatial frameworks, i.e. the supply (radius of the length of a single journey) and contact zones (radius beyond that of the supply zone). Renfrew’s model, with its strong links to modern concepts of commercial trade, cannot have a direct application to the earlier stages of prehistory although the concept of direct procurement has been positively addressed in Palaeolithic research. The theoretical background/terminology he introduces, for example specialists and professional merchants, and the quantitative data his results are based on is of limited use in reconstructing Palaeolithic events. Nevertheless, some of the ideas he puts forward, especially those regarding a preferential treatment of particular items, may assist in the generation of a new way of looking at Palaeolithic raw material movement with respect to obsidian. Finally, by concentrating on obsidian for his analyses Renfrew's model allows direct comparisons between Neolithic and Palaeolithic obsidian use.

A more recent development in the study of raw material transport and the organisation of forager mobility is the use of stochastic statistical models based on a mathematical approach. Prominent among these models is Brantingham's (2003; 2006). The theoretical framework for the development of his approach is a procurement model according to which the moving individual adopts a neutral behaviour within a uniform environment in which he/she randomly moves in order to acquire raw material. This resource is randomly distributed on the landscape but always of the same quality and quantity. Brantingham's probabilistic model is highly original for archaeology, but in building it he deliberately ignores a number of factors as «unnecessary complications» (2006: 447), mainly because the simulation would not be possible with their inclusion. I am not in disagreement with the use of simplified models in order to explain complicated phenomena on a smaller or larger scale; on the contrary my wish is to develop a simple theoretical framework applicable to large scale events in order to overcome the problems associated with small scale interpretations. However, excluding topography and raw material quality and abundance from an analytical device that aims to explain hominin mobility and raw material transport distances can be misleading. Landscape and raw material qualitative characteristics are two factors that crucially affect the decisions of the moving individuals and must not be ignored. Even though Brantingham believes this exclusion to be «a necessary formality» (2006: 447), I argue that explorative theories including these factors are meaningful. Human beings, even in the earliest stages of the Palaeolithic, have never been automatons aimlessly and randomly moving on a flat uniform environment collecting whatever was there to be found. On the contrary, Palaeolithic individuals were able to optimally explore their territory, to decide what materials they wanted or needed to use in order to get the optimum results from their actions and to detect the best path/s on a rich and varied landscape in order to get to those materials' sources.

The more widely applied method in the study of raw material movement relies on quantitative models based on Geneste' s notion of techno-economic system according to which there is a distinction between a local procurement zone with a 5 km radius and a distant zone falling outside this radius and especially over 20 km (Geneste 1988a; b; 1990). Specifically, Geneste (1988a; b) proposes a model accrording to which raw material movement distances fall within a three-part system: local (a within 5 km radius), regional (a 5-20 km radius) and exotic (a 30-80 km radius).

Several scholars have attempted to determine the terms «local» and «distant» with regard to lithic procurement and exploitation and based on the analysis of several small-scale lithic assemblages from a variety of regional and chronological backgrounds. Table 3.1 summarises the models that have been reported in association with such quantitative schemes.

Author	**Model**
Renfrew C. (1968)	Supply zone: 250-350 km, Contact zone: >350 km
Byrne, D. (1980)	Local: 0-2.5km, intermediate: 2.5-10km, distant: 10-30km
Geneste, J.-M. (1988)	Local: <5km, regional: 5-20km, exotic 30-80km
Féblot-Augustins, J. (1993)	Western Europe: local (<5km), intermediate (5-20km), distant (>20km) Central Europe: local (<5km), intermediate (5-20km), distant (20-100km), exotic (200-300km)
Weniger, G.-C. (1991)	Local: <20km, intermediate: <100km, distant: <200km
Gamble C. (1996)	Local Hominid Network: 40-100km, Social Landscape: >100km
Eriksen, B.V. (2002)	On-site, local: <10km, regional: 10-50km, exotic: >50km
Fisher, L.E. (2002)	Local: <10km, regional: 10-50km, long-distance: >50km
Floss, H. (2002)	Local: 0-20km, intermediate: 20-100km, distant: >100km
Teheux, E. (2002)	Local zone: ≤20km, semi-local zone: 20-40km, distant zone: 40-80km
Bicho, N.F. (2002)	Local: 1-5km, non-local: <5km
Hahn, J. (2002)	Local: 2-5km, neighbourhood: <20km, morainic area: 50-60km, exotic:

	>60km
Brantingham P.J. (2003)	Simulation
Zvelebil, M. (2006)	Regional: <100km, inter-regional: 100-300km, long-distance: >300km

Table 3.1. A summary of the models associated with raw material movement discussed in this thesis. The presentation of the models follows the year of publication of each of them starting with the oldest.

Starting from two different ends and using two different sets of data, Eriksen (2002) and Fisher (2002) reach the same conclusions with respect to the distribution patterns of raw materials both in terms of categorisation and quantified distances. Although they adopt different names for their schemes' classes the two models are essentially the same and this is why they are presented together here. Eriksen focuses on the distribution of fossil ornamental molluscs and exotic lithic raw materials from 77 Late Upper Palaeolithic and Early Mesolithic contexts from Germany, whereas Fisher's interest is centred on stone (specifically microlithic industries) ranging over the same spatial and temporal span. Despite the exclusion of the «on-site» category from Fisher's model and the emphasis on the transferred material in the generation of the classes' names, as opposed to areas in Eriksen's system, the two models are identical in every other respect. I prefer the terminology used by Eriksen, as it emphasises the spatial aspect of the raw material distribution, and as far as I have looked into the subject of lithics movement the quantitative scheme both she and Fisher establish seems suitable for application to a wide temporal and spatial range of archaeological assemblages. My only concern regards the characterisation as «exotic» of anything coming from over 50 km. I would argue that any distance less than 100 km should not be designated as «exotic» or «long-distance» since such an approach would result in a substantial increase in the number of assemblages called «exotic» diminishing the significance of the really long-distance transported materials (especially for the later stages of the Palaeolithic) and thus their value as interpretative tools of the social phenomena they are employed to investigate.

Floss' (2002) model with regards to the Palaeolithic of the middle Rhine region has a strong potential for fruitful application to a wide range of archaeological assemblages both for the terminology it adopts and the quantitative categorisation. However, I believe that the addition of a fourth class, distinguishing between distant (100-200 km) and exotic (>200 km), could prove more informative than the current system, especially in terms of explaining hominins' behaviour and sociality. In this respect, Hahn's (2002) four-class hierarchy (but not the values he gives), for Upper Palaeolithic Buttental in particular, seems a very appropriate approach for the generation of a more satisfactory model for the phenomenon of raw material movement; such a scheme provides enough detail for a clearer perception without becoming too narrow and specific to be broadly applied.

The remaining schemes are either associated with highly localised spatial frameworks, i.e. assemblages accumulated in a site from a closely located source, as is the case with Bicho (2002) and Byrne (1980), or a period other than the Palaeolithic, for example Zvelebil (2006), so they will not be further discussed here.

Up to this date Féblot-Augustins' work (1990; 1993; 1997; 1999a; b) provides the most frequently referenced analytical framework in any discussion interested in the procurement of raw material, mobility strategies and the subsequent implications for hominin behaviour. The examination of approximately 40 stratified sites from the Aquitaine Basin served as a baseline for comparison with the rest of Europe and the identification of three zones of lithic procurement: local, intermediate and distant (with different distance limits according to region). Féblot-Augustins' research on Lower and Middle Palaeolithic Europe provides as yet the most extensive and coherent record of raw material movement. My concern regards the regional scale on which this model was built since it applies to Western Europe and, equally, it is restricted to this area. As such it cannot find a direct application to other regions of the world (for example, Africa) - not even to other parts of the same continent as a matter of fact. For example, as I will repeat in chapter 6 my own research specifically concentrating on Central European Palaeolithic obsidian use and movement has provided results that are not in agreement with the picture emerging from Féblot-Augustins' data. So, irrespective of its potential, this model is unable to facilitate comparative research. Furthermore, I have a more substantial criticism to make which regards the distances recognised as the limits of each procurement zone. I believe that the values are too restricted and skew the actual scale of the past economic and social phenomena.

The previous sections have shown that no suitable methodology has as yet been developed in raw material studies despite the archaeologists' engagement with the topic for over 40 years.

It is surprising what a great variety of opinions (table 3.1) can exist on a subject that has received so little attention; and I do not mean the range of approaches to the phenomenon under investigation. This is more than welcome. What I am referring to is the controversial opinions on the quantitative aspect of distances and their implications on hominins' behavioural and social abilities. There is no single agreement (with the only exception that of Eriksen & Fisher 2002) among the above models not only with respect to the spatial classification of raw material transport but, most importantly, on the quantitative limits of each of the spatial units on which movement is organised. Much more detailed than Higgs & Vita-Finzi's (1972) initial statement for the 10 km radius threshold as these discussed previously models may be, they do not manage to reach an agreement with regards to the quantification of the «local»-«distant» notions. It is true that in general the methodologies have been developed with respect to specific case studies of either one site or a particular region and as such a wider application is expected to prove unsuitable.

The above discussion has shown that none of the existing models is satisfactory enough for a wide regional and temporal application. All these models cannot be directly applied to archaeological data on a wide geographical and temporal scale since they are based on the scrutiny of specific raw materials and archaeological sites. Furthermore, none of these exploratory devices have attempted to explain raw material movement as something more than an economic practise driven only by utilitarian criteria.

3. DEVELOPING A MODEL FOR PALAEOLITHIC OBSIDIAN

3.1. Anatomical and Life History Implications for Raw Material Movement

Anatomy is a subject usually ignored in raw material studies; however, the link between the two themes is obvious as it is human beings that are actively engaged in the circulation of raw materials and objects. This is especially true when long transport distances, for which natural means are not a sufficient explanation, are involved in the movement of raw materials. For all these reasons it is necessary to include anatomy in the examination of obsidian circulation and investigate the extent and the ways it affected the formation of obsidian assemblages.

Table 3.2 shows all the Palaeolithic obsidian-bearing sites for which skeletal evidence for hominin presence has been unearthed (data from Johanson & Edgar 2001, Klein 1999, Schwartz & Tattersall 2002). Table 3.3 shows the hominin species related to them. It is clear that no pre-*Homo* species have been identified in direct association with obsidian movement. However, due to the general scarcity of fossil data, the Earlier Stone Age obsidian data are used as indirect evidence for the inclusion of late *Australopithecine* species in the discussion that follows. Long distance movement is dependent upon the anatomical ability for bipedalism and load-carrying.

site	**region**	**species**	**date**
Melka- Kunturé	Ethiopia	*Homo ergaster/erectus*	1.08-0.83Ma
Mumba Höhle	Tanzania	*African contemporaries of Neanderthals*	130-109ka
Porc Epic	Ethiopia	*African contemporaries of Neanderthals*	>60ka
Olduvai Gorge	Tanzania	*Homo sapiens sapiens (AMH)*	22-15ka
Lukenya Hill	Kenya	*Homo sapiens sapiens (AMH)*	18-13ka
Shanidar	Iraq	*Homo neanderthalensis*	80-50ka
Subalyuk	Hungary	*Homo neanderthalensis (early group)*	70-60ka
Kůlna	Czech Republic	*Homo neanderthalensis (late group)*	50±5ka
Bacho Kiro	Bulgaria	*Homo sapiens sapiens (AMH)*	>43ka
Stránská Skála	Czech Republic	*Homo erectus*	41-38ka?
Dolní Věstonice	Czech Republic	*Homo sapiens sapiens (AMH)*	29-26.4ka
Pavlov	Czech Republic	*Homo sapiens sapiens (AMH- archaic)*	26ka
Prědmosti	Czech Republic	*Homo neanderthalensis (late group)*	26ka

Table 3.2. Archaeological sites within the study areas which have yielded both worked obsidian and human fossils.

specimen	**species**	**region**	**arch site**	**date**
Laetoli footprints	*Australopithecus afarensis*	Tanzania	Laetoli	3.7Ma
Ileret footprints	*Homo ergaster/erectus*	Kenya	Ileret	1.51Ma
Theopetra footprints	*Homo neanderthalensis*	Greece	Theopetra	>130->60ka
Stw 573 («Little Foot»)	*Australopithecus africanus*	South Africa	Sterkfontein	3.6Ma
Hadar AL 288-1 («Lucy»)	*Australopithecus afarensis*	Ethiopia	Hadar	3.4-3.0Ma
Hadar 333-115	*Australopithecus afarensis*	Ethiopia	Hadar	3.4-3.0Ma
Omo	*Homo habilis/rudolfensis*	Ethiopia	Omo	2.3-2.2Ma
TM 1517	*Paranthropus robustus*	South Africa	Kromdraai	2.0Ma
OH 8	*Homo habilis*	Tanzania	Olduvai	1.8Ma
KNM-ER 813	*Homo ergaster*	Kenya	Koobi Fora	1.64Ma
Tabun 1	*Homo neanderthalensis*	Israel	Tabun	90Ka
Skhul 4	*Homo sapienss*	Israel	Skhul	122Ka
La Ferrassie 1	*Homo neanderthalensis*	France	La Ferrassie	70Ka
La Ferrassie 2	*Homo neanderthalensis*	France	La Ferrassie	70Ka
Shanidar 1	*Homo neanderthalensis*	Iraq	Shanidar	46Ka

Table 3.3. Hominin specimens for which fossilised foot bones are preserved (the Laetoli and Ileret footprints are included as indirect evidence of hominid locomotion). Klein (1999) mentions the recovery of two footprints in the South African Langebaan Langoon but due to the lack of diagnostic details and agreement in their dating they are not included here.

Time and space restrictions do not allow embarking into a thorough discussion of the anatomical/biomechanical aspect of hominin evolution. The relevant palaeoanthropological record (see tables 3.2 and 3.3) including the available foot fossils and the rare footprints preserved in palaeosols indicates that the hominins occupying both Pleistocene Africa and Eurasia were fully capable not only of upright standing but also walking on a bipedal mode successfully from very early on. The Laetoli footprints can convince even the greatest sceptics that bipedalism was well established by 6 My BP (for a discussion extending prior to this date see Nakatsukasa 2004). Of course, the hominin foot (and the rest of the anatomical parts associated with locomotion) did not acquire its modern shape at once; the surviving specimens indicate a gradual process with transitional stages before the development of the anatomical characteristics that match modern populations (Campbell 1998). Nevertheless, it cannot be disputed that bipedalism as a successful function dates as far back in time as the Australopithecines' era taken to its extreme with the emergence of *Homo*.

With respect to raw material movement the following observation is of critical importance: hominins' efficiency in long distance stride/walking and, occasionally, long distance running. Beginning with the Australopithecines and perfected with the appearance of *Homo* the inhabitants of the Palaeolithic world were capable of moving on a very wide spatial radius and covering long distances on the landscape. The point to be taken away is that all hominin species associated with the Palaeolithic record acquired the anatomical/biomechanical package necessary for long distance movement from the very beginnings of the Palaeolithic era. With special reference to the circulation of obsidian, the above discussion shows that its differential spatial coverage cannot be attributed to varying anatomical abilities of the species associated with obsidian. With the exception of the early Australopithecines of the Earlier Stone Age when shorter distances prevail, probably due to the transitional stage of their anatomical evolution, all the other hominin species associated with the use of obsidian were equally capable of successfully covering long distances.

3.2.1. Walking, Home Range Sizes and Movement of Mating Partners

So far it has been established that the Palaeolithic «obsidian hunters» acquired the essential anatomical and biomechanical abilities for long distance travel and hand-carrying of loads sufficient for the manufacture of effective tool-kits early on. Home ranges, as they are reconstructed based on ethnographic data and simulation approaches, will now be included in the discussion in order to examine whether the observed obsidian transport distances fall within the daily foraging radii of hunter-gatherer life, or if its acquisition required specially organised trips.

A home range is the «area typically traversed by an individual animal (human) or group of animals (humans) during activities associated with feeding, reproduction, rest, and shelter seeking» (Burt 1943). From the above statement it is clear that in ethnographic/archaeological research the concept of home range has taken up a meaning invariably connected to the acquisition of food resources (subsistence) and mating partners. Lithic resources should be included here as well; although rocks are rarely taken into account in these studies, they are of great significance in the successful accomplishment of hominin life.

The estimation of home range sizes has received a lot of attention in research and a variety of approaches have been employed aiming at the generation of the best possible approximations. Home range size is strongly correlated with body weight and the necessary bioenergetic requirements for its subsistence (see McNab 1963, Harestad & Bunnel 1979). Based on this theory a number of researchers tried to quantify population densities and group sizes of Palaeolithic societies.

The extent of «walkable» distances on a daily basis (foraging radius) is controlled by body size (stature), musculature and metabolic rate. However, even with the exhibition of excellent physical performance on behalf of the walking hominin, there are certain limits on the size of the area he/she could readily cover in a single day in the course of his/her subsistence activities. Binford's analysis of modern hunter-gatherer foraging distances (based on ethnographic sources) is very informative in this respect. Tables 3.4 and 3.5 (Binford 2001) illustrate the minimal subsistence area of foraging parties from various parts of the world divided according to sex; table 3.6 shows the size of foraging area for seven hunter-gatherer groups and the time required to cover that area and, finally, table 3.7 summarises the available ethnographic data on hunter-gatherer foraging groups. If a single value is produced from the data presented on this last table (i.e. the combined record for female and male foraging activities) by using the means of the female (6.66 km) and male (9.9 km) foraging radii that would be 8.28 km. This generated result applies to the radius of a circle encompassing ~215 km². Binford accepts as a standard unit of geographic space within which a foraging group operates the 225 km² value (generated after adjusting for the ~215 km² value; see Binford 2001: 238).

Number in party	**Round-trip distance (km)**	**Duration of expedition (hr)**	**Rate of travel (km/hr)**
1. Ten berry-picking foraging expeditions by Nunamiut Eskimo women (summer 1972 and 1973)			
3	13.5	6.7	2.01
5	14.3	5.9	2.41
3 women and 2 girls	14.6	7.3	1.99
1 woman and 2 girls	9.3	2.9	3.21
2	9.5	3.1	3.05
3	15.9	4.7	3.38
4	13	6.1	2.12
2 women and 2 girls	10.8	5.5	1.94
2	11.9	5.6	2.12
4 women and 3 girls	12.4	5.7	2.17
Total	**123.3**	**53.5**	**21.54**
Mean	**12.5**	**5.35**	**2.16**
Mean foraging radius	**5.36 km±0.98km**		
2. Three foraging expeditions by Alyawara-speaking Australian women to collect seed and bush potatoes At MacDonald Downs, Northern Territories (1974)			
4	11.3	3.6	3.06
2	12.9	6.3	2.03
3 women and several children	8	4	2.01
Total	**20**	**13.97**	**7.1**
Mean	**6.66**	**4.65**	**2.37**
Mean foraging radius	**3.33 km±0.61 km**		
3. Miscellaneous female foraging data			
3 Pitjandjara-speaking Australian women and 5 children	16.89	6.6	2.56
Anbarra women Collecting shelfish (64 day-trips)	6.1875		
Pume women	6.767		

Table 3.4. Ethnographic data on foraging distances for female-only foraging parties collected by Binford. Data from Binford (2001).

Number in party	**Round-trip distance (km)**	**Duration of expedition (hr)**	**Rate of travel (km/hr)**
1. Eight sheep and caribou hunting expeditions by Nunamiut Eskimo men (mid-summer 1972)			
2	27.4	5.6	4.89
3	25.1	9.6	2.61
2	27.7	13.6	2.03
4	23.7	10.6	2.23
2	29.7	18.7	1.58
1	15	5.1	2.94
2	23.5	10.5	2.24
1	24.9	11.5	2.17
Total	197	95.1	20.69
Mean	24.62	1.8	2.59
Mean foraging radius	12.31 km±3.96 km		
2. Sixteen hunting expeditions by Dobe !Kung males with same-day return (1968)			
1 male and 1 boy	3.7		
1 male and 1 boy	15.9		
2	11.1		
1	11.4		
2	18.5		
4	6.8		
2 males and 1 boy	9.2		
2	19.6		
5	15.6		
3	16.7		
2	20.4		
3	18.8		
2	14		
1	6.4		
3	4.2		

	3	15.9
Total		208.2
Mean		12.2
Mean foraging radius	6.1 km± 2.78 km	
3. Miscellaneous male foraging data		
Pume		12

Table 3.5. Ethnographic data on foraging distances for male-only foraging parties. Data from Binford (2001).

Group	**Foraging data**
Hadza (Tanzania)	walking time=4.15km/hr
	foraging area of single camp= 20 km^2
	foraging radius= 2.52 km
	annual foraging range= 75 km^2
	annual foraging radius= 4.89 km
Aka (Central African Republic)	foraging radius of single camp= 4.279 km
	foraging area of three 'bands'= 280, 210 and 265 km^2 respectively
	mean foraging area= 250 km^2
	mean foraging radius= 8.92 km
Bambote (Zaire)	foraging area of single camp= 80 km^2
	foraging radius= 5.05 km
Efe (Zaire)	average daily distance of hunting trips= 4.61 km
Mbuti (Zaire)	band foraging area= 133 km^2
	foraging radius= 6.50 km
	band foraging area= 107 km^2
	foraging radius= 5.84 km
	foraging area= 88.8 km^2
	foraging radius= 5.32 km
Hill Pandaram	foraging area= 79.66 km^2
	foraging radius= 5.04 km

Table 3.6. Foraging area sizes for a number of hunter-gatherer groups. Compiled by the author with data from Binford (2001).

Group	Number in party	Round-trip distance (km)	Duration of expedition (hr)	Rate of travel (km/hr)	Foraging radius (km)
1. data on women					
Nunamiut	2.9	15.9	5.35	2.16	6.26
Alyawara	3.01	10.72	4.65	2.36	5.36
Pitjandjara		16.89	6.6	2.53	8.37
Anbarra		6.19			
Pume		6.77			
Mean	**2.97**	**14.5**	**5.53**	**2.35**	**6.66**
2. data on men					
Nunamiut	2.1	26.4	11.8	2.26	13.2
!Kung	2.1	13.4			6.6
Pume		12.3			
Mean	**2.1**	**17.37**	**11.8**	**2.26**	**9.9**
males & females combined	**5.07**	**15.94**		**2.31**	**8.28**

Table 3.7. Summary of data regarding hunter-gatherer foraging trips. After Binford (2001).

Other ethnographic data combining information for body weight and diet quality (table 3.8) determine the home range size per individual (HRi) as follows (for details of the methodology employed see Leonard & Robertson 2000):

Species	**Weight (gr)**	**HRi (ha)**	**HRi (km²)**
Ache	55700	714	7.14
Guayaki	55700	387	3.87
Hadza	50000	333	3.33
!Kung	43500	1896	18.96
Mbuti	40700	588	5.88
Waorani	55000	2583	25.83

Table 3.8. Home range sizes for some modern hunter-gatherer groups. Data from Leonard and Robertson (2000). HRi (km²) data generated by Moutsiou.

The same researchers tried to estimate the home range size of fossil hominin species (table 3.9) based on two models of assumed diet quality: a) diet quality similar to that of a modern great ape, and b) diet quality similar to that of a modern tropical human forager).

Species	**HRi-Ape (ha)**	**HRi-Human (ha)**	**HRi-Ape (km²)**	**HRi-Human (km²)**
A. afarensis	46	240	0.46	2.4
A. africanus	43	227	0.43	2.27
A. robustus	44	232	0.44	2.32
A. boisei	58	307	0.58	3.07
H. habilis	54	281	0.54	2.81
H. erectus	84	440	0.84	4.4
H. sapiens	86	451	0.86	4.51

Table 3.9. Estimated home range sizes for fossil hominid species *per individual*. [HRi-Ape= home range assuming a diet similar to that of a modern ape, HRi-Human= home range assuming a diet similar to that of a modern tropical human forager]. Data from Leonard and Robertson (2000). HRi (km²) data generated by Moutsiou.

Some indications for the size of hominin home ranges can also be inferred through Wobst's (1974; 1976) models on mating network areas, developed through a simulation approach and based on the ethnographically generated observation that hunter-gatherer societies are surrounded by six neighbours. Wobst used the concepts of minimum and maximum bands in order to estimate the number of individuals within each of them and the area of a sufficient mating network at different population densities. Table 3.10 shows the distances of mating networks according to population density and based on a hexagonal territory (every group has six nearest neighbours). Given that in reality no so ideal and clearly defined spatial relationships exist, Wobst estimated the mating network distances for a number of irregularly arranged scenarios. Finally, the area and diameter of mating networks for a number of cases of population densities are given in table 3.11 followed by the summed distances from a given local group to all other local groups of a mating network at a population density of 0.01 persons/km² (table 3.12).

Population density (persons/km²)	**Area (km²)**	**Diameter (km)**
0.05	9500	120
0.04	11875	135
0.03	15833	156
0.02	23750	191
0.01	47500	270
0.009	52777	285
0.008	59375	302
0.007	67857	323
0.006	79166	349
0.005	95000	382

Table 3.10. Area and diameter of mating networks at different population densities as described by Wobst (1976).

Population density (persons/km²)	**Distance between NN (km)**	**Distance between most distant local groups (km)**	**Distance between central and most distant group(km)**
0.05	24	96	48
0.04	26	107.4	53.7
0.03	31	124	62
0.02	37.9	151.9	75.9
0.01	53.7	214.8	107.4
0.009	56.6	226.5	113.2
0.008	60	240.2	120.1
0.007	64.2	256.8	128.4
0.006	69.3	277.4	138.7
0.005	75.9	303.9	151.9

Table 3.11. Intra-mating network distances based on different population densities. Dataset compiled with information from Wobst (1976).

summed distances from central group to all other groups (closed mating system)	2157 km
summed distances from marginal group to all other groups (closed mating system)	3337 km
summed distances from any local group to the other groups it exchanges partners with (open mating system)	2157 km

Table 3.12. Summed distances from a given local group to other local groups in a mating network. After Wobst (1976).

The conclusion to be drawn from this interplay among bodies, diets, foraging radii and mating networks is that human foragers have substantially larger home ranges than predicted for their size. What is the reason behind such disproportionately large home range sizes for hominins? And where do the obsidian movement estimates fall within these reported foraging areas?

A comparison between the minimum site-to-source obsidian distances (tables 3.13 and 3.14) and Wobst's intra-mating network distances (table 3.11) reveals a striking pattern with regards to obsidian (tables 3.14 and 3.15). It becomes apparent that in the vast majority of cases obsidian distances far exceed the ones recognised between mating groups' a) nearest neighbours and b) central and most distant groups. Furthermore, in many instances obsidian distances are even greater than the ones between most distant local groups (minimum bands). When the obsidian minimum distances are used to estimate the possible home range sizes of the groups that utilised it a similar pattern emerges (table 3.13). Cases where a home range is smaller than those estimated by Wobst are not absent but instances with sizes greater than the mating networks' sizes are more common. This is especially true with respect to the Central European, Turkish and Mediterranean data (table 3.15). Assuming that choosing a marriage partner was not an activity conducted on a daily basis and thus the modes associated with it are not reflective of a common/daily process, this conclusion receives an even more crucial connotation.

	AFRICA			EUROPE			NEAR EAST	
R		Area	R		Area	R		Area
198	Mumba Höhle	123101	484	Aggsbach	735564	360	Çarkini	406944
168	Olduvai-Naisiusiu	88623	467	Krems-Hundssteig	684799	354	Karain	393492
137	Nasera	58935	471	Senftenberg	696581	359	Okuzini	404686
6	Lukenya Hill	113	385	Dolni Věstonice	465427	238	Shanidar	177862
38	Isenya	4534	410	Neslovice	527834	355	Zarzi	395719
25	Olorgesailie	1963	382	Pavlov	458201	139	Arapkir Çayi	60668
8	Enkapune Ya Muto	201	386	Kůlna	467847	103	Karatas Kaya Siginagi	33312
22	Wetherall's	1520	293	Stránská Skála	269566	36	Liz	4069
21	Cartwright's	1385	324	Nová Dědina	329625	55	Erçis	9499
12	Ol Tepesi	452	333	Předmosti	348191	186	Yüksecova	108631
24	Prospect Farm	1809	475	Kraków-Zwierzyniec	708463	137	Yazilikaya	58935
8	Kariandusi	201	43	Tibana	5806	45	Borluk	6359
28	Gamble's Cave	2462	27	Kechnec	2289	59	Kisla	10930
37	Prolonged Drift	4299	7	Bodrogkeresztúr	154	3	Acigöl Etekleri	28
8	Elmenteita	201	72	Istállóskö	16278	5	Kalatepe Deresi	79
8	Kilombe	201	42	Püskaporos	5539	129	Erikli Deresi	52253
36	Songhor	4069	52	Diósgyőr-Tapolca	8491	16	Suvermez	804
87	Muguruk	23767	53	Mexicóvölgy	8820	205	Pendik-Hacet Deresi	131959
2	Kapthurin A	13	215	Hermam Ottó	145147	205	Domali-Alacali	131959
21	Kaptabuya	1385	56	Széléta	9847	163	Parganli-Kerpe Arasi	83427
46	KFR-A5	6644	74	Kecskésgalya	17195	124	Kudaro	48281
8	Melka	201	2	Cejkov	13	28	Erivan	2462

	Kunture							
161	Gadeb 8E	81392	305	Ságvár	292099	57	Azych	10202
5	K'one	79	228	Mogyorósbánya	163230	49	Tsalka	7539
40	Erer	5024	216	Esztergom-Gyurgyalag	146500	46	Trialeti	6644
33	Aladi Springs	3419	202	Dömös	128125	29	Satani-dar	2641
9	Porc Epic	254	192	Nógrádveröce	115753	2	Dzhraber	13
77	Kulkuletti	18617	206	Szob	133249	12	Arzni	452
77	Gademotta	18617	204	Pilismarót-Díos	130674	114	Ortvale Klde	40807
4	Modjio	50	13	Arka	531			
11	Little Gilgil	380	23	Hidasnémeti	1661			
191	Magosi	114550	2	Kašov	13			
8	Ntuka	201	46	Sajóbábony	6644			
43	Ntumot	5806	106	Ballavölgyi	35281			
8	GtJi15	201	63	Büdöspest	12463			
42	Shurmai	5539	61	Farkaskö	11684			
36	Kakwa Lelash	4069	68	Subalyuk	14519			
56	Aduma	9847	39	Barca I&II	4776			
168	HWK-East	88623	136	Jászfelsőszentgyörgy	58077			
			45	Görömböly-Tapolca	6359			
			46	Sajószentpéter-Nagykorcsolas	6644			
			82	Ëger	21113			
			12	Malyj Rakovets	452			
			198	Pillisszántó	123101			
			294	Amaliada 13	271409			
			623	Bacho Kiro	1218725			

Table 3.13. Home range sizes estimated by the obsidian movement. The minimum source-to-site distances serve as the radius of the circle that encompasses the home range area of a foraging group. [*R*= km; area= km²].

AFRICA		EUROPE		NEAR EAST	**WOBST**
area		*area*		*area*	*area*
123101	5806	735564	35281	406944	**9500**
88623	201	684799	12463	393492	**11875**
58935	5539	696581	11684	404686	**15833**
113	4069	465427	14519	177862	**23750**
4534	9847	527834	4776	395719	**47500**
1963	88623	458201	58077	60668	**52777**
201		467847	6359	33312	**59375**
1520		269566	6644	4069	**67857**
1385		329625	21113	9499	**79166**
452		348191	452	108631	**95000**
1809		708463	123101	58935	
201		5806	271409	6359	
2462		2289	1218725	10930	
4299		154		28	
201		16278		79	
201		5539		52253	
4069		8491		804	
23767		8820		131959	
13		145147		131959	
1385		9847		83427	
6644		17195		48281	
201		13		2462	
81392		292099		10202	
79		163230		7539	
5024		146500		6644	

3419		128125		2641	
254		115753		13	
18617		133249		452	
18617		130674		40807	
50		531			
380		1661			
114550		13			
201		6644			

Table 3.14. Summary of the East African, Central & South-eastern European and Near Eastern home ranges sizes as estimated by MIN obsidian distances compared with Wobst's mating networks' home range sizes (measured in km²).

AFRICA	EUROPE		NEAR EAST	**WOBST NN**	**WOBST C-D**
198	484	45	360	**24**	**48**
168	467	46	354	**26**	**53.7**
137	471	82	359	**31**	**62**
6	385	12	238	**37.9**	**75.9**
38	410	198	355	**53.7**	**107.4**
25	382	294	139	**56.6**	**113.2**
8	386	623	103	**60**	**120.1**
22	293		36	**64.2**	**128.4**
21	324		55	**69.3**	**138.7**
12	333		186	**75.9**	**151.9**
24	475		137		
8	43		45		
28	27		59		
37	7		3		
8	72		5		
8	42		129		
36	52		16		

87	53		205		
2	215		205		
21	56		163		
46	74		124		
8	2		28		
161	305		57		
5	228		49		
40	216		46		
33	202		29		
9	192		2		
77	206		12		
77	204		114		
4	13				
11	23				
191	2				
8	46				
43	106				
8	63				
42	61				
36	68				
56	39				
168	136				

Table 3.15. Summary of the East African, Central & South-eastern European and Near Eastern MIN obsidian distances compared to Wobst's nearest neighbour (NN) and central to most distant (C-D) groups distances.

Based on the information provided in this section, obsidian shows a stronger correlation to the model of partners' movement/exchange than to that of food resources (plants and animals). In other words, the patterns underlying obsidian movement resemble those of the movement of people, a process during which groups exchange individuals but also get in touch, communicate, socialise. Subsequently, in order to understand and explain the extent and modes of obsidian exploitation an interpretative model based on humans and their social abilities/preferences must be adopted.

3.3. Birth Spacing, Load-carrying

Bipedalism is admittedly an effective mode of moving on the landscape but it is beyond doubt that the hominins we are interested in were not roaming on the Palaeolithic world without any load even if this was restricted to a basic tool-kit. It seems necessary then to investigate the effect of load-carrying on the locomotor abilities of those hominins and the distances they could travel on a single journey for the acquisition of raw materials such as obsidian.

An examination of the fossil record with regards to the load-carrying abilities of the various hominin species (Wang *et al.* 2003, Wang & Crompton 2004) suggests that *Australopithecus afarensis* could only have carried loads equivalent to 15-50% of their upper limb weight while maintaining swing symmetry, the early forms of *Homo (Homo ergaster)* could carry loads three times heavier than their upper limb mass and, finally, modern humans would have been capable of carrying up to eight times their upper limb mass. Subsequently, the IMI (intermembral index) of *Homo* is optimised for hand-carrying of loads indicating that the species of the human lineage were fully adapted to erect locomotion while carrying loads on their hands.

Load-carrying while walking would have been a particularly essential ability for the female hominins with children in an early age. Increased bipedalism and tool using in the collection of food resulted in hominin offspring increasingly relying to their mothers for their successful survival (Tanner 1981: 162). Females' parental investment was not restricted to internal gestation, birth and nursing of their offspring. They also had the responsibility to provide their newborns with physical care, protection and food. Irregular supplies of food would have been particularly problematic both for lactating women and growing children. Infants and offspring up to four or five years of age or even older would have to be carried at least part of the time by their mothers (Tanner 1981: 150). Bipedalism freed the arms and hands of the females and allowed them to move over large areas while carrying their children, supplies for the children (e.g. water), their tools and the gathered food (assuming that female movement involved «gathering excursions»). The marked skeletal and muscular robusticity of the Neanderthals is indicative of the high levels, occasionally including their participation in large game hunting, female activity would have reached during the Palaeolithic (Kuhn & Stiner 2006). Ethnographic parallels include bush women in the Kalahari who have been observed to carry their children up to about three years of age (Draper 1976). After that age they usually leave them in camp because otherwise they would have to carry water for them or pick them up and carry them if they get too tired to walk making the food gathering procedure more difficult for them.

It is difficult to quantify the loads that could have been successfully carried by the Palaeolithic hominins in their daily movements. The example of the females illustrated above suggests that the weight would have been significant. Containers (Gamble 2007) were most likely in use for the carrying of the various objects but their absence from the archaeological record does not permit any inferences with regards to their carrying capacity. Modern ethnographic accounts are instead used as a proxy of the coverage areas and load-carrying. Examples from various parts of the world illustrate a mixed record of the load that can be effectively carried on the landscape by anatomically modern humans: for Mesoamerica 30 kg have been carried for 8 hours over 36 km (Drennan 1984a; b), in Thailand an average carrier could travel 29 km with a load of 27.2 kg, in Africa the Bemba have been reported to cover approximately 15-20 miles on a daily basis carrying 50 pounds on their heads, in Tibet the usual load-carrying is 90 kg for distances over 10 km and 177 kg for shorter distances while in exceptional cases a Kashmiri (India) can habitually carry 192 pounds and as much as 240 pounds for over than 100 miles (Devine 1985).

The comparison of the obsidian transport data with the results of other studies from the ethnographic and palaeoanthropological record showed that the obsidian distances exhibit a stronger correlation with movement for reasons other than subsistence, i.e. Wobst's mating network. The implication is that the circulation of obsidian during the Palaeolithic was controlled by factors unrelated to economic phenomena. An alternative scenario, emphasising a behavioural interpretation to the observed patterns, will be proposed and investigated in this thesis. Prior to that, the theoretical framework of the proposed model needs to be discussed.

4. SOCIAL NETWORKS IN THE PALAEOLITHIC

«*The social network perspective starts with individual actors and observes their social, economic, political and communicative ties to others and the emerging patterns of order. In social networks, resources are unequally distributed and the particular locations of actors the network provides opportunities and constraints for action*» (Schweizer *et al.* 1997: 740).

The concept of networks as an analytical technique has independent beginnings in several disciplines; social network analysis in particular has been established as a cross-disciplinary research paradigm in the social and behavioural sciences. Networks have been used in economic anthropology largely associated with the notion of social exchange, in ethnology, sociology and human geography applied as sociometric network theory, and in economic geography as movement theory (Beschers & Laumann 1967, Haggett 1969, Mitchell 1969). In all these instances, networks were used in a discussion of pre-existing social systems relying on economic/exchange systems and depending on the value of the moving objects (Haggett 1965). Epstein (1969) in particular worked towards the definition of specific networks by distinguishing between effective, i.e. communication through multiplex linkages of great density, and extended, i.e. more specialized relations, networks and their equivalents in larger regional interaction patterns.

In archaeology, networks were initially introduced by Irwin-Williams with the aim to discuss the notions of reciprocity, distribution and trade of materials using a coherent quantitative methodology. Within this framework, networks are implicitly connected to the concept of exchange which is considered «…a form of interaction that creates and reflects specific socioeconomic linkages between individuals, groups, societies...» (Irwin-Williams 1977: 142). Sahlins (1965) concentrated on the distinction between types of «primitive» exchange (reciprocity and redistribution), Binford (1962) was more interested in defining classes of goods according to their systemic function (ecotechnic, sociotechinc and ideotechnic) whereas Renfrew (1977) provided a quantitative model for discussing exchange (down-the-line-model). All in all, the term «network» came to be regarded as «exchange network» exclusively associated with the movement of objects of material culture (characteristic of this direction is the 1977 volume of *Exchange systems in prehistory* edited by Earle & Ericson). As such, «networks» were only used in describing economic phenomena and in association with events dating to late prehistory. In several instances, the social and behavioural aspects of those economic transactions were acknowledged but always remained in the background. Most importantly, the formation and development of networks to a period prior to the Neolithic remained an unexplored scenario.

Wobst (1974; 1976; 1978) was the first archaeologist to bring the concept of networks and the Palaeolithic period together. Wobst acknowledged that Palaeolithic archaeology lacked an analytical concept compatible with the «society» of ethnology or with the «population» of general ecology and tried to remedy this situation with the introduction of mating networks as a model that would allow Palaeolithic archaeologists to organize and integrate socio-cultural processes that relate individuals and populations. In brief, Wobst categorises social interaction into minimum and maximum bands and examines the way communication is established within each of them bringing together the members of those groups into smaller (intra-band) or larger (inter-band) social units, with special emphasis on the choice of a partner. Although Wobst's model does not make explicit use of the social networks theory it introduces a spatial and demographic element in Palaeolithic research, concepts that were traditionally related to other disciplines or later periods (see above).

Despite their contribution to scientific research, none of the above scholars discussed the origin of networks and the way they evolved on the social landscape. By not doing so, they assumed that networks are external pre-existing systems imposed on already organised societies. However, this is not the case. Networks shape social relationships and they are formed by them; they create the social landscape and they are further developed by it. So, by understanding how networks are created and how they operate, it is possible to comprehend how the first social bonds were created and the first societies organised. The first to connect networks, material and hominin movements and their social/behavioural implications into a united whole was Gamble (see later section for a detailed description); what is more, he did it using a Palaeolithic temporal framework. Recently, other researchers have applied the network concept within a broader Palaeolithic context, e.g. Marwick (2003; using exchange networks as evidence for the evolution of language), although the connection to economic events remains as strong as ever.

4.1. Local versus Extended Networks

Gamble applied network models in Palaeolithic archaeology aiming to achieve a better understanding of human social evolution. In his 1996 paper, Gamble introduces two social networks, namely the Local Hominid Network (LHN) and Social Landscape (SL), as the two socio-spatial units that characterise hominin life on the Palaeolithic environment. These two units are mainly associated with the social aspect of hominin life in the past, but quantitative information is also provided for a better perception of the scale of each of these regions. Although the application of these regional social units to the archaeological record are mainly associated with the possibility for a better understanding of human evolution, they also, and most importantly in the context of the current project, define the dimensions of these social systems. The big contribution of the Local Hominid Networks and Social Landscapes is that they provide a quantitative framework for the analysis of social organisation. In defining the dimensions of these socio-spatial units Gamble relies on Geneste's data on Middle Palaeolithic raw material movement in south-west France. According to Geneste (1988a; b) the raw material movement distances follow a three-part system: local (a within 5 km radius), regional (a 5-20 km radius) and exotic (a 30-80 km radius).

For a presentation of the model under discussion see Gamble (1993; 1996; 1999) where all the details of the model and definitions are provided. Here I will only present the core of the model, the two networks and their dimensions, as it is them that offer the means to a quantitative approach of the scale of social life in the Palaeolithic.

- <u>Local Hominid Network:</u> this first order regional system emphasises the individual and his/her daily decisions and it encompasses other hominids, non-hominid competitors and resources. It is the «immediate spatial forum for the negotiation and reproduction of social life» (Gamble 1996: 254); social life which is performed in a highly varied way but it always remains complex and socially and spatially limited. «Complex» here is meant as the embracement of many objects where the capacity for simultaneous transactions sets a limit to what can be achieved in terms of social arrangements (Rowell 1991: 260).

- Scale of Local Hominid Network: the radius of raw material transport and movement of individuals is estimated at 40 km; the upper limit of such a network is indicated as an 80-100 km radius (Gamble 1993). Within this radius «we can refer to all activities as local in terms of their social and organizational implications» (1996: 256, 269).

- Social Landscape: this is a second order system which is centred on the group rather than the individual; more precisely, the social landscape consists of a number of available local hominid networks and is constructed by negotiation. The crucial difference between a Social Landscape and a Local Hominid Network is that in the first case it is not necessary for an interaction to take place in order for social life to be constructed. Just the possibility of such an interaction/negotiation is enough. At this point we are dealing with a really spatially extended and socially complicated life. «Complicated» is the social life where the negotiation of one variable at a time makes it seem as a succession of simple operations and, thus, less complex (Strum & Latour 1987: 791).
- Scale of Social Landscape: the geographical limits of such a network are harder to define; basically, everything in a radius over 100 km belongs to this unit and no upper limits to its spatial dimensions can be established. Archaeological and ethnographic examples of long-distance movement of materials are used with the aim to give an estimation of the area a social landscape may encompass. The transfer of material mentioned refers to stone in the Lower and Middle Palaeolithic and stone, shells, ochre in the Upper Palaeolithic, late prehistory and recent hunter-gatherers. All these objects have been recorded moving over distances ranging from 600 km to 2,000/3,000 km; it is distances of this scale that Gamble presents as possible dimensions of the social landscape.

In general, Gamble's model provides a satisfactory way of approaching the behaviour of our earliest ancestors. However, there is a feature of the model that I do not find persuasive. I am not particularly convinced by the dimensions Gamble uses in defining the scale of his two networks. The boundaries of the two different systems are not precisely enough defined making the application of the model to empirical data problematic.

5. A MODEL OF PALAEOLITHIC OBSIDIAN USE AND MOVEMENT

The discussion so far has shown that although studies on raw material movement and social networking are on the right track on providing useful insight on the Palaeolithic past, still need some elaboration. In order to do so, I arbitrarily distinguish distances in two orders: 10 km and 50 km and examine how obsidian behaves within each class. The results of this analysis constitute an objective tool in interpreting 'local' and 'exotic' distances on a world-wide scale and form the basis for a universal model of social networks. I argue that by using obsidian as my analytical tool this caveat can be overcome. The models are not wrong; they are just site-specific and as such they cannot be applied on other sites or large scale phenomena. According to the perception generated by the obsidian data on a worldwide scale and running a deep chronological sequence a social networks model has been developed with the aim of satisfactorily bringing together raw material movement distances and social relationships. It is argued that Palaeolithic research will only benefit from the application of social concepts into an archaeological period that has traditionally not considered such issues. A social network model emphasising a behavioural interpretation is much better suited to explain the obsidian circulation patterns.

A strong link binds together material culture and hominin social life. Similarly to other materials, the circulation of obsidian was a practice that brought Palaeolithic individuals together in interactions through which they negotiated their social lives and built their social environment. Those interactions helped the creation of hominin relationships which differed in quality and content based on the distance between the individuals involved in the obsidian transfers. Social networks were created as a result of relationships exhibiting distinctive spatial boundaries and, more importantly, unique/individual behavioural connotations. These component networks work together to create the social environment of the communicating individuals any time interaction occurs. They are likewise variable in the use of space and resources. However, it is feasible to investigate them through the movement of obsidian artefacts. Obsidian transfer ranges define the networks which contributed to the negotiation of society during the Palaeolithic. Moreover, the flows and use of obsidian and particularly its circulation distances facilitate the examination of qualitative and quantitative changes of these networks at particular times and places.

The social network model put forward here argues that communication and a feeling of relatedness can be achieved even when great distances are involved as long as: a) the exchanged material has the power to clearly communicate messages to a wide spatial scale and, b) the hominins have the behavioural ability to create interactions to such scales and the cognitive capacities to translate the conveyed messages. Interaction occurs both in face-to-face contacts (co-presence) and from a distance (*in absentia*). Although both types of communication are vital in the creation of the social environment different degrees of behavioural/cognitive complexity are implied in each of them. Interaction during co-presence is easy to be achieved. On the contrary, communication *in absentia* requires advanced cognitive capacities controlling the behaviour of the participating hominins. The ability for the affirmation of alliance through long-distance exchange is considered the trademark of modern hominin social behaviour. It allows an individual to overcome otherness by bringing selected persons into his/her personal network (Gamble 1998: 433) and it implies the ability to successfully conceive materials as symbols.

Undoubtedly, the use of artefacts as a means of transferring messages and social representations in a symbolic form enabled Palaeolithic hominins to negotiate their social landscape to a limitless scale. This skill is traditionally perceived as an Upper Palaeolithic development absent from the hominin social interactions of earlier periods. Previous studies argue that the major breakthrough in Palaeolithic society occurred when hominin interactions changed to encompass a global scale and materials empowered with a symbolic form.

Using the obsidian movement ranges as a proxy for the scale of social interactions in Africa and Eurasia a social network model was developed in order to investigate the scale of social life during the Palaeolithic. Drawing upon the same data, the timing of this breakthrough will be addressed and the implications regarding hominin behavioural evolution will be discussed (chapter 8). Based on the classification scheme of the distances obsidian travels on the Palaeolithic landscape a model of five networks was developed. Each of these five units has distinctive spatial boundaries and is characterised by a differing level of interaction intensity. The recognition of spatial boundaries among these networks does not mean that the hominins were restricted in a single network in their ability to interact. The same individuals could negotiate their lives in a local or a larger scale depending on the demands they aimed at fulfilling. The social landscape that these five networks illustrate is not a pre-existing entity into which individuals entered when communicating; it is rather a creation occurring every time two or more people interacted. What seems to change with time, as the obsidian data suggest, is the upper limit of this created environment.

5.1. The Model

Based on the distances of obsidian circulation discussed defined in the units mentioned in the beginning of this section the model graphically illustrated in figure 3.1 was generated. A comparison with earlier studies (Féblot-Augustins 1997; 1999 and table 3.1) that attempted to build network models of hominin movement has provided clear indications of the limitations of the existing models in explaining the patterns the analysis of the obsidian movement has brought to light. The dimensions and social connotations of the five networks will be presented in this section whilst the results of their application to the obsidian dataset will be addressed in chapter 6.

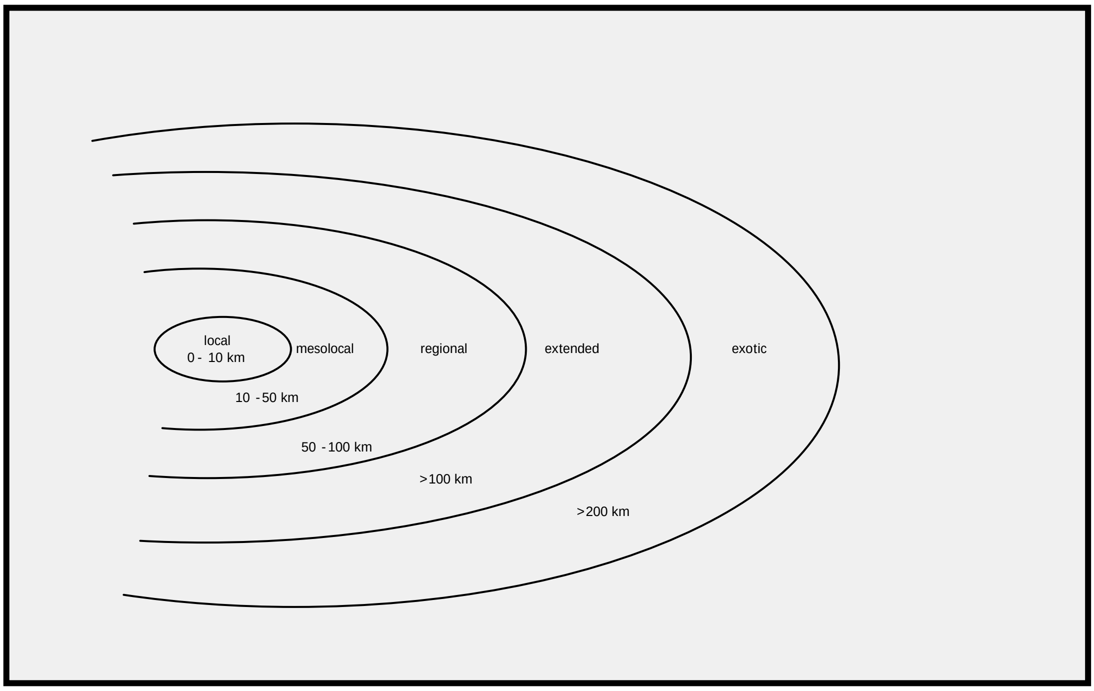


Figure 3.1. A scheme for converting raw material distances to spatial units of social networking.

Local: associated with a spatial radius of 1-10 km, an area easily covered on a daily basis. The local network is the «immediate spatial forum for the negotiation and reproduction of social life» (Gamble 1996: 254). The handling of artefacts within this network does not require an exchange system and the materials are but part of the locally available resources. Interactions are strictly face-to-face but intimate as they involve the communication of personal emotions (similar to primate grooming). Although it cannot be proved, the co-presence of close kin/family members must be expected.

Mesolocal: site-to-source distance ranging from 10 to 50 km. Within this area the transport of materials is again an easily accomplished task irrespectively if it is embedded on a subsistence strategy or not. The hominin interactions taking place within this spatial unit follow a face-to-face mode although it does not necessarily involve the intimacy levels of the local network. The immediate neighbours with whom communication occurs on a daily basis form this network. A certain degree of relatedness is established through daily encounters resulting in the communication of materials and emotions functioning as safety nets in times of stress.

Regional: site-to-source distance ranging from 50 to 100 km. The acquisition of raw materials and other items within this range is not a task whose fulfilment could have easily been achieved as part of a more general subsistence system. On the contrary it requires the establishment of a basic exchange system within which some face-to-face interaction may occur (likelihood of encountering), possibly in times of stress, but the co-presence is not necessary for the movement of materials. The interactions that take place within the regional network are better regarded as temporary coalitions between acquaintances. The materials exchanged within this framework are objects that only carry their net value (practicality).

Extended: a wide range of source-to-site distances exists within this network but its upper limit does not exceed 200 km. In such a spatial scale the acquisition and distribution of materials is an activity with distinctive rules completely independent from a general subsistence system. A specially organised exchange system is necessary for the circulation of items as this task is no longer part of habitual action. The creation and maintenance of social relations within this network requires special effort from the participating parties. The ability to forward plan and retain social bonds over a distance is crucial in the successful functioning of the extended network (social extension). The items that are exchanged here acquire a use-value that denotes them with the power of acting as symbols. Sophisticated behavioural/cognitive abilities on behalf of the hominins involved in these networks are a prerequisite for the successful operation of these networks.

Exotic: the spatial scale of this network exhibits only a lower limit, namely 200 km, and no upper boundaries. As in the previous case, the exploitation and circulation of materials does not comply with any other but its own rules based on forward planning and the development of a web of social relationships that extend to truly distant areas. No face-to face interactions can occur in this scale but communication is achieved *in absentia* through the exchange of items empowered with high affordances (use-value). Materials lose their utilitarian functions completely in the exotic network and purely function as symbols bringing strangers together. Objects are denoted with social value as through their rarity and scale of transfers they create a feeling of relatedness to otherwise complete strangers. The behavioural/cognitive capacities of the participating hominins are characterised as essentially modern.

The networks presented here should not be regarded as inclusive territories controlling the movement of Palaeolithic hunter-gatherers. Similar to Gamble's (1999) paths and tracks my networks are lines that bring people together and enable them to interact to different spatial levels and degrees of complexity. The circulation of obsidian that takes place along those paths functions as the mean for the negotiation of the social lives of the individuals participating in its exchange. As such, its patterns can be used as a proxy for the exploration of the scale of the Palaeolithic social environment.

Chapter 4

Methodology

1. INTRODUCTION

The *modus operandi* that forms the core of this thesis will now be presented. A twofold procedure was employed: initially, all the available information from the relevant literature was gathered and then five sites were chosen to serve as the representatives of their regions/periods in the form of case studies. By way of facilitating reading, I have separated this chapter into two major sections: in the first part the data collection based on literature research is presented whereas in the second the emphasis is shifted to the case studies. In the final part, the problems and limitations of the methodology employed will be discussed, as these also have an effect on the overall assemblage analysis and their subsequent interpretations.

2. BASIC TERMINOLOGY

Before moving on to the presentation of the actual methodological issues related to this thesis it is essential to clarify some of the terms that will be repeatedly used throughout this project and are central to this research.

Regions: The regional framework on which the present project takes place is divided into a number of smaller spatial units with the aim of generating a meaningful dataset and facilitating a comparative analytical procedure. There are three regions under examination (see section 3.2.2. of previous chapter). The distinction does not comply with modern country boundaries; rather a different method of artificial spatial separation is developed. The criterion for the division of the specific spatial units is the adoption of a scale that would enable general but meaningful comparisons among the chosen different parts of the world. A country-level scale would unnecessarily complicate things; conversely an all encompassing scale would not make any sense. Furthermore, the study area is dictated by the available data density. The approach followed here may still not be the best reflection of the past, but it is the best way of getting a fruitful glimpse of that distant period of time.

Sites: A «site» is defined as any occurrence of archaeological obsidian without taking into account its horizontal (spatial) and vertical (stratigraphic) extent or appearance; in this sense the sites analysed as part of this research are better described as «findspots», i.e. singular points on the landscape. This choice was founded on the amount of data and the need to treat them all equally in answering the project's first main question, i.e. the presence and extent of obsidian in Palaeolithic contexts.

Sources: The definition of what will constitute a «source» in the present research was a more difficult issue to handle mainly because of the differing implications the term has in different disciplines. Geologically, the limits between two or more lithic sources are defined by their discrete chemical signatures with distinctions even between flows and outcrops of the same volcanic origin. Recent scientific advancements have provided the technical ability of determining obsidian subsources by separating obsidians with distinct sub-signatures (Eerkens & Rosenthal 2004). However, for the purposes of this research such a distinction was neither feasible nor meaningful. The obsidian sources under examination do not exist as extensive volcanic fields comparable to the American sources on which the Eerkens & Rosenthal (2004) study has concentrated. For the purposes of my project, a «source» is defined as any occurrence of geological obsidian with characteristics that would allow successful production of artefacts but no evidence of such a process, i.e. knapping, is present within its geographical limits. Moreover, the different outcrops of the same volcanic event that produced them are perceived as a single obsidian source even if there is some variability with respect to their chemical characteristics.

In accordance with the above definitions, stone quarries are not included in the «sources» category, despite being geological sources of lithic raw materials. The preservation of on-site exploitation evidence makes their inclusion to the «sites» category more appropriate. Quarries are a special feature on the archaeological landscape from which extremely interesting inferences with respect to human behaviour can be drawn. Quarries with clear extraction structures dating to the Palaeolithic have only been documented from Egypt (the

Middle Palaeolithic sites of Nazlet Khater, Nazlet Safaha and Beit Allam with evidence for chert quarrying) so far (Vermeersch 2002). Obsidian quarries were in operation during later prehistory, especially in the Neolithic, receiving a high degree of popularity in certain instances (the island of Melos is a characteristic case: see Torrence 1982). However, no obsidian quarries in association with Palaeolithic exploitation have been located in any of the regions under examination or any other part of the world where Palaeolithic man has reached. There are a few instances (interpreted as workshop areas) where procurement of obsidian seems to have taken place in the proximity of a geological source, for example the Ethiopian sites of Gademotta and Kulkuletti (Wendorf & Schild 1974), but these cannot be considered as quarries *per se* as they also exhibit evidence of habitation and they, thus, conform to the «site» category.

3. PRACTICAL PARAMETERS OF THE METHODOLOGY

3.1. Framework for Data Collection

The choice of the specific attributes that will be discussed below was based on the concept of the *chaîne opératoire* (term coined by Leroi-Gourhan 1964; 1993) and more recently reviewed by Pelegrin *et al.* 1988, Pelegrin 1993, Sellet 1993) and the idea that the effect of distance on lithics is echoed at it. In other words, the material forms that individual actions take (i.e. chaîne opératoire) can be ordered into a number of different production stages beginning with raw material acquisition and ending with the discard of the utilised artefact. The concept of the operational sequence is usually discussed in association with topics such as intentionality, agency (e.g. Dobres & Robb 2000) and decision making (e.g. Perlés 1992) but here it will receive a more dynamic character. The various production stages of the analysed assemblages are reported with the aim of examining the ways and extent to which distance affects lithic tool manufacture. In addition, the utilisation of the chaîne opératoire as an interpretative framework in lithic production will serve as a means to examine the patterns of hominin interaction with obsidian as a natural resource and, thus, allow for the elucidation of Palaeolithic social behaviour.

3.1.1. Typologies

The use of the chaîne opératoire concept as the main interpretative framework for lithic production placed greater emphasis on a technological categorisation of the analysed lithic assemblages. By doing so it freed them from the «fallacy of the finished artefact» (Davidson & Noble 1993) and the restrictions of a pure typological classification scheme. However, some basic typological distinction was necessary and for these instances a simplified version of Bordes' (1961) typologies was used. For both the global dataset and the case studies a very basic typological classification scheme is adopted, followed by a more detailed typological distinction only in the analysis of the specific sites' obsidian assemblages.

3.1.2. Definitions of Lithic Terminology

The general criteria and terminology for lithic analysis as put forward by Inizan *et al.* (1999) formed the basis for the recording and analysis of the individual lithic assemblages. Based on this scheme a definition of the following terms is necessary.

Débitage: although in the wide archaeological literature this term is usually associated with waste here a different approach is employed. According to Inizan *et al.* (1999: 138) débitage is «a term conventionally used to denote the intentional knapping of blocks of raw material, in order to obtain products that will either be shaped or retouched, or directly used without further modification». In this thesis the term débitage is associated with the primary products of the knapping procedure, namely flakes and blades.

Debris: this term refers to shapeless fragments that cannot be assigned to any categories of objects; as such it is taken to mean the waste products of the knapping procedure.

Cortex: cortex is defined as an alteration of the outer part of a block of raw material (Inizan *et al.* 1999), an integral part of the raw material in its natural condition. Its presence and extent on the surface of the analysed artefacts provides information about the management of the raw material and stage of tool manufacture. Cortex on obsidian is relatively easily defined and ascribed with certainty and, thus, it constitutes an important parameter of the final analysis.

Retouch: retouch is defined as any removal obtained by percussion or pressure with the intention of making, finishing or sharpening tools (Inizan *et al.* 1999). Retouch is considered a crucial parameter in understanding the effect of distance on raw material procurement and the behavioural implications of the phenomenon since it allows prolonged use of far-travelled material.

3.2. Global Dataset

3.2.1. Framework for Data Collection

The first section of the data collection involves the recovery of all the existing published information with regards to the use of obsidian in Palaeolithic contexts from Africa, Europe and the Near East. The research for the acquisition of these data has followed a purely literature investigation method. A wide range of sources, not confined solely to excavation reports, Anglophone documents or very recent publications, was consulted.

Why this period?

The choice of the Palaeolithic is based on the observation that obsidian was very differentially represented among the various stages of prehistory. In particular, it is extremely popular from the Neolithic onwards but it does not appear to be commonly utilised in earlier periods. Given that the Palaeolithic individuals were the pioneers in the use of stone it seems peculiar that obsidian is almost absent during this stage. My research aimed at filling this gap and it can now be securely stated that obsidian is present, and in many instances preferred, in the Palaeolithic. The decision not to restrict my investigation to a certain substage of the Palaeolithic is based on the desire to test how the phenomenon develops over time. In terms of the second big question that my thesis aims to approach, social evolution and behavioural modernity, the study of the Palaeolithic in its totality was deemed necessary for the investigation of the first documented manifestation and the subsequent development of the signs traditionally associated with modern behaviour.

Why these regions?

Putting aside the obvious reason that for this part of the world obsidian formations are only found in the areas under examination, the selection of the particular regional units is based on the fact that their occupation spans a longer period, especially with respect to Africa and Europe, than those from other areas where obsidian and Palaeolithic horizons have been found in association, as in Australia. In addition, East Africa is usually perceived as the homeland of modern humans and I wanted to investigate to what extent raw material movement supports this argument. This would not have been possible without comparing it with another region, but in order to provide a fair judgement a common frame of reference was needed. Obsidian constitutes this common reference point and when examined in a wide regional scale, fruitful inferences can be made. Finally but equally importantly, I wanted to separate my research from the popular method of microscale regional studies and examine the obsidian use interregionally, i.e. in more than one area of the Palaeolithic world, my aim being to build a comparative cross-cultural framework of the phenomenon.

3.2.2. Recorded Criteria

The data provided with each obsidian-bearing Palaeolithic site are:

Site: name of site with evidence of obsidian use dating to the Palaeolithic

Age: a general chronological framework of archaeological horizons where obsidian presence has been identified; although I do not intend to imply that any of the substages of the Palaeolithic are the exact equivalent of the respective Stone Age substages I record them as being chronologically equivalent for simplicity's sake. A three-part classification scheme is adopted («Palaeolithic» is for Europe and the Near East and «Stone Age» is for Africa):

1. LP/ESA: Lower Palaeolithic/Earlier Stone Age

2. MP/MSA: Middle Palaeolithic/Middle Stone Age

3. UP/LSA: Upper Palaeolithic/Later Stone Age

In terms of absolute dates (table 4.1) the above classification scheme translates as follows:

AFRICA		EUROPE	
period	**chronological boundary**	**period**	**chronological boundary**
Earlier Stone Age (ESA)	2.5 Myr-300 kyr	Lower Palaeolithic (LP)	~1 Myr-300 kyr
Middle Stone Age (MSA)	300-40kyr	Middle Palaeolithic (MP)	300-40 kyr
Later Stone Age (LSA)	40/30-10 kyr	Upper Palaeolithic (UP)	40-10 kyr

Table 4.1. Chronological boundaries of each of the Palaeolithic/Stone Age sub-phases examined in this project.

Region: name of region of sites under investigation; a three-part classification scheme is followed in this project:

1. East Africa (Ethiopia, Kenya and Tanzania)

2. Central and South-eastern Europe (Hungary, Slovakia, Ukraine, Poland, Czech Republic, Austria, Greece, Bulgaria)

3. The Near East (Turkey, Armenia, Georgia, Azerbaijan)

Quantity: quantities of obsidian recovered from the Palaeolithic horizons of the sites under examination. Due to the differential quality of the available data an ordinal system has been developed making use of the concept of percentages instead of exact counts:

1. Minor (1-10%)

2. Moderate (10-30%)

3. Frequent (30-50%)

4. Majority (51-95%)

5. All (95-100%)

6. Undetermined (any quantitative inference missing)

Typology: typology of the obsidian assemblages (in total) based on the form of the most abundant category of obsidian specimens; seven broad groups are recognised:

1. débitage (flakes/blades)
2. cores
3. SRTs/LCTs (small retouched tools/large cutting tools)
4. nodules
5. debris/waste
6. all products
7. not specified

Chaîne opératoire stages: the above information is translated into the following phases of the manufacture process:

1. Stage 1; raw material procurement
2. Stage 2; primary reduction
3. Stage 3; secondary reduction 1
4. Stage 4; secondary reduction 2 & use/discard of tools
5. All stages; complete sequence

Literature source: name of the author(s) who provided the data and publication date of the relevant article/ book.

3.2.3. Digitisation of Data

The second large set of data is associated with the recording of the distances of obsidian movement in the areas where its presence has been confirmed. Some difficulty was encountered in the identification of the exact location of the sites in this study since the inclusion of sites' coordinates in the publications that were consulted was not a common practice. When this information was available it was used; when it was lacking the coordinates were indirectly estimated by locating their closest neighbours mentioned on a map.

A Geographical Information System (GIS) formed the basis of the digitisation process. The transformation of the aforementioned data to a language readable by the software used (ArcGIS 9.1) was the prerequisite for the digitisation of the dataset. A number of consolidated maps were generated indicating, as precisely as possible, the location of all the sites and sources associated with obsidian in the areas of my concern.

The high degree of accuracy in the generation of these maps was crucial for the analysis of the distances obsidian has moved. The calculation of the distance from each site to all the obsidian sources was undertaken using the distance measurement facility available in ArcGIS 9.1. Although a time-consuming task, this procedure was deemed necessary as it provided the results with a degree of accuracy and objectivity that could not have been achievable otherwise. To test the credibility of my results I performed the same procedure using spreadsheets and calculating distances from the generated scatterplots; in general, the results of this cruder method corroborated the distances generated by the application of a GIS technique. Keeping in mind the varying level of precision inherent in the method of data assortment the distances/numbers produced should be considered satisfactory.

It is important to note that in several instances my data are not in agreement with the data from other studies. However, in this research I rely on the data produced from my own analyses as the methodology I used for the generation of this information allows me to be very confident of the integrity of the data I discuss. Moreover, this approach ensures the internal consistency of the dataset I produced.

3.2.4. Obsidian Distances

The most straightforward method for the calculation of the distance between two points is using the Euclidean theorem of lines which in the archaeological terminology is translated into the «as the crow flies» model. The unique quality of obsidian for precise fingerprinting of its sources of origin could have enabled the exact reconstruction of the material’s transport distances but the absence of published relevant information necessitated the use of more traditional archaeological means. Based on the principles of the «as the crow flies» model the obsidian distances were calculated as:

Minimum (MIN)

Corresponds to the shortest distance from a certain site to all the obsidian sources present in its respective region (East Africa, Central & South-eastern Europe, the Near East); in this manner it is the equivalent of the as the crow flies distances mentioned in other studies.

Although the mathematical validity of this method cannot be disputed, it is clear that such a technique is a problematic convention in archaeology. Not only it does not take into account the topography and geographical obstacles/constraints imposed on the landscape and affecting the archaeological data but it, also, minimizes the scale of human activity and the abilities of our ancestors.

Despite the shortcomings of the application of the shortest distance concept to studies interested in raw material movement and my personal criticism against it I do realise that a common language/referencing system is compulsory if archaeological thought is to communicate its ideas effectively. Furthermore, with the use of minimum values the plausibility of exaggerations skewing the pragmatic events is also avoided. It is under these premises that I decided to base my analyses on the minimum recorded distances of obsidian movement. However, these results must be perceived as reflecting the minimum extent of hominin abilities of movement, material transport and socialisation. Until better quality data - and obsidian provides a unique possibility of accessing it - becomes available this approach seems to provide the most conservative estimate of our ancestors' capacities and the archaeological interpretations of them.

3.3. Case Studies

3.3.1. Excavation and Museum Research

Since the aim of this research is not related to purely technological aspects of obsidian use the examination of the chosen assemblages followed a basic procedure of lithic analysis. Much of the information usually collected by lithic analysts was omitted and the emphasis was placed towards features that could be potentially associated with distance and hominin behaviour.

3.3.2. Recorded Criteria

The attributes collected (and their classification schemes) from the selected obsidian assemblages for systematic treating are briefly presented below.

Site: name of site whose obsidian assemblage is analysed

Level: stratigraphic level from which the analysed material comes from

Bag#: number of bag to which the analysed specimens belong

Artefact#: number of analysed specimen which forms its ID

Artefact category: classification of the analysed specimens in general terms of typology, i.e. morphological characteristics, based on a simplified model of Bordes' (1961) classification scheme. A general classification model of the analysed items which is adopted making use of the following scheme:

1. débitage (flakes/blades)
2. core
3. SRTs/LCTs (small retouched tools/large cutting tools)
4. nodule
5. debris/waste

Tool types: separation of the analysed obsidian artefacts in their specific tool classes and intra-class distinction (table 4.2, note: no large cutting tools have been recorded):

FLAKE TYPE	**BLADE TYPE**	**CORE TYPE**	**SMALL RETOUCHED TOOL TYPE**	**POINT TYPE**	**BURIN TYPE**	**NOTCH TYPE**	**KNIFE TYPE**	**TRUNCATION TYPE**	**SCRAPER TYPE**
whole	whole	complete core	raclette	mousterian	burin blow	notch typical	knife typical	truncation typical	endscraper
proximal	proximal	core remnant	point	leaf	burin spall	notch on truncated flake	denticulate knife	concave	doublescraper
medial	medial	core on flake	scraper	bifacial	burin on notched blade	notch on trimming flake		atypical	truncated
distal	distal		limace	unifacial	burin on retouched flake				convergent
retouched	retouched		burin	blade	dihedral				concave
flaked	backed		burin blow	point typical	burin typical				sidescraper
trimming	decortication		burin spall						endscraper on retouched flake
core preparation	blunted		truncation						carinated endscraper
decortication	bladelet		denticulate						
platform removal	lame a crête		bec						
janus			knife						
proximally truncated			notch						
			awl						
			utilised piece						
			composite						

Table 4.2. Tool classes and intra-class distinction of the analysed obsidian artefacts.

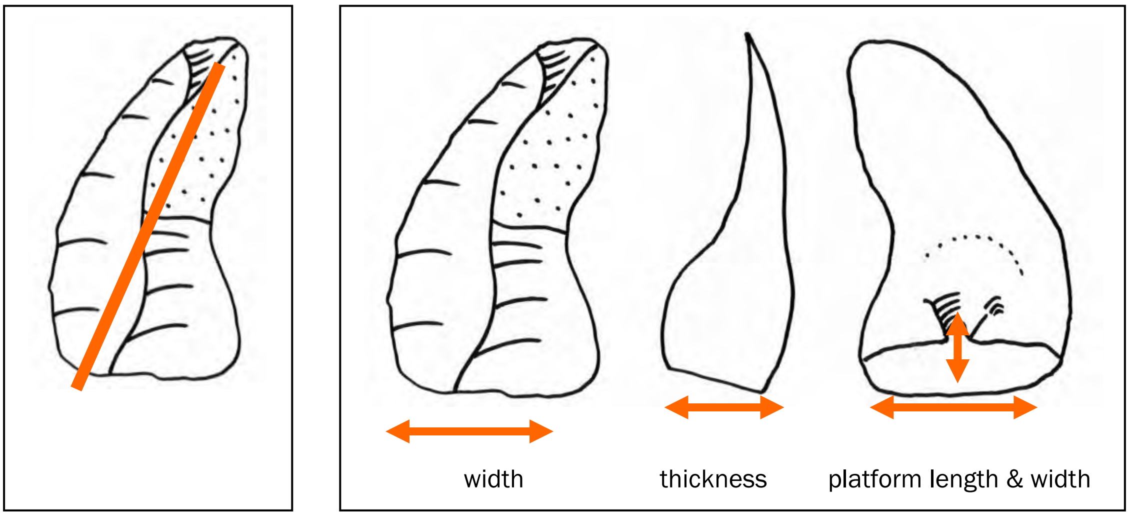
Completeness: quality of the analysed specimens:

1. complete
2. fragmented

Dimensions: the following tool dimensions have been recorded in the analysis of the obsidian assemblages:

- **Maximum length-width-thickness-weight:** these dimensions (figures 4.1 and 4.2) provide a precise «reconstruction» of the analysed specimens' size. Maximum dimensions are preferred to axial ones as they constitute a better means for recording the actual size of the item under examination. The axial dimensions have also been recorded but were not analysed (axial length-width).

- **Platform width-thickness:** the platform dimensions of the relevant tool types provide a useful insight into the techniques involved in the manufacture of these tools, for example the use of soft or hard hammer.



Figures 4.1 (left) and 4.2. (right). Visual presentation of flake measurements as conducted in this project:
Figure 4.1 shows maximum flake length.
Figure 4.2. indicates flake width, thickness and butt/platform length and width.

Platform type: again, platform typology is revealing of tool production techniques (figure 4.3). The types identified are (simplified version of Bordes 1961):

Platform type 1:

1. non-cortical

2. partially cortical

3. fully cortical

Platform type 2:

1. cortical
2. flat
3. dihedral
4. facetted
5. chapeau
6. linear
7. punctiform
8. undetermined

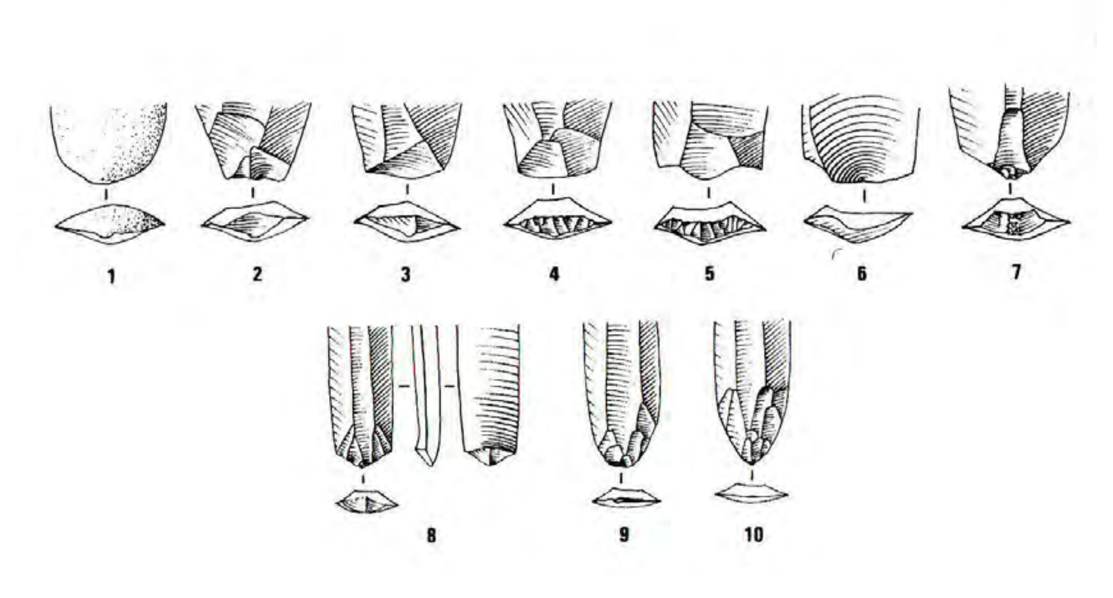


Figure 4.3. Visual presentation of types of butts. The figure shows blades but the same patterns were also applied on flakes in the analysis of the obsidian assemblages of this project. [1= cortical, 2= plain, 3= dihedral, 4= facetted, 5= 'en chapeau de gendarme', 6= winged, 7= pecked, 8= spur, 9= linear, 10= punctiform]. After Inizan *et al.* (1999: 136).

Platform scar count: actual numbers of scars on the specimens' platforms.

Cortex: two characteristics are recorded following Toth's (1982) descriptor model:

- Cortex quantity: percentage of cortex on the pieces under examination; this parameter gives an estimate of the stage of manufacture the analysed specimen was when discarded. A six-grade system is employed:

1. 0%

2. 0-25%

3. 25-50%

4. 50-75%

5. 75-100%

6. 100%

- **Cortex position:** location of cortex on the surface of analysed cortical specimens (figure 4.4). A six-grade system is followed:

1. cortical butt & 100%dorsal

2. cortical butt & partial dorsal

3. cortical butt & 0%dorsal

4. non-cortical butt & 100%dorsal

5. non-cortical butt & partial dorsal

6. non-cortical butt & 0%dorsal

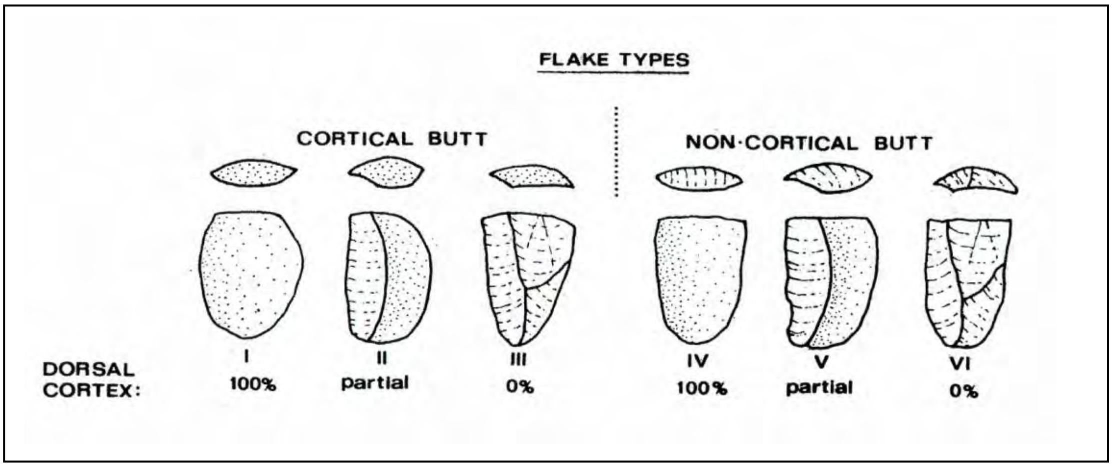


Figure 4.4. Visual presentation of cortex position. After Toth (1982).

Retouch: based on the questions set for this project only two of the retouch characteristics have been recorded (for their descriptors I heavily draw from Inizan *et al.* 1999 and Bordes' 1961 classification scheme with modifications when necessary for a more precise description of the analysed artefacts):

- **Retouch extent:** degree of retouch coverage on the surface of analysed specimens that preserve evidence of this secondary procedure (figure 4.5). Five grades of retouch extent are identified (model heavily relying on Bordes' 1961 system):

1. no retouch

2. short

3. long/semi-invasive

4. invasive

5. covering

- Retouch position: position of retouch on the surface of analysed specimens that preserve evidence of this secondary procedure (figures 4.6 and 4.7).

Retouch position 1:

1. direct
2. inverse
3. alternate
4. bifacial

Retouch position:

1. left
2. distal
3. right
4. proximal
5. left & right
6. left & distal
7. right & distal
8. distal & proximal
9. proximal & left
10. proximal & right
11. circular

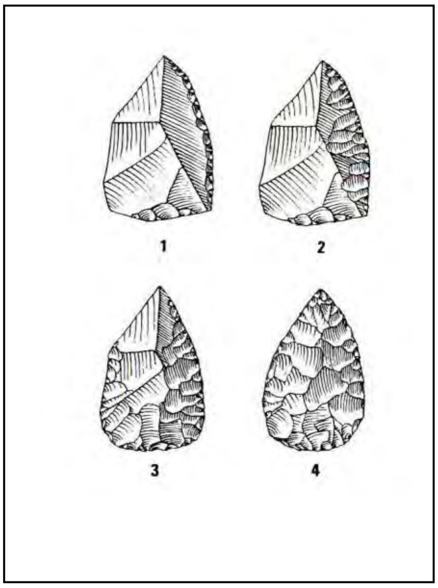


Figure 4.6. Extent of removals (retouch). [1= short, 2= long, 3= invasive, 4= covering]. After Inizan *et al.* (1999: 141).

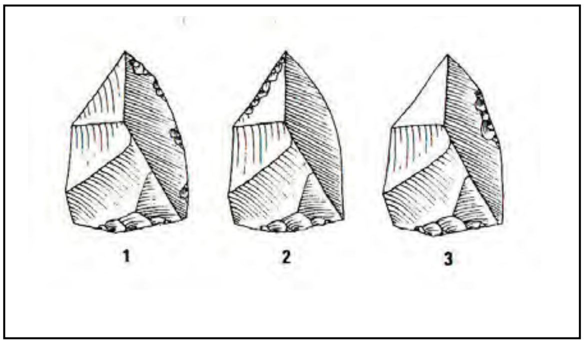


Figure 4.5. Distribution of removals (retouch). [1= discontinuous, 2= total on the distal edge, 3= partial on the right edge]. After Inizan *et al.* (1999: 140).

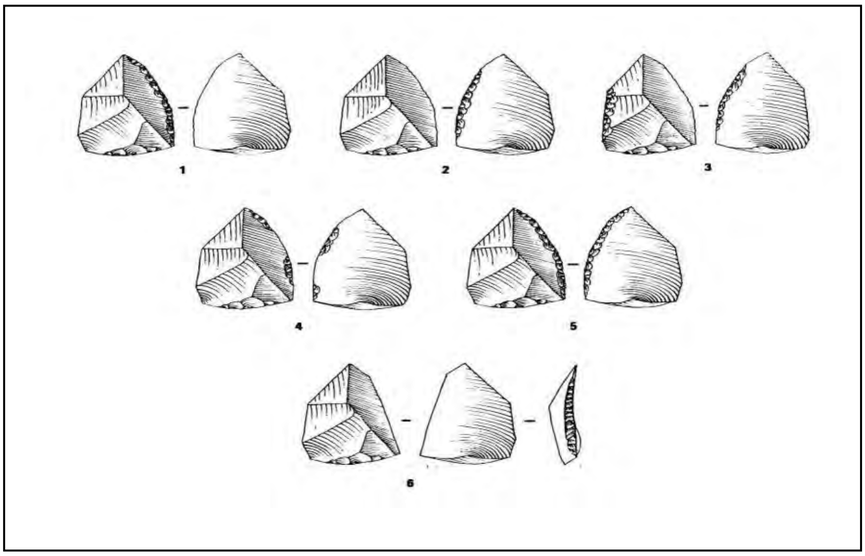


Figure 4.7. Position of removals (retouch). [1= direct, 2 = inverse, 3= alternate, 4= alternating, 5= bifacial, 6= crossed]. After Inizan *et al.* (1999: 152).

Dorsal scar pattern: a variable important for the same reasons as explained in cortex and retouch sections and determined on the conchoidal fracture of flake scars. A six-part scheme is employed:

1. radial

2. semi-radial

3. convergent

4. parallel

5. cortical

6. parallel & cortical

7. convergent & cortical

8. undetermined

Museum: name of the museum that holds the analysed lithic assemblage in its collections.

Figure: figure (s) of the analysed specimens in the literature (if applicable).

3.4. Problems and Biases of the Sampling and Recording Strategy

The multi-proxy methodological approach employed for the data collection and analysis of the lithic assemblages studied as part of this research has caused a number of problems that must be accounted for.

Global dataset: the first section of my data collection is exposed on the predispositions inherent in the procedure that had to be adopted, i.e. dependence on information deriving from studies conducted by other investigators (literature research). For the acquisition of the data that would form the basis of my dataset I had to rely on documentation from a wide range of chronological and regional backgrounds (with the respective effect on the quality of the information) that inevitably limited cross-referencing and direct comparisons and lent a fragmentary character to the dataset. Despite the innate problems of the methodology used an additional bias was caused by the fact that all the available information had to be transformed into an ordinal scale system (thus omitting details when present) in order to make sensible use of as much of the gathered data as possible. However, the unequal representation of different categories has been a problem that could not be overcome and thus constitutes one of the major factors restricting the interpretative strength of my results.

Case studies: with respect to the case studies reported in the practical section of this thesis there are a number of issues that must be taken into account. First of all, despite being representative, the analyzed assemblages are small limiting the interpretative value of the results. Approximately 200 specimens have been recorded from each of the two main case studies whereas the rest of the analyzed obsidian assemblages were represented by only a few specimens and, thus, generated a very small dataset. Moreover, my research has focused on obsidian portions of lithic assemblages where other rock types are also present; a procedure necessary to serve the aims of this thesis but resulting in interpretative biases since it removed obsidian from its wider lithic context.

4. SUMMARY

This chapter discussed the methodological issues associated with the data collection and analysis of the lithic assemblages from specific sites conforming to the criteria set by this project. The procedure followed in the collection of the information that constituted the database on which my analyses were based was described and the reasons for the selection of the particular variables explained. The chapter ended with a discussion of the problems and biases of the analytical procedure I employed for the manipulation of my data and the extent to which they affected the quality of the results presented in the following chapters. The empirical part of this thesis (chapters 5, 6 and 7) begins by presenting the context of the obsidian assemblages examined for the purposes of this thesis.

Chapter 5

Gazetteer of Palaeolithic Obsidian in Africa, Europe and Near East

1. INTRODUCTION

This chapter describes the obsidian sources and archaeological obsidian-bearing sites in the three study areas. Each section-divided according to region- begins with a brief description of the tectonic events that resulted in the production of the obsidian sources later utilised by the Palaeolithic hominins followed by a list of the sources identified for the purposes of this thesis. In addition, a gazetteer of the obsidian-bearing Palaeolithic sites discovered in each of the three areas under investigation is presented, encompassing information on their location, age, obsidian quantities and typologies. A series of maps, specifically produced for this project, is included in the discussion for illustrative purposes.

2. CONTINENTS AND REGIONS

2.1. Africa

2.1.1. Tectonic Evolution and Obsidian Sources in Africa

The tectonic evolution (Summerfield 1996) of Africa has been dominated by crustal extension and continuing episodes of rifting which date as far back as ca. 3500 Myr (for an extended overview see Cahen & Snelling 1984). During the last 200 Myr basic intrusions and anorogenic igneous activity resulted in the formation of the Great Rift Valleys of East Africa, the area where subsequent volcanic activity produced the plethora of obsidian sources scattered in the region.

Volcanism greatly influenced the geology and topography of the African continent (for details concerning the volcanic activity in East Africa see King 1970, and for specific examples see Scott & Skilling 1999). The late-Cenozoic East African Rift System and the Tertiary Ethiopian flood basalts are two of the major rift systems with associated volcanism.

The East African Rift System is identified as a feature formed by normal faulting caused by crustal tension and associated with the subsequent eruption of large volumes of volcanic rock (Oxburgh 1978, Williams 1978). At least in Ethiopia and Kenya, it has been demonstrated that rifting and subsidence preceded domal uplift, thus, relating to an active model of rifting in which an upwelling mantle plume is the driving force. The initiation of the East African Rift System probably occurred during early Cenozoic, with the northern zone of rifting being younger than the ones to the south. Chorowicz *et al.* (1987) identify a four-stages mechanism for the opening of the East African Rift System; 1st stage or pre-rift, dating back to the Late Oligocene-Early Miocene when horizontal slip movement takes place and results in the opening of the north east-south west faults, and, consequently, to tholeiitic volcanism. Fracturing was dense and covered a large area while mechanisms of compression and extension moved horizontally creating poorly delineated depressions, swamps and shallow lakes. During this stage fissural eruption of basaltic flood lavas is experienced in Ethiopia (Late Oligocene) and the Gregory Rift (Late Oligocene/Early Miocene). The 2nd stage is named initial rifting, and began during the Middle Miocene (16-15 Myr); vertical compression and horizontal extension striking north west-south east characterise this stage. In the east branch of the East African Rift System the associated volcanic activity resulted in magma (alkaline to peralkaline) reaching the surface. The 3rd stage is the typical rift formation phase and its start dates to the Late Miocene (10-9 Myr); the faults become mainly normal while extension remains horizontal and compression vertical. The final stage is the advanced rifting phase starting during the Pliocene (4 Myr); as in the previous rifting episode a combination of local and regional stresses affects the motions along the faults. Subsidence is fast and accompanied by extensive alkaline volcanism. Most of the ridges that existed between the basins have now disappeared but this process is not synchronous all along the East African Rift System. The eastern branch is better known and shows evidence of the more advanced development of rifting while the western branch is still undergoing changes and is, thus, younger.

The discrete episodes of volcanism and tectonism discussed above resulted in the current configuration of the East African Rift System (for specific examples regarding the development of topographic features see: Tryon & McBrearty 2002, Deino & McBrearty 2002 for the Kapthurin Formation, Baringo, Kenya; Ngecu & Njue 1999 for Munyu wa Gicheru Formation, south Kenya; Merrick *et al*. 1973 for Shungura Formation; Aronson *et al.* 1977; 1980 and Schmitt *et al.* 1980 for Hadar Formation, Ethiopia). The rifting processes followed a north-south direction from the Gulf of Aden to Tanzania. In terms of volcanic activity, the East African Rift System is broadly divided into high-volcanicity zones, that preserve large volumes of magma, and low-volcanicity zones, where magma production was either minimal or absent. The Afar Depression, the Main Ethiopian Rift and the Gregory Rift belong in the first group while the Albert, Tanganyika and Malawi Zones are part of the second. Volcanic activity had been extensive and resulted in the impressive eruption of 220,000 km^3 in Kenya and Tanzania or 600,000 km^3 in the total of the East African Rift System. It is during these volcanic events that the African obsidian sources were formed with the East African Rift System being the region that accommodated them.

For many years now geochemical research, with the aim of distinguishing and chemically fingerprinting obsidian sources in areas of the world rich in such geological formations, for example Mesoamerica and New Zealand, has been conducted with success. But despite the satisfactory results of these applications and the fact that East Africa comprises one of the most abundant obsidian-bearing geographical regions, research has been slight and slowly developed. Our knowledge of the obsidian sources location and chemical composition still heavily relies on Merrick and Brown's pilot study that was initiated at 1981 after an invitation by M.D. Leakey to locate obsidian sources used in the Naisiusiu Beds of Olduvai Gorge. Previous research includes Leakey's (1945) optical discrimination of material from the Neolithic levels of Hyrax Hill, Cole's research on Njorowa Gorge and Mt Eburru, Walsh & Powys' (1970) refractive index and specific gravity studies on Kenyan material. Michels' *et al.* (1983) undertook chemical studies from Kenya, dating back to 1976 Schmid & Stern provide the only chemical study (Merrick & Brown 1984) on Northern Tanzania followed by a number of petrological studies on obsidian from the region (e.g. Baker & Henage 1977). Currently research on the identification, location and chemical characterisation of obsidian in Kenya is being undertaken by Ambrose (pers. comm.).

For this study I rely on the data collected by Merrick & Brown (1984) and Merrick *et al.* (1994) as their work is still the most comprehensive and reliable for the regions of Kenya and Tanzania. Their work concentrated on obsidian sources located in Kenya and northern Tanzania and although the coverage of potential source localities should not be regarded as complete, they managed to locate 54 geographically discrete obsidian sources. To this number at least 10 more localities can be added, from previously published studies. The majority of the identified obsidian sources are located around the Lake Naivasha basin and Mt Eburru many sources are found in the eastern highlands flanking the central Rift Valley while minor localities are present in the northern part of Kenya, east of Lake Turkana, at the southern end of the Suguta Valley, the southern Kenyan rift zone and Mt Kilimanjaro.

There is a considerable variability in the nature of the occurrence of the obsidian in the identified regions; it is found in seams along the chill zones at the bases or tops of lava flows, e.g. Njorowa Gorge, Masai Gorge and Eburru areas, and in other instances as lapilli or nodules (ranging in size from small pebbles to boulders up to 1 m in diameter) embedded in pyroclastic deposits that vary from soft ash to well cemented tuff. At many Central Rift localities loose blocks of obsidian are still quite plentiful on the surface of outcrops. On the other hand, there are localities where the obsidian bearing tuffaceous agglomerates contain such low densities of lapilli that quarrying would have been unproductive. In these cases, the best approach for the collection of raw material would have been the gathering of nodules from pebble lag concentrates on the eroded exposures of the agglomerates and from the stream channels dissecting the exposures (Merrick & Brown 1994: 134). Finally, there are a number of identified localities where the material is of very poor quality making its use in tool manufacture highly unlikely; e.g. Suswa and Kampi ya Moto.

As with the nature of occurrence, the chemical composition of the recorded obsidian exhibits a considerable variability. Merrick & Brown (1984) and Merrick *et al.* (1994) undertook the chemical analysis of the samples they collected using a combination of XRF (X-ray Fluorescence) and EPMA (Electron Probe Microanalysis). In their initial study they relied on the XRF analysis of 12 elements (Fe, Ca, K, Ba, Mn, Nb, Rb, Sr, Ti, Y, Zn and Zr) while in the later analyses they used 10-13 major, minor and trace elements. Emphasis was given to three elements, Fe, Ca and Ti, that are perceived as the best discriminates and wherever the distinction was not possible additional elements were taken into account. In general, however, the East African obsidians proved so distinctive that characterisation was satisfactorily based on the major and minor elements rather than the rarer trace elements.

The above applications resulted in the identification of 35 petrologically distinct groups of source obsidians in Kenya and northern Tanzania. This number was revised and decreased to 30 in their 1994 study when it became apparent that some of the previously recognised distinctive groups are actually products of successive flows from single sources whose magma compositions evolved gradually over time. In cases where many eruptions have occurred in close chronological intervals, e.g. Mt Eburru, the allocation of each outcrop (in particular Mt Eburru groups and Njorowa Gorge-Naivasha Lake Edge South groups) to a particular petrological group became too difficult to be satisfactorily dealt with. In these instances, the researchers lumped two or more petrological groups into larger composite units that still represent a geographically distinctive entity.

This fact must be kept in mind in any attempt to assign material to specific outcrops but for the purposes of this thesis, where the primary goal is the identification of long-distance obsidian movement, it makes essentially no difference. Information on the region and exact location of the African obsidian sources used in this thesis is provided below. The multiple localities in the Naivasha region are mentioned here (marked with an asterisk) but in the map of figure 5.1 and during the analysis are represented by the source named ‘Naivasha Scarp’. Their close proximity in combination with the resolution used in the analysis did not permit a greater degree of detail. The numbers next to each source are cross-referenced with the locations on figure 5.1 and an evaluation of the accuracy of coordinates is provided in table 5.1.

Finally, recent advances in the research of obsidian use in Ethiopia have led in a significant improvement of our knowledge of the geological sources of obsidian in the specific area and its use in Palaeolithic sites. The information presented below regarding the Ethiopian obsidian is mainly based on the work of Chavaillon & Piperno (2004), Pleurdeau (2003; 2006) and Negash *et al.* (2006).

1. Suregei-Achille (latitude 4.17207/ longitude 36.28358, Kenya), multiple localities

2. Shin: (latitude 3.76918/longitude 36.31568, Kenya)

3. Nasaken: (latitude 1.65471/longitude 36.26365, Kenya)

4. Emuruangogolak: (latitude 0.54823/longitude 35.72123, Kenya)

5. Salawa Hill: (latitude 0.60000/longitude 36.01667, Kenya)

6. Kampi ya Samaki: (latitude 0.56048/longitude 36.28551, Kenya)

7. Karau: (latitude 0.15000/longitude 37.30000, Kenya), multiple localities

8. Mt Kenya: (latitude -0.16667/longitude 35.60000, Kenya)

9. Londiani: (latitude -0.02102/longitude 35.95995, Kenya)

10. Kampi ya Moto: (latitude -0.43613/longitude 36.19348, Kenya)

11. Kisanana: (latitude 0.48572/longitude 36.15989, Kenya)

12. McCall's Siding: (latitude -0.87725/longitude 36.26829, Kenya)

13. Menengai: (latitude -0.91942/longitude 36.32999, Kenya), multiple localities

14. Masai Gorge: (latitude -0.97709/longitude 36.31218, Kenya)

15. Eburru: (latitude -0.98754/longitude 35.83967, Kenya)

16. Naivasha Scarp: (latitude -0.89449/longitude 37.21683, Kenya)

17. Ololerai: (latitude -9.58333/longitude 41.86667, Kenya)

18. Oserian no. 1&2: (latitude -38.67095/longitude 26.76095, Kenya)

***Njorowa Gorge South no.1:** (latitude -39.42038/longitude 29.97566, Kenya)

***Njorowa Gorge:** (latitude -39.99347/longitude 31.69135, Kenya)

***Hell's Gate no.1:** (latitude -40.68333/longitude 33.18333, Kenya)

***Gilgil Toll:** (latitude -0.86252/longitude 36.36239, Kenya)

***Sonanchi:** (latitude -0.78250/longitude 36.26194, Kenya)

19. Akira: (latitude -40.63504/longitude 33.11583, Akira)

20. Olagirasha: (latitude -0.96750/longitude 35.83333, Kenya)

21. **Suswa:** (latitude -1.15000/longitude 36.35000, Kenya)

22. **Kedong Escarpment:** (latitude 1.16667/longitude 36.41667, Kenya)

23. **Gicheru:** (latitude -1.20000/longitude 36.55000, Kenya), two localities

24. **Githuya:** (latitude 0.86667/longitude 36.96667, Kenya)

25. **Gacharage:** (latitude -0.93330/longitude 36.75000, Kenya)

26. **Githumu:** (latitude -0.81670/longitude 36.90000, Kenya)

27. **Mangu:** (latitude -1.00000/longitude 36.95000, Kenya)

28. **Lukenya:** (latitude -1.48194/longitude 37.07222, Kenya), multiple localities

29. **Ol Donyo Nyegi:** (latitude -1.80000/longitude 36.36666, Kenya), multiple localities

30. **Mt Kilimanjaro:** (latitude -3.07583/longitude 37.35333, Tanzania), multiple localities

31. **Modjio:** (latitude 8.60000/longitude 39.11667, Ethiopia)

32. **K’one:** (latitude 8.91667/longitude 39.66670, Ethiopia)

33. **Fantale:** (latitude 8.97500/longitude 39.93000, Ethiopia)

34. **Ayelu:** (latitude 10.13333/longitude 40.63333, Ethiopia)

35. **Assabot:** (latitude 9.21667/longitude 40.76667, Ethiopia)

36. **Afdem:** (latitude 9.46670/longitude 41.00000, Ethiopia)

37. **Dire Dawa:** (latitude 9.58972/longitude 41.85972, Ethiopia)

38. **Kibikoni:** (latitude -0.83333/longitude 36.31667, Kenya)

39. **Longonot:** (latitude -0.83333/longitude 36.40000, Kenya)

40. **Kinangop:** (latitude -0.71777/longitude 36.65000, Kenya)

41. **Opuru:** (latitude -0.58333/longitude 36.25000, Kenya)

42. **Balchit:** (latitude 8.75444/longitude 38.63861, Ethiopia)

43. **Kusrale:** (latitude 15.04200/longitude 39.82000, Eritrea)

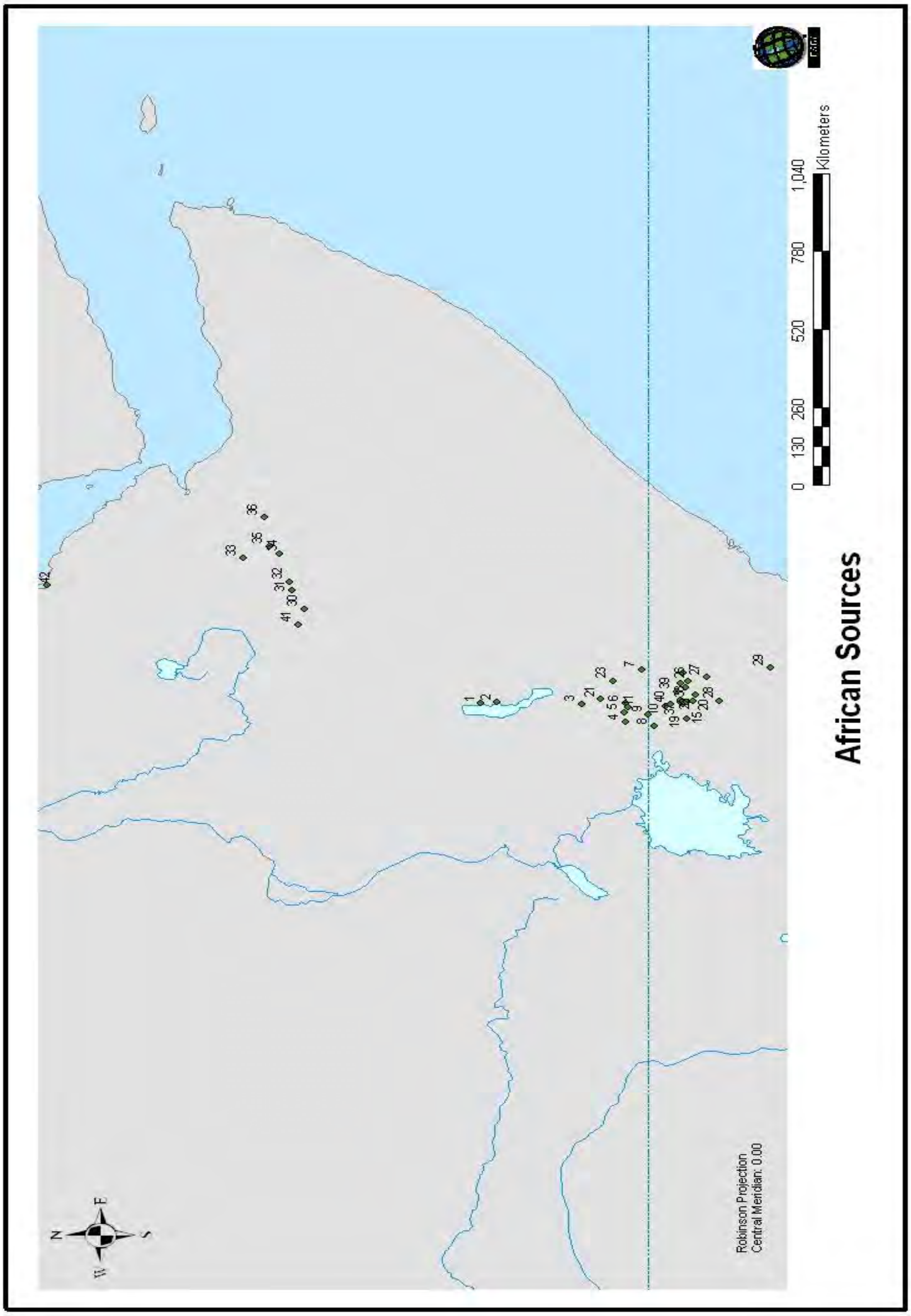


Figure 5.1. Obsidian sources in East Africa identified for the purposes of this project.

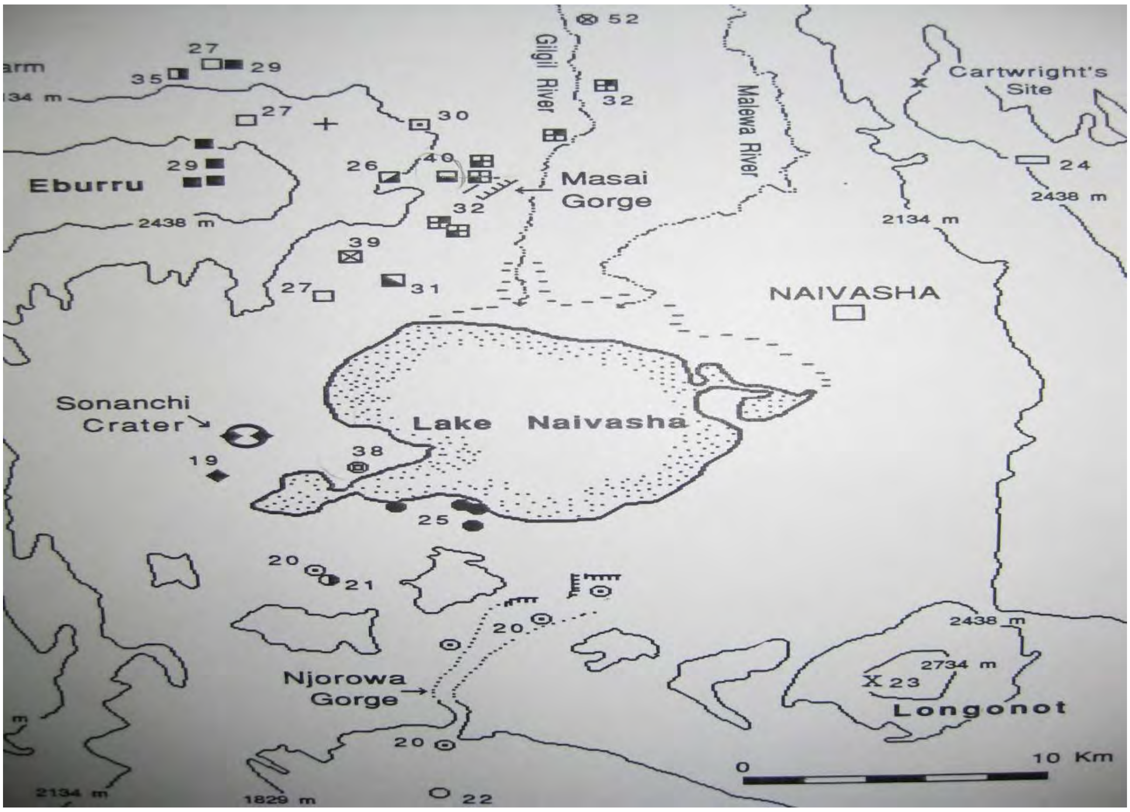


Figure 5.2. The Lake Naivasha area obsidian sources. After Merrick & Brown (1984).

2.1.2. Gazetteer of African Palaeolithic Obsidian-bearing Sites

The abundance of obsidian sources scattered on the East African landscape has resulted in the material's broad use by the Palaeolithic hominins occupying the region. A gazetteer of these sites, including information on dates, obsidian frequencies and typologies, is presented in the following paragraphs. The numbers next to each site can be used to cross-reference them with the illustration in figure 5.3 (they do not follow an arithmetical order as the gazetteer was created using a chronological sequence). Table 5.2 presents an evaluation of the coordinates used for the generation of the map in figure 5.3. Table 5.3 provides a summary of the gazetteer information.

1. Gadeb 8E (latitude 7.11670/longitude 39.36670, Ethiopia):

Féblot-Augustins 1997, Ambrose 2004, Clark & Kurashina 1979, Williams *et al.* 1979, Clark 1980; 1988, Haileab & Brown 1994, Kurashina 1987

Lower Stone Age open-air site dated at approximately 1.5Myr ago; 20276 lithics have been unearthed of which 222 Acheulean handaxes; only four of them are made of obsidian- three elongate ovate and one ovate (the ratios are 3/80 and 1/16)

2. Kariandusi (latitude -0.45000/longitude 36.28333, Kenya):

Féblot-Augustins 1997, Ambrose 2004, Merrick *et al.* 1994, Gowlett 1980, Gowlett & Crompton 1994, Merrick & Brown 1984

Lower Stone Age open-air site with an approximate date over 780Kyr; 15% of the Acheulean industry is made of obsidian although the exact number of lithics is not provided; obsidian bifaces have been found in the Upper site of Kariandusi whereas in the Lower site obsidian is used for the manufacture of handaxes, choppers, discoids, large and core scrapers, small scrapers and other small tools

3. Kilombe (latitude -0.1000/longitude 35.88333, Kenya):

Féblot-Augustins 1997, Gowlett 1980, Ambrose 2004, Merrick *et al.* 1994, Merrick & Brown 1984, Gowlett & Crompton 1994

Lower Stone Age open-air site; obsidian is extremely rare in the lithic industry of this site; in the literature only two obsidian bifaces are mentioned

4. Olorgesailie (latitude -1.56667/longitude 36.45000, Kenya):

Féblot-Augustins 1997, Ambrose 2004

Lower Stone Age open-air site; Acheulean industry including three obsidian bifaces

5. Gamble's cave (latitude -0.28487/longitude 35.83155, Kenya):

Coles & Higgs 1975, Ambrose *et al.* 1980, Merrick & Brown 1984

Later Stone Age cave; the lithic assemblage belongs to the Kenyan Capsian Industry and it is completely dominated by obsidian

6. Magosi (latitude 2.91700/longitude 34.51700, Uganda):

Merrick & Brown 1984, Coles & Higgs 1975, Posnansky & Cole 1963

Later Stone Age rockshelter; not much is known about this site except for the fact that 'few' obsidian artefacts have been found in its lithic assemblage; it is included here as it is the only other known African site with obsidian in its assemblage although Uganda is not further considered in this thesis

7. Porc Epic (latitude 9.58333/longitude 41.86667, Ethiopia):

Coles & Higgs 1975, Michels & Marean 1984, Clark & Williamson 1984, Ambrose 2004, Pleurdeau 2003; 2006, Negash & Shackley 2006, Assefa *et al.* 2008

Middle Stone Age cave dating at over 50kyr; specifically, Pleurdeau (2006) puts it at approximately >70kyr; the lithic assemblage comprises of pebbles, cores, waste and retouched products with Levallois or pseudo-Levallois characteristics; obsidian is preferably used for bladelets and geometric tools; the obsidian débitage is 29%, flakes are 54% (192/3641), blades are 13% (45/960), bladelets are 29% (104/664) and points are 4% (16/294); in total there have been unearthed 357 obsidian specimens from a total of 12000 artefacts generating an obsidian percentage of 5.5%

8. Prospect Farm (latitude -0.65139/longitude 36.00556, Kenya):

Michels *et al.* 1983, Clark 1988, Merrick *et al.* 1994, Ambrose 2004

Middle Stone Age open-air site dating between 119-106kyr; technologically the lithic assemblage belongs to Prospect Industry with some transitional MSA to LSA characteristics in the upper layers; obsidian is the most abundant raw material used in this site comprising 90% of the total lithics in the earliest level, 96.9% in the middle and 99.5% in the latest MSA level

9. Naisiusiu beds, Olduvai Gorge (latitude -2.99457/longitude 35.18396, Tanzania):

Leakey *et al.* 1972, Merrick & Brown 1984, Ambrose 2004

Later Stone Age horizon of the famous open-air Stone Age site dating at approximately 17kyr; the lithic assemblage is dominated by tools and flakes many of which show evidence of burning; obsidian forms 44.3% of the microliths, 25.6% of the blades, 5.4% of other small retouched tools and 5.1% of the débitage (of which 1 core); overall 60 obsidian artefacts have been unearthed from this horizon making up 5% of the total assemblage

10. HWK-East, Olduvai Gorge (latitude -2.99457/longitude 35.18396, Tanzania):

Ambrose 2004, Leakey 1971

Lower Stone Age horizon of the famous open-air site; Leakey (1971) mentions that two fair-sized pieces of obsidian were found in the lowest level 1, Bed II of HWK-East; the significance of these two peculiar manuports lies on the fact that the nearest source they could have originated from is located in Kenya (although current research may prove otherwise- personal communication with de la Torre)

11. Little Gilgil (latitude -0.58333/longitude 36.35000, Kenya):

Wymer 1982, Clark 1988

Middle Stone Age open-air site mentioned by Wymer as having some obsidian (leaf-points) in its lithic industry but they have not been described in any detail

12. Elmenteita (latitude -0.48300/longitude 36.15000, Kenya):

Wymer 1982

Middle Stone Age open-air site for which Wymer mentions that some obsidian (leaf-points) is included in its lithic industry but no further information is available

13. Muguruk (latitude -0.15000/longitude 34.66667, Kenya):

Merrick & Brown 1984, Merrick *et al.* 1994, McBrearty 1988, Clark 1988, Ambrose 2004

Middle Stone Age open-air site; according to McBrearty (1988) the lithics belong to the MSA Pundo Makwar Industry; knapping debris of phonolite dominates but some obsidian (less than 1%) is also present; in member 6, 5 out of 5726 artefacts are made of obsidian (1 unfinished bifacial foliate point and 4 tiny bits of waste) whilst in member 4, from a total of 6509 pieces only 4 (0.1%) are made of obsidian

14. Songhor (latitude -0.03662/longitude 35.20828, Kenya):

Merrick & Brown 1984, Merrick *et al.* 1994, McBrearty 1988, Clark 1988

Middle Stone Age open-air site with very little obsidian (less than 1% of the total lithic assemblage)

15. Cartwright's (latitude -0.59722/longitude 36.45833, Kenya):

Merrick & Brown 1984, Merrick *et al.* 1994, Waweru 2002, Clark 1988

Middle Stone Age open-air site dated at 440kyr; the lithic assemblage of the site is totally made of obsidian but no exact numbers are provided in the literature

16. Wetherall's (latitude -0.70277/longitude 36.68752, Kenya):

Merrick & Brown 1984, Merrick *et al.* 1994, Waweru 2002

Middle Stone Age open-air site with an absolute date of 557kyr; the authors mention that the lithic industry of this site is completely made of obsidian but they do not provide further information on quantities and typological characteristics

17. Gombore, Melka Kunture (latitude 8.68300/longitude 37.63300, Ethiopia):

Chavaillon & Piperno 2004, Muir & Hivernel 1976, Ambrose 2004, Negash *et al.* 2006, Chavaillon 1968; 1980, Chavaillon & Chavaillon 1982, Chavaillon *et al.* 1979

Lower Stone Age open-air site of the Melka Kunture complex; the Gombore I lithic industry is characterised as Developed Oldowan /Lower Acheulean (~1.7-1.6 Ma) specifically in Gombore I obsidian is present in the following quantities: 120 cores (48%), 561 débitage products (47%) of a 1194 total (these numbers include retouched flakes for which from a total of 133 specimens, 65 are obsidian), 307 flake fragments of a 551 total, 172 tools on flake from a 355 total (including, among other types, scrapers, burins and notches; obsidian is mainly used for end-scrapers with 31 pieces belonging to this category); interestingly, the cores of this technology are more elongated (manily between 40 and 80 mm long) than those made of other raw materials and rather thick; in Gombore Ib obsidian is more rare but used for the manufacture of tools on pebble, such as choppers (less than 8%), and pointed or prismatic polyhedrons (18% and 22% respectively), 23.3% of beaked pebbles and 2% casually trimmed pebbles are also made of obsidian; furthermore, obsidian constitutes the 45% of the identified archaic handaxes and 77% fragments of debris; Gombore II dates at approximately 0.85Ma; sectors 1,3,4 and 5 (together they produced a total of 1753 lithics) are characterised as Middle Acheulean whereas sector 2 as Middle/Upper Acheulean; overall, Gombore II is an Acheulean industry where obsidian is more frequent (although still not abundant) and appears in the form of débitage and small obsidian handaxes; actually it seems that during that time obsidian was often preferred for the manufacture of handaxes; finally, Gombore III, IV, V and VI have been identified and characterised as Middle/Upper Acheulean with a plausible date of the upper level at 0.70-050 Ma

18. Garba, Melka Kunture (latitude 8.68300/longitude 37.63300, Ethiopia):

Chavaillon & Piperno 2004, Muir & Hivernel 1976, Piperno 1980, Ambrose 2004, Negash *et al.* 2006, Chavaillon 1968; 1980, Chavaillon & Chavaillon 1982, Chavaillon *et al.* 1979, Clark 1988

Lower Stone Age open-air site of the Melka Kunture complex dating at approximately 1.6Myr; various localities have been discovered in this site ranging from the Oldowan (IV), Early/Middle Acheulean (XII, 1.1-0.80 Ma), Upper Acheulean (I) and Late Acheulean (III); a typical Upper Acheulean lithic assemblage (10000 artefacts in total) has been unearthed from

Garba I; obsidian is present in the form of large handaxes worked from lumps of obsidian brought to the base camp having already been roughly prepared at source (possibly Balchit); in Garba III layers E and D (~0.70Ma) are characterised as Upper/Middle Acheulean; lithics from layers C and B are typical Acheulean but mixed with small tools characteristic of a Middle Stone Age typology; in Garba IV (Developed Oldowan) obsidian is present in level C with 439 artefacts from a total of 872 (69.9%), in level D with 3983 specimens from a total of 12401, level and in level E with only 8 artefacts from a total of 78; the lithic analysis of levels C and D has shown that obsidian is preferentially used for the production of flakes and flake artefacts and only sporadically for tools on pebble; specifically in level C obsidian is present in the following quantities: 40 flakes, 29 small retouched tools, 23 cores, 40 fragments, 7 choppers, 1 handaxe and 9 casually trimmed pebbles; in level D obsidian is the second most abundant raw material (basalt is the dominant with 5228 specimens) and is found in the following quantities: 2425 unmodified flakes (64.2%), 133 utilised flakes (66.17%), 212 retouched flakes (73.87%), 136 sidescrapers (76.40%), 77.88% of clactonian notches, 80% of denticulates, 414 fragments (65.20%), 197 cores (55.14%), 19 choppers (2.14%), 2 polyhedrons (3.92%), 3 rabots, 21 casually trimmed pebbles (21.43%), 5 battered pebbles (0.38%), 1 broken pebble (0.08%) and 2 bifacial tools; finally, some obsidian has been found in the nearby Simbiro III, Karre and Warraba sites but as the sites have only been located and sampled rather than excavated they will not be included in the analysis

19. Wofi II, Melka Kunture (latitude 8.68300/longitude 37.63300, Ethiopia):

Chavaillon & Piperno 2004, Muir & Hivernel 1976, Chavaillon 1980

Middle Stone Age open-air site part of the Melka Kunture complex (note: in the 2004 publication, the researchers characterise Wofi as a Later Stone Age site); the lithic industry is Sangoan/Lupemban and it consists mainly of flakes with points, side-scrapers and little bifacial pieces; some handaxes and a few cleavers have also been discovered; the majority of the artefacts are made of obsidian

20. Kella, Melka Kunture (latitude 8.68300/longitude 37.63300, Ethiopia):

Chavaillon & Piperno 2004, Muir & Hivernel 1976, Chavaillon 1968; 1980, Chavaillon et al. 1979, Chavaillon & Chavaillon 1982, Clark *et al*. 1984, Kurashina 1987, Ambrose 2004

Later Stone Age open-air site part of the Melka Kunture cluster; three archaeological elvels have been identified with the entire lithic assemblage made of obsidian; the researchers describe the débitage as of Upper Palaeolithic type; the most characteristic tool types are: end-scrapers, burins, backed blades, notches and truncations

21. GtJi12 (Enkapune Ya Muto) (latitude -0.83333/longitude 36.16389, Kenya):

Clark 1988, Ambrose 1998; 2004, Pleurdeau 2006

Late Middle Stone Age rockshelter dating at >46kyr; the lithic assemblage exhibits strong transitional characteristics with elements of both the MSA Nasampolai Industry, such as backed blades and bladelets, scrapers, burins and geometric microliths, and the LSA Sakutiek Industry, such as microlithic backed flakes and bladelets; obsidian is the main raw material used but neither artefact numbers nor percentages are given by the above authors

22. GnJm1 (Shurmai) (latitude -0.50833/longitude 37.21518, Kenya):

Dickson & Gang 2002

Later Middle Stone Age rockshelter in the Mukogodo Hills region dating at 45kyr; obsidian is only marginally present in this site as from the 4782 lithics solely 8 are made of the particular raw material; a Later Stone Age horizon has also been excavated at the same location with an increase of obsidian presence in its lithic assemblage

23. GnJm2 (Kakwa Lelash) (latitude -0.55278/longitude 37.17083, Kenya):

Dickson & Gang 2002

Later Stone Age rockshelter in the Mukogodo Hills region with a date after 40kyr; some obsidian has been unearthed in this location but it constitutes a small proportion of the lithic assemblage as from the 7862 artefacts only 106 are made of obsidian

24. GrJi11 (Prolonged Drift) (latitude -0.48472/longitude 37.06667, Kenya):

Clark 1988, Merrick *et al.* 1994, Ambrose 2004

Middle Stone Age open-air site dated at approximately 35kyr; on site all stages of the manufacture of stone tools are present although the débitage dominates; bifacial and unifacial points are also abundant; the majority of the lithic specimens are made of obsidian

25. GsJi53 (Ol Tepesi) (latitude -0.69194/longitude 36.20667, Kenya):

Ambrose 2004

Later Stone Age rockshelter dating at 14kyr; not much information is available for this site apart from that obsidian is present in the lithic assemblage which is typologically characterised as a microblade industry; peculiarly, the small size of these microblades cannot be attributed to the conservation of the raw material as the site is located within 10 km of several of the most widely used obsidian sources in East Africa

26. Isenya (latitude -1.85000/longitude 36.78300, Kenya):

Roche *et al.* 1988, Merrick *et al.* 1994, Ambrose 2004

Lower Stone Age open-air site; according to the respective literature solely an obsidian flake has been recovered

27. GnJi16 (Kaptabuya) (latitude 0.72507/longitude 35.82009, Kenya):

Merrick *et al*. 1994, Ambrose 2004, Gowlett & Crompton 1994

One of the two Lower Stone Age open-air sites in the Lake Baringo area; Acheulean industry in which a fragment of an obsidian biface has been found

28. GnJi15 (Kapthurin 'A') (latitude 0.60000/longitude 36.01700, Kenya):

Ambrose 2004, Gowlett 1980, Merrick *et al.* 1994, Clark 1988, Gowlett & Crompton 1994

The second Lower Stone Age open-air site located in the area of Lake Baringo dated at 230kyr; according to Ambrose (2004) one obsidian artefact has been found in the lithic assemblage of this site

29. Nasera (latitude -2.73694/longitude 35.35806, Tanzania):

Merrick *et al.* 1994, Ambrose 2004, Barut 1994; 1996, Clark 1988, Merrick & Brown 1984

Middle Stone Age rockshelter with an approximate age between 56-26 uncal kyr; obsidian is not abundant, a phenomenon accentuated by the fact that obsidian has been lumped with the other utilised raw materials; ten obsidian artefacts, but no cores, are present in the Kisele Industry whereas the Naseran includes some cores and little flaking debris, as far as small retouched tools are concerned, the Kisele layer has three obsidian scrapers (10%) and the Naseran obsidian retouched specimens comprise the 20% of the assemblage but exact numbers are not provided

30. Mumba Höhle (latitude -3.53779/longitude 35.29929, Tanzania):

Clark 1988, Merrick *et al.* 1994, Ambrose 2004

Middle Stone Age rockshelter dating between 130-109kyr; obsidian is very rare in the lithic assemblage partly due to the fact that obsidian has been lumped with other raw materials present in the site; definite obsidian artefacts are three from the Sanzako and eleven from the Kisele Industry; it is worth mentioning that the nearest obsidian sources that could have been utilised in Mumba Höhle are located in Kenya and at least 300km away

31. GvJm46, Lukenya Hill (latitude -1.48194/longitude 37.07222, Kenya):

Barut 1994; 1996

Later Stone Age open-air site forming part of the Lukenya Hill cluster of Stone Age sites and dating at 30kyr; technologically and typologically the lithics of GvJm46 resembles that of GvJm16 discussed above; Barut (1996) discusses the assemblage in raw material weights and gives a percentage of approximately 1% for a ‘few’ obsidian (738 gr) artefacts

32. GvJm19, Lukenya Hill (latitude -1.48194/longitude 37.07222, Kenya):

Barut 1994; 1996

Later Stone Age rock overhang; a radiocarbon date from apatite puts it at approximately 14kyr; the lithic assemblage is characterised by the same features as those of the other Lukeyna Hill localities; quartz is the dominant raw material (96%), followed by chert (4%); 'few' obsidian artefacts have been found in this site but in a smaller quantity than the neighbouring sites as the raw material weight suggests (340 gr)

33. GvJm62, Lukenya Hill (latitude -1.47361/longitude 37.07500, Kenya):

Barut 1994; 1996

Later Stone Age rock overhang dating at approximately 21kyr; its lithic assemblage has the same elements as those of the other Lukenya Hill localities; 315 obsidian artefacts (913 gr) have been found in this site with the raw material deriving from various sources: 221 from Lukenya (6km), 37 from Kedong (65km), 6 Oserian (105km), 1 Kinangop (110km), 39 Sonanchi (125km), 3 Baixia (135km), 5 Eburu (145km) and 3 from unknown sources

34. KFR-A5 (Kisima Farm) (latitude 0.48333/longitude 36.75000, Kenya):

Merrick & Brown 1984

Later Stone Age rockshelter; obsidian forms 10-15% of the total lithic assemblage and it comes from a variety of obsidian sources, located 70-160 km away, based on the results of the chemical analyses conducted by Merrick and Brown (1984)

35. ETH-72-1, Kulkuletti (latitude 7.92972/longitude 38.71000, Ethiopia):

Clark *et al.* 1984, Clark 1988, Negash & Shackley 2006, Wendorf & Schild 1974, Brandt 1986

Middle Stone Age open-air site dating at 235kyr; the lithic assemblage belongs to the Stillbay Industry rich in small retouched tools such as points, scrapers, burins, notches and denticulates; a rich amount of 2000 obsidian artefacts have been found on-site

36. ETH-72-8B, Gademotta (latitude 7.92972/longitude 38.71000, Ethiopia):

Clark *et al.* 1984, Clark 1988, Wendorf & Schild 1974, McBrearty 1988, Negash & Shackley 2006, Tryon & McBrearty 2002, Brandt 1986

Middle Stone Age concavity dating at 235kyr (235±5 ka, K/Ar estimates); ETH-72-8B is a locality of the Gademotta extensive multi-purpose site; the lithic assemblage follows the tradition of the Stillbay Industry with the same elements as those of the two above sites; obsidian is very highly represented in this site with 9188 specimens

37. ETH-72-7B, Gademotta (latitude 7.92972/longitude 38.71000, Ethiopia):

Clark *et al.* 1984, Clark 1988, Brandt 1986

Middle Stone Age open-air site dating at 235kyr (one of the Gademotta localities discussed previously); the lithic assemblage belongs to the Stillbay Industry rich in small retouched tools; contrary to the other localities obsidian is not very popular in this site with 332 artefacts of which 96 are described as very weathered

38. ETH-72-6, Gademotta (latitude 7.92972/longitude 38.71000, Ethiopia):

Clark *et al*. 1984, Clark 1988, Brandt 1986

Middle Stone Age open-air site dating at 235kyr; a Stillbay lithic assemblage has been unearthed from this site similarly to the other Gademotta/Kulkuletti localities; 1459 obsidian artefacts have been unearthed here

39. ETH-72-5, Gademotta (latitude 7.92972/longitude 38.71000, Ethiopia):

Clark *et al.* 1984, Clark 1988, Brandt 1986

Middle Stone Age open-air site dating at 235kyr; the last of the Gademotta localities and with the same technological elements in its lithic assemblage; 1699 artefacts are made of obsidian

40. ETH-72-9, Kulkuletti (latitude 7.92972/longitude 38.71000, Ethiopia):

Clark *et al.* 1984, Clark 1988, Brandt 1986

Middle Stone Age open-air site dating at 235kyr (the second locality of the Kulkuletti site); technologically the lithic assemblage resembles the one of the above locality; obsidian is very abundant at this site too with 1239 retouched tools and 4.548 un-worked obsidian pieces

41. GvJm22, Lukenya Hill (latitude -1.48194/longitude 37.07222, Kenya):

Barut 1994; 1996, Gramly 1976

Later Stone Age rock overhang dating at <20kyr; technologically/typologically the GvJm22 lithic assemblage is very similar to the other Lukenya Hill sites; Gramly provides the following values for volcanic glass use on-site: Occurrence E: 671/1673 flaked tools and fragments, 151/631 cores and 4805/38434 waste, Occurrence F: 52/435, 35/129, 1494/21357 respectively; unfortunately he lumps obsidian with other volcanic rocks and it is impossible to know the exact obsidian artefact numbers; Barut mentions that obsidian is present at 'moderate' quantities (101 specimens or 737 gr) comprising approximately 3% of the total raw material weights; quartz is again the most abundant raw material

Note: overall Lukenya Hill is a very interesting cluster of sites with regard to obsidian use as discussed in relevant sections of this thesis; in total 30% of the obsidian utilised (94 artefacts) derives from non-local, and most importantly distant, sources although good quality obsidian sources are available in the proximity; site GvJm62 exhibits the highest proportions of local material, site GvJm22 is the second highest in the use of local obsidian; on the contrary most of the levels of sites GvJm16 and GvJm22 are dominated by imported obsidian

42. GvJm16, Lukenya Hill (latitude -1.48194/longitude 37.07222, Kenya):

Merrick & Brown 1984, Barut 1996, Clark 1988, Merrick *et al.* 1994, McBrearty 1988, Ambrose 2004

Late Middle Stone Age rockshelter dating at >35-40kyr; the lithic technology is of a MSA to LSA transitional character; cores, waste and scrapers in a variety of raw materials, including obsidian from various sources, dominate the assemblage; according to the researchers microliths and scrapers are made of local obsidian whereas non-local obsidian is used for blades; in general the non-local specimens are of larger sizes than the artefacts of locally originated obsidian; although several obsidian sources are present in the vicinity, obsidian is not the dominant raw material on-site found only in moderate quantities (Barut mentions 197 obsidian artefacts in total or 568 gr) with 74% of the assemblage made of quartz and 19% of chert

43. GvJh12, Ntuka River 4 (latitude -0.01528/longitude 35.89167, Kenya):

Ambrose 1994; 2004

Late Middle Stone Age open-air site at the transition from the MSA to the LSA dating at >60kyr; the lithic industry exhibits transitional MSA to LSA characteristics dominated by large backed geometric microliths; obsidian is common (44.5%) but not the most popular raw material utilised on-site

44. GtJi15 (Marmonet Drift) (latitude -0.75278/longitude 36.17500, Kenya):

Fieldwork, personal communication with Stanley Ambrose

Case study

Middle Stone Age open-air site; obsidian is the dominant raw material used in this site but as the research is on-going, absolute quantities and typologies are not yet known; see chapter 6 for more details

45. GvJh11 (Ntumot), Ntuka River 3 (latitude -1.34361/longitude 35.91306, Kenya):

Ambrose *et al.* 1994; 2004

Late Middle Stone Age open-air site at the transition from the MSA to the LSA and dating at >50kyr; the MSA horizon of the site has not been studied/published in detail so far and all is known about it is that obsidian comprises approximately 64% of the total lithics; the layer overlying the first LSA horizon 8 out of 37 specimens are made of obsidian; in the LSA horizons obsidian is present at 16%; 119 from a total of 212 artefacts are on obsidian in LSA horizon 1, 214 out of 510 in LSA horizon 2 and 6 obsidian artefacts have been found in the otherwise culturally sterile level between horizons 1 and 2

46. Aladi Springs (latitude 9.50380/longitude 42.05598, Ethiopia):

Brandt 1986, Clark 1988, Clark *et al.* 1984

Later Stone Age open-air site dating at 12-11kyr; the lithic assemblage exhibits features of a Terminal Pleistocene-Early Holocene microlithic technology with blade cores, backed blades and scrapers; obsidian is the dominant raw material

47. Lake Besaka/Erer (latitude 9.56667/longitude 41.38333, Ethiopia):

Brandt 1986, Clark *et al.* 1984

Later Stone Age open-air site dating between 18-10kyr; a lithic assemblage with Terminal Pleistocene microlithic technological features has been excavated in this site; a few pieces of obsidian débitage are included in the assemblage

48. K'one (latitude 8.86700/longitude 39.66700, Ethiopia):

Clark & Williamson 1984; 1988, Negash & Shackley 2006

Middle Stone Age open-air site; the total assemblage is comprised of 42650 lithics but Clark does not give the obsidian ratios; obsidian cores, debris but also small retouched tools (mainly notches, denticulates, scrapers and burins) are present; obsidian forms only the 0.5% of the shaped tools recovered in the site

49. Modjio (latitude 8.60000/longitude 39.11667, Ethiopia):

Clark 1988, Ambrose 2004

Middle Stone Age open-air site with some obsidian; Clark mentions that the assemblage consists of Levallois flakes and points which must be the case for obsidian too although quantities and technological details are not available

50. Aduma (latitude 10.02500/longitude 40.03100, Ethiopia):

Ambrose 2004, Yellen *et al.* 2005

Middle Stone Age open-air site with a date of >70kyr; obsidian is scarce forming no more than 10% of the lithic assemblage; in particular from 16215 artefacts collected from four different localities 1675 are made of obsidian; in technological terms the assemblage suggests a full reduction sequence although obsidian was preferentially used for the manufacture of small specialised scrapers (97% on obsidian) and points

Recent research conducted along the Gulf of Zula and the Buri Peninsula, on the Red Sea coast of Eritrea, provides evidence for the exploitation of obsidian by the Palaeolithic inhabitants of this region. The information derives from the survey of a 400 km area and not from secure stratigraphic horizons; furthermore, quantitative information is not provided; for these reasons, those sites cannot constitute part of the database and they will not be included in the data analysis. However, they are briefly discussed here with the aim of presenting an as accurate picture of Palaeolithic obsidian use as possible.

51. Ingel 3, Ingel Study Area (latitude 15.45766/longitude 39.87763, Eritrea):

Beyin & Shea 2007

Possible Later Stone Age open-air site with a lithic assemblage characterised by flakes and blades; some of these artefacts are made of obsidian

52. Ingel Hill Site, Ingel Study Area (latitude 15.45359/longitude 39.88516, Eritrea):

Beyin & Shea 2007

Possible Later Stone Age open-air site with a small quantity of obsidian in its lithic assemblage

53. Harerti, Meka Enile Study Area (latitude 15.22441/longitude 39.87772, Eritrea):

Beyin & Shea 2007

Open-air site characterised by scatters of obsidian and quartz artefacts; the majority of the assemblage consists of non-diagnostic material but the presence of blades and microliths suggests a possible dating to the Later Stone Age

54. Triple Ridges Site, Meka Enile Study Area (latitude 15.199997/longitude 39.86440**,** Eritrea):

Beyin & Shea 2007

Open-air site featuring several scatters of lithic artefacts (tools and débitage), many of which are made of obsidian; the site possibly dates to the Middle Stone Age

55. Asafat East, Irafailo Study Area (latitude 15.04771/longitude 39.74941, Eritrea):

Beyin & Shea 2007

Middle Stone Age open-air site with a lithic assemblage encompassing mainly flakes, blades and Levallois cores; obsidian is the only utilised raw material

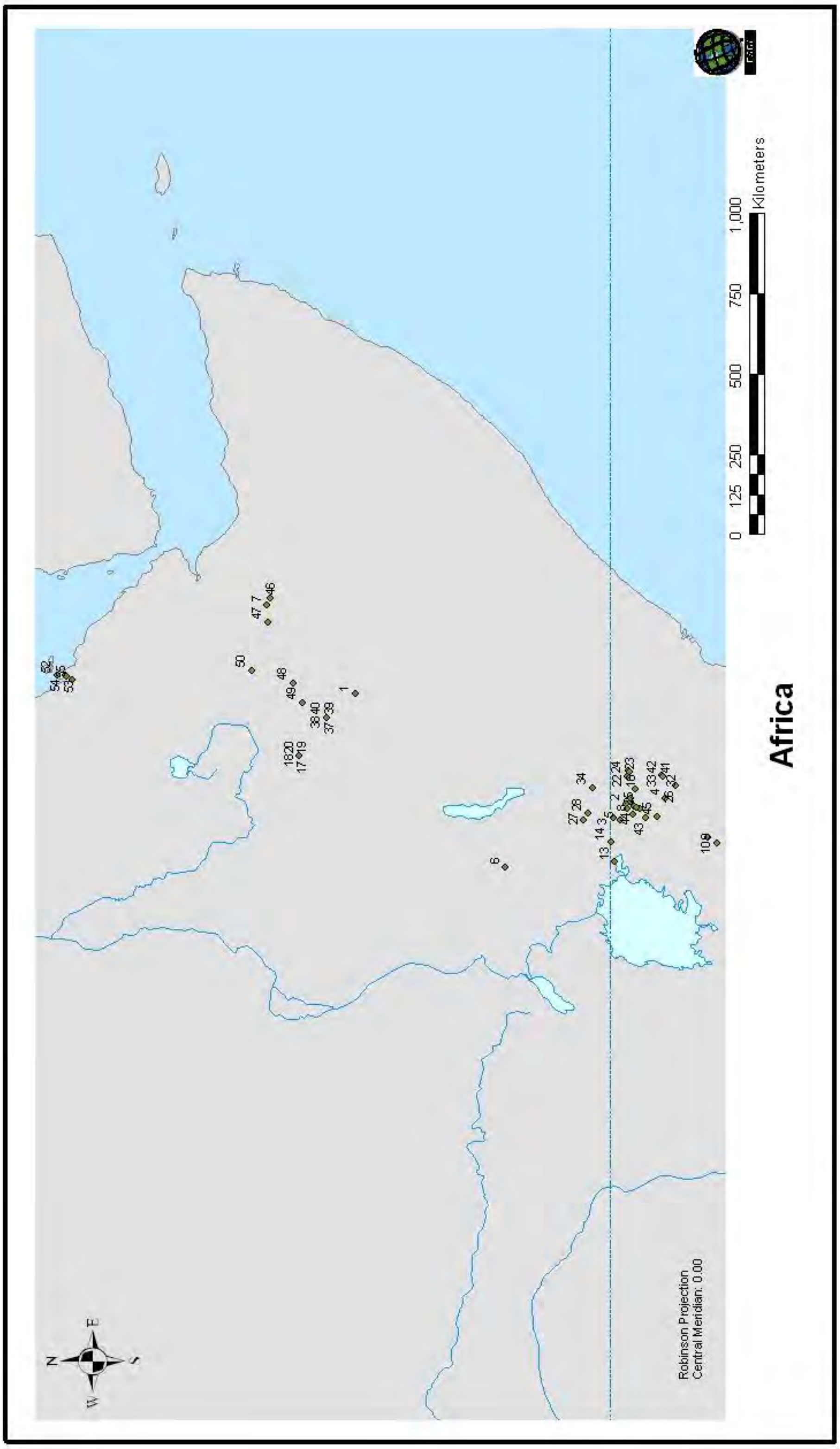


Figure 5.3. Map showing the location of the African Palaeolithic obsidian-bearing sites discussed in the gazetteer.

2.2. Europe

2.2.1. Tectonic Evolution and Obsidian Sources in South-eastern Europe

In the Mediterranean Sea, two major island arc formations, the Hellenic Island arc system in the Aegean and the Calabrian Island arc system in the Tyrrhenian Sea, are associated with the long-lasting tectonic phenomena of the region (Blot 1978). The kinematics caused by the interaction between the African and European lithospheric plates is responsible for the intensive volcanic activity and its effect on the regional terrain. The Mediterranean is an area with some of the richest deposits of obsidian that interestingly are all located on islands. Numerous investigations have been undertaken in the area and a large amount of experiments for the development of new dating and provenance techniques have used samples from the Mediterranean (e.g. Cann & Renfrew 1964, Gale 1981, McDougall *et al.* 1983, Williams-Thorpe 1995, Acquafredda *et al.* 1999, Duttine *et al.* 2003). The Mediterranean data are divided into two groups: the western one, comprising of the Italian sources, and the eastern one, comprising of the Greek sources.

Hellenic Island Arc System and Mainland Greece

Kiskyras (1978) and Berckhemer (1978) provide an overview of the geological evolution of the Aegean region. Here, I will concentrate on a specific section of this region, namely the South Aegean volcanic arc, because it constitutes the area of my thesis. Research undertaken by Fytikas and his co-workers (1986) in the south part of the Hellenic Island Arc provides some insight in the type of plate motion that resulted in the formation of the South Aegean volcanic arc and the obsidian sources associated with it. Data deriving from the small archipelago of Melos, area of particular concern in this project, indicate that the northward subduction of the African plate beneath the Aegean one during the Pliocene gave the Aegean Sea its special character. Volcanism has been widespread in the region, significantly affecting the island of Melos and its surroundings, from the Upper Pliocene until late Quaternary. The initial phases of this volcanic activity in Melos (west) were characterised by submarine eruptions followed by subaerial ones and covering a time span from 3.5 to 2.0 Myr. The same patterns are evident during the second phase covering now north-eastern territories. At about 0.5 Myr, volcanism is concentrated in the central part of the island and affected by strong tensional tectonics. The latest volcanic event dates to 0.1 Myr. The Pliocene period of volcanism is related to a feeding system set deep in the earth's crust and is dominated by andesites and dacites whereas the Pleistocene one is associated with multiple feeding systems in the form of shallow magma chambers producing mainly rhyolites.

Obsidian in Greece

The eastern Mediterranean obsidian sources are all located in Greece and most specifically in the south part of the Aegean (Shelford *et al*. 1982). Four distinct sources of workable material have been identified in the area situated on three different islands; two are found in Melos, one in Giali and another one in Antiparos. Melos is the place of origin of the most important obsidian deposits where two different sources are documented, namely Adhamas-A (previously referred to as Sta Nychia) and Dhemenegaki-D, both located at the coast of the island, northwest and northeast respectively. Although they are differentiated according to their chemical composition they actually show a great degree of homogeneity. The material produced in these flows is of grey-black colour, almost opaque, non-translucent and its most characteristic feature is a pearly lustre surface (personal observation). Sometimes striations with a greenish tinge are present and when these striations are very pronounced they are recorded as a distinct group (visual distinction). Giali provides a very characteristic type of obsidian which is transparent and black in colour but dotted by uniformly distributed, white spots (spherulites). The quality of the raw material is not as good as that of Melos but it was workable and it came in large blocks facilitating tool-making. In Antiparos the only identified source produces nodules of very small size (nearly always less than 5 cm) a fact that minimizes its archaeological significance. However, the material is of workable quality and is characterized by an overall shiny appearance evident even at the external surface of the lumps. It is black in colour (brown to grey in transmitted light) and of variable translucency.

When the Palaeolithic record is taken into consideration an interesting pattern becomes immediately apparent: evidence of obsidian use in the period is extremely scarce. Actually, so far only in two instances has obsidian been reported in association with Palaeolithic findings and these not from undisputable stratigraphic horizons or archaeological contexts. Some evidence for the exploitation of obsidian on the island of Melos during the Palaeolithic has been reported but without further research not much can be said (Chelidonio 2001). The lack of extensive research in the area may be an explanation but it is definitely not the only or the best one. The factor that has the greatest contribution to this scarce character of the available information is, I argue, the obsidian sources themselves. The characteristic that all those sources have in common is that they are all located on islands, i.e. provinces not directly connected to the mainland. Although this picture would have been dramatically altered during the Pleistocene stages of low sea-level, the most distant sources would have never been completely connected to the mainland. Furthermore, much of the information that archaeologists seek to discover is very likely under the sea.

Calabrian Island Arc System

Somewhat more complex is the perception generated by the Italian data due to the presence of several different centres of volcanic activity. The Eolian Islands archipelago holds the central part of the Calabrian volcanic arc and it is here where the Liparian obsidian sources (Cortese *et al*. 1986, Dellino & La Volpe 1995) are located. Despite the long geological history of the Calabrian arc, obsidian was a product of only the last 10 kyr and so it will not play a central role in this research. In the Sicilian Channel continental rift the island of Pantelleria can be found, a region where obsidian is present as a result of the volcanism taking place in the broader area during the Quaternary (the obsidian outcrops are only connected to the first of the six stages of the above volcanic activity). Palmarola is part of the Pontine Islands archipelago where obsidian formation took place in a period ranging from the Upper Pliocene to Pleistocene. Possibly the most important part of the Italian periphery where obsidian occurs is the island of Sardinia where the Monte Arci volcanic complex is located (Montanini *et al*. 1994). The formation of this complex was the result of a magmatic cycle dating to the Plio-Pleistocene period, while the Monte Arci itself was responsible for four distinct volcanic episodes, the first one of which produced a large amount of calc-alkaline obsidian (distinguished in nine chemically different source groups). Despite the great number of volcanic centres and the numerous obsidian outcrops incorporated in the Italian periphery no evidence of its Palaeolithic use has as yet been recovered and so Italy will not be examined in the rest of this thesis.

Obsidian in Italy

In Italy obsidian is found in four different locations, all being islands, namely Lipari, Palmarola, Pantelleria and Sardinia but more than one obsidian groups have been identified in some of them. Lipari has only very recently (no more than 12,500 BP) produced obsidian in localities along its eastern and northern coasts and inland. Gabellotto, Canneto and Acquacalda are the best known (and the only old enough to have been used in prehistoric times) obsidian source areas on the island. So far chemical analyses do not show any differentiation among the various outcrops and, thus, they are all perceived as a single source. Macroscopically there is a distinction between a black (or sometimes brown) and highly transparent group and a grey-banded, often with spherulites one. Palmarola is the place of origin of another obsidian source, the deposits of which are found along the island's south-eastern and north-western coasts. Monte Tramontana is the major outcrop on the island and despite the fact that there is a visual distinction between a southern group of black and quite transparent obsidian and a northern one of grey, nearly opaque and with more crystals than Liparian obsidian, chemical analyses could not reveal any substantial differences between them. It is worth mentioning that the obsidian nodules found on Palmarola are in general of small size and limited quantity. The most remote obsidian source in the Mediterranean is located on the island of Pantelleria, where five obsidian groups have been distinguished based on their chemical differences (Francaviglia 1988). While the exact location of some of them is still uncertain, three vertically-differentiated sources exposed at Balata dei Turchi (southern end of Pantelleria) comprise the richest source of obsidian on the island, although its lowest level does not seem to have been used in prehistory. Salta La Vecchia, Lago di Venere and Gelkhamar are the other identified outcrops; obsidian was found *in situ* within pumice deposits in the second region and surface finds were the only ones discovered in the third region. Pantellerian obsidian (transparent and moderately shiny) is easily distinguished from the other Mediterranean sources by its dark green colour and its peralkaline chemical affinity.

The most complex picture is generated by the analysis of the Sardinian data as nine different obsidian groups have been identified based on their chemical characteristics. Tykot's detailed work in Sardinia has provided all the necessary information for the generation of a clear perception of the obsidian presence in Sardinia (Tykot 1997, Tykot & Ammerman 1997). Of these nine groups only five are represented in archaeological assemblages and it seems they were the only materials of workable quality. They are divided into the following groups: SA, very black and glassy, highly translucent, SB1, black and glassy but to a lesser extent than SA and usually opaque, SB2, usually very glassy, ranging from transparent to nearly opaque and sometimes phenocrysts are present, SC1, black with external grey bands (occasionally) and completely opaque, occasional finds of red or brown material, not very glassy, and SC2, which differs from SC1 only in its concentrations of strontium and a few other trace elements. Magnetic studies revealed an SD group but this is of no importance to archaeological research (McDougall *et al*. 1983). Of small significance to archaeology is also the distinction between the SC1 and SC2 obsidian types and the subdivision of the SB1 subgroup into SB1a, SB1b and SB1c. All these groups are located at the Monte Arci region, in the west central part of Sardinia. SA obsidian is found near Conca Cannas (the best-known obsidian source on the island), SB is found along the western flanks of Monte Arci (e.g. Conca S’ Ollastu) and SC in the Perdas Urias area, on the northeast side of the same geological feature.

2.2.2. Missing Obsidian Sources in Other Parts of Europe?

Finally, a comment must be made with regards to reports mentioning the presence of obsidian outcrops in Bulgaria (Yanev *et al.* nd). The tectonic evolution of the specific part of the Balkans and the subsequent volcanic events that have been examined in relation to Bulgaria’s topographic features (see for example Marchev *et al*. 2004, Yanev & Bardintzeff 1997, Angelova nd) do not constitute such an event improbable. However, the existent occurrences of obsidian are of a size and quality not suitable for flaking (Kunov *et al*. 2003) and thus could not have been used by the Palaeolithic inhabitants of the area. Furthermore the catalogue of the International Association for Obsidian Studies (IAOS) mentions few geological sources of obsidian in France. More recently, Kasztovszky & Biró (2004) included an obsidian source in Auvergne, France, in their analyses of geological/archaeological specimens. However, no material from the French source/s has been unearthed from Palaeolithic archaeological horizons (Williams-Thorpe *et al.* 1984). Hence, I will not engage to a further discussion of the tectonic and volcanic history of either Bulgaria or France.

Similarly, recent research has addressed the possibility of obsidian outcrops in Romania (Cârciumaru *et al.*2006/2007; 2007). Archaeological research conducted in the 1970s had brought to light obsidian artefacts from Upper Palaeolithic stratigraphic units in both Romania and Moldavia which were then linked to the well-known Tokaj source in Hungary (Bitiri 1971; 1972; 1981). Chirica *et al.* (1998) claim they have discovered local (Romanian) outcrops of obsidian in the depression valleys of Oaş and Maramureş and in streams in the

Lăpuş and Tipoasa villages. However, and if it is agreed that these localities are indeed obsidian sources, it still remains to be investigated whether they constitute distinctive sources or outcrops of the larger Tokaj Hungarian obsidian source. Furthermore, given the paucity of geochemical data and the extensive presence of perlite deposits throughout the region, which could be mistakenly recognised as obsidian, this thesis does not include Romania as an obsidian source locality. The Romanian and Moldavian sites that seem to have used obsidian in their Upper Palaeolithic assemblages are similarly excluded from the analysis on the basis of the unsolved utilised sources' problem.

2.2.3. Tectonic Evolution and Obsidian Sources in Central Europe

In central Europe the tectonic events linked to the formation of obsidian sources are associated with the evolution of the Pannonian region (figure 5.4) and the Carpathian Mountain Chain. The Pannonian region is located in the buffer zone of the Eurasian and African continental plates and as such it has been prone to a series of tectonic evolution events (ocean openings and continent collisions). The formation of the Pannonian Basin followed a multiphase evolution that was initiated during the Permian and ended with the filling up of the Basin (Neogene to Quaternary). The formation of the Carpathians took place during the Miocene-Quaternary. The process commenced with the rifting of the Inner Carpathian and the late East Carpathian volcanic arcs. These processes led to the uplift of the Alp-Carpathian Chain and to the collapse of the Pannonian Basin.

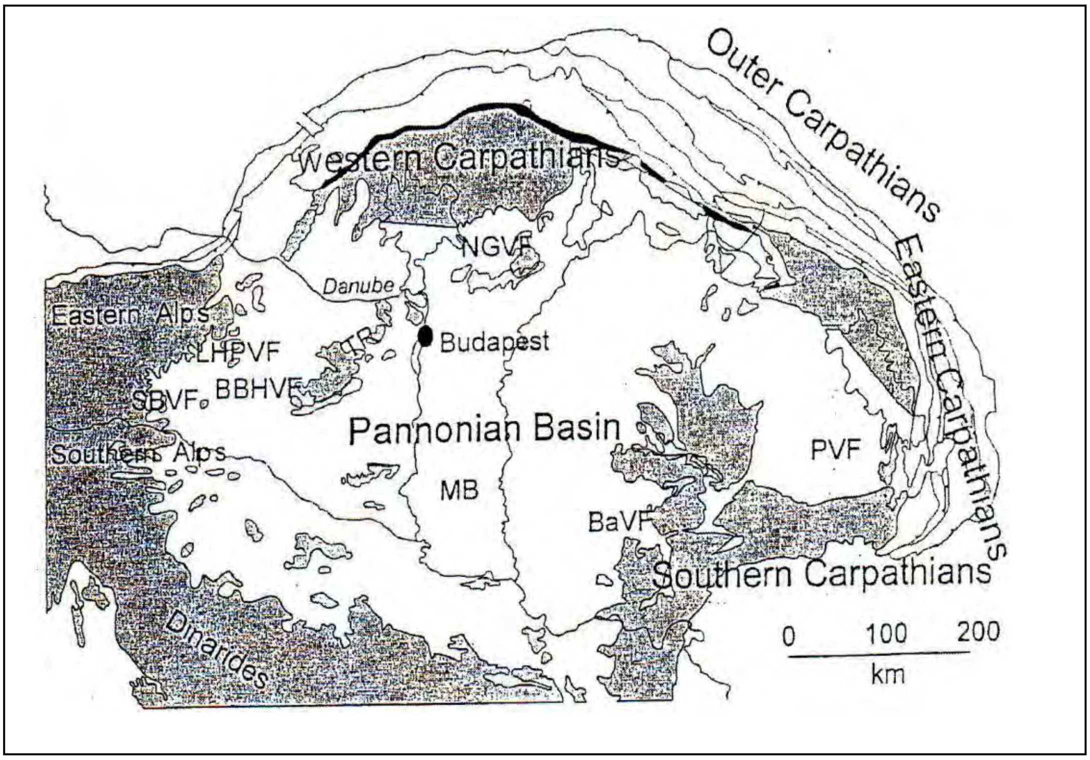


Figure 5.4. The Panonnian Basin and its surrounding geological features: LHPVF= Little Hungarian Plain Volcanic Field; BBHVF= Bakony-Balaton Highland Volcanic Field; SBVF= Styrian Basin Volcanic Field; BGVF= Nograd-Gomor Volcanic Field; BaVF= Banat Volcanic Field; PVF= Persany Volcanic Field; MB= Mako Basin. After Martin & Németh (2003).

The tectogenesis of the Pannonian Basin is divided into four cycles with alternating changes of compressional and tensional intervals and stress fields. The first cycle, the Savian, lasted for seven million years (26-19 Myr) and was characterised by an intense north-eastward piling up of the Alpine systems. Following this initial phase, is the Styrian cycle (19-15 Myr) during which the uplift of the Alps and Carpathians took place. The Leithan cycle (15-6 Myr) was characterised by the completion and uplift of the Alpine-Carpathian-Dinaridic system formation with the parallel collapse of the Pannonian Basin. During this phase the East Carpathian Arc volcanism reached its peak. Finally, in the Rhodanian cycle (6-2.4 Myr), the uplifting of the Alpine-Carpathian mountain chain continued as well as the uplifting of the Pannonian Basin. Volcanic activity was completed by rifting events during the late Miocene and Quaternary that generated basalts on the Balaton Highland, the Little Plain, the Great Plain, in the north of Hungary and the numerous obsidian sources to be found along the Hungarian-Slovakian border.

Haas *et al*. (1999) provide a graphic presentation of the tectonic evolution of the Pannonian Basin while a more detailed discussion on the same subject with reference to special tectonic events or specific sections of the Pannonian Basin-Carpathian chain region see Martin & Németh 2003a; b; 2005, Berenyi Üveges *et al*. 2003 (Hungarian, Slovakian and Austrian Carpathians), Szakacs *et al.* (nd) (Slovakian Carpathians), Vityk *et al.* 1996, Seghedi *et al.* 2001 (Ukrainian Carpathians) and, CVS/CEV workshop 1996 (Romanian Carpathians).

The tectonic and orogenic phenomena that have been discussed in the previous section have led to the formation of a number of obsidian sources that have played a significant role in the lives of the hominin species occupying the continent; from its initial occupation up to the recent past. In Central Europe obsidian is only found in close proximity to the Carpathians and its various flows can be divided into a number of well-defined groups/sources (see below). Researchers from a variety of scientific backgrounds - mineralogists, geologists and archaeologists - have long been engaged in the investigation of obsidian sources in the area. From the nineteenth century onwards a number of geological studies discussed the obsidian issue either peripherally or as the core of their work, for example, Beudant (1818), Richthofen (1860), Szádeczky (1887). A more archaeologically oriented research took place during the twentieth century with the emphasis shifting towards the collection of archaeological obsidian and the identification of sources that provided archaeological sites with workable material (Marțian 1909, Orosz 1911, Roska 1925, Janšak 1935 for Slovakia; Kostrżewski 1939 for Poland). More recently, Gábori (1950) and Vertés (1953; 1960) discussed the obsidian in Palaeolithic contexts but it is mainly in the work of Williams Thorpe and Nandris that we owe our current state of knowledge on the Carpathian obsidian. Williams-Thorpe and Nandris are the two main researchers that actively and extensively engaged to the identification and provenance of Central European obsidian (Williams-Thorpe *et al*. 1984, Williams & Nandris 1977, Nandris 1975 and pers.comm.) and the current project heavily relies on their data.

Several obsidian sources (figure 5.5) have been identified spreading throughout the regions that constitute the Central European unit and although the lack of research in the area since 1984 may have resulted in an incomplete list, the information that exists is sufficient for the generation of a satisfactory classificatory scheme of the European obsidian sources. A number of obsidian occurrences included in some of the earlier works previously mentioned have been discarded by more recent research on the premise that: a) they were instances of confusion between obsidian and other visually similar materials (e.g. opalates), and b) they were not producing material of workable quality (see earlier discussion on Romanian «sources»).

Sources of obsidian occur in the Carpathians in three regions:

- Central Slovakia
- Southeast Slovakia/Northeast Hungary (Zemplén Mountains)
- Former Western U.S.S.R (Ukraine)

The current model on obsidian sources' presence in Europe is based on the chemical discrimination of the various obsidian samples on the basis of the obsidians' trace element content (15 trace elements for archaeological samples and 16 for geological samples) and using INAA (Instrumental Neutron Activation Analysis) following a slightly different procedure from that originally described by Hallam *et al.* in 1976 (for details about the technique see Williams-Thorpe *et al.* 1984). The results indicate that the obsidians present in Central Europe constitute seven geological groups:

- Szöllöske and Malá Toroňa
- Streda nad Bodrogom; SE Slovakia perlite periphery
- Erdöbénye, Olaszliszka, the Tolcsva area and Csepegö Forrás
- Erdöbénye
- Tokaj, upper section
- Tokaj, lower section
- Telkibánya

With respect to obsidian from archaeological contexts, the analysis showed that it can be divided into three chemically distinct groups (originating from at least four Hungarian and four Slovakian source areas):

- Carpathian 1: material from Slovakia and in particular from Szöllöske and Malá Toroňa
- Carpathian 2a: material from Hungary, specifically Erdöbénye, Olaszliszka, the Tolcsva area and Csepegö Forrás

- Carpathian 2b: material from the re-deposited source of Erdöbénye, Hungary

The majority of obsidian in Central European geological and archaeological contexts comes from Hungary and Slovakia; it is very fortunate that the material from the two regions can be readily distinguished through a visual inspection. Despite the fact that macroscopic analysis must be treated with caution, in the case of Hungary and Slovakia there is an overall difference in colour and transparency between the obsidians from the two areas that enables a distinction based on such criteria. Hungarian obsidian is almost exclusively black and opaque whereas Slovakian material is grey or grey-brown and semi-transparent (personal observation).

Another general aspect of Central European obsidian is the form in which it is found on the landscape and, more crucially, the form in which it was encountered by the Palaeolithic inhabitants of the region. Unlike the big obsidian flows that characterised the obsidian production in East Africa, the material that derives from Central Europe is mainly found in the shape of «‹bombs», with maximum dimensions ranging between 12-17cm. There are two main rhyolite areas in Hungary (Zemplén Mountains region), one in south/south-west Hegyalja and towards Abdujszanto and one in the north around the Bozsva drainage, but in general massive, solid obsidian flows are absent in Europe. Often, the obsidian in the area under consideration is found in secondary deposits, again in varying sizes, but always small, scattered nodules. This appearance of the obsidian leads to the suggestion that the nodules were either volcanic ejecta scattered over the areas in question or have been weathered out of a matrix of a soft, less glassy rhyolitic lava flow.

The obsidian sources in the European mainland and islanding region are (figure 5.5 and table 5.1 for coordinates evaluation):

1. **Mád:** (latitude 48.20000/longitude 21.28300, Hungary)

2. **Erdöbénye:** (latitude 48.26700/longitude 21.36700, Hungary)

3. **Tolcsva:** (latitude 48.28333/longitude 21.45000, Hungary)

4. **Csepegö Forrás:** (latitude 48.31700/longitude 21.43300, Hungary)

5. **Kašov:** (latitude 48.48330/longitude 21.75000, Slovakia)

6. **Cejkov:** (latitude 48.46700/longitude 21.76700, Slovakia)

7. Szöllöske: (latitude 48.40000/longitude 21.75000, Slovakia)

8. Streda nad Bodrogom: (latitude 48.36700/longitude 21.76700, Slovakia)

9. Beregovo: (latitude 48.21700/longitude 22.65000, Ukraine)

10. Mukacevo: (latitude 48.45000/longitude 22.71700, Ukraine)

11. Gertsovtse-Fedeleshovtse: (latitude 48.58300/longitude 22.65000, Ukraine)

12. Khust: (latitude 48.18100/longitude 23.29800, Ukraine)

13. Olaszliszka: (latitude 48.25000/longitude 21.43300, Hungary)

14. Malá Toroňa: (latitude 48.45000/longitude 21.68300, Slovakia)

15. Melos: (latitude 36.68000/longitude 24.45000, Greece)

16. Antiparos: (latitude 37.03000/longitude 25.08000, Greece)

17. Giali: (latitude 36.67000/longitude 27.12000, Greece)

18. Lipari: (latitude 38.46700/longitude 14.95000, Italy)

19. Palmarola: (latitude 40.93300/longitude 12.85000, Italy)

20. Pantelleria: (latitude 36.83300/longitude 11.95000, Italy)

21. Monte Arci: (latitude 39.75000/longitude 8.80000, Sardinia, Italy)

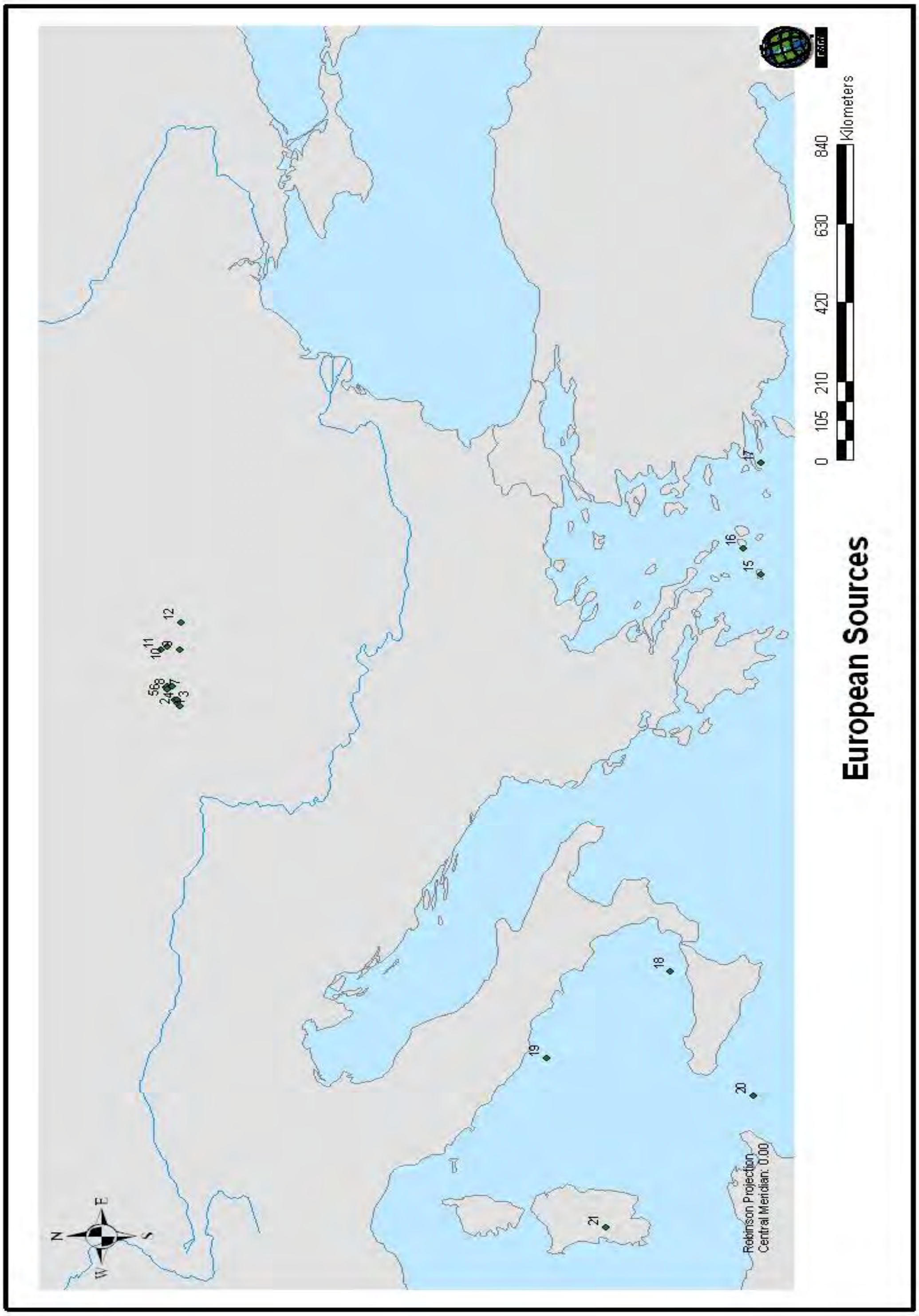


Figure 5.5. Map showing the distribution of obsidian sources, identified for the purposes of this project, in the European continent.

2.2.4. Gazetteer of European Palaeolithic Obsidian-bearing Sites

Although obsidian sources are scattered throughout the European continent with examples located both in the mainland and on islands, as discussed above, Palaeolithic sites with obsidian in their lithic assemblages are confined in the mainland of central Europe (figure 5.6). Information on these sites is provided in the gazetteer that follows (the site numbers cross-refer to the numbers on the map; they are out of sequence because the gazetteer follows a chronological order). Table 5.2 gives an evaluation of the coordinates used for the generation of the map in figure 5.6. Table 5.3 summarises the information provided in the gazetteer.

1. **Kecskésgalya** (latitude 47.88212/longitude 20.48152, Hungary):

Biró 1984, Féblot-Augustins 1997, Allsworth-Jones 1986

Middle Palaeolithic cave in the Bükk Mountains; the lithic assemblage (only 12 artefacts) consists of complete and fragmented retouched tools of the Mousterian tradition; obsidian is represented in the assemblage by 6 artefacts; based on macroscopic criteria the obsidian comes from a Slovakian source (Féblot-Augustins' Carpathian obsidian 1)

2. **Neslovice** (latitude 49.15000/longitude 16.38300, Czech Republic):

Oliva 1995, Féblot-Augustins 1997

Upper Palaeolithic open-air site; a rich lithic assemblage of 5599 specimens has been recovered from which one is made of obsidian; it is not known whether the source of the raw material is Slovakian or Hungarian

3. **Széléta, c.4** (latitude 48.10000/longitude 20.63300, Hungary):

Allsworth-Jones 1978, Biró 1984, Féblot-Augustins 1997, Simán 1995, Adams 2002, Ringer 2002, Mester 2002

Upper Palaeolithic cave in the Bükk Mountains; the oldest layers of the site dates at approximately 40kyr; a Szeletian lithic assemblage with leaf-points, scrapers and half-finished tools has been collected; little obsidian (at least one blade core) is included in the assemblage originating from a Hungarian source (Féblot-Augustins' Carpathian obsidian 2); some mixing seems to have occurred

4. Herman Ottó (latitude 47.78300/longitude 18.75000, Hungary):

Biró 1984, Féblot-Augustins 1997

Upper Palaeolithic cave in the Bükk Mountains; a small Aurignacian lithic assemblage has been unearthed in this location; 498 stone artefacts comprise the collection of which 20 (4.01%) are made of obsidian of Slovakian and Hungarian origin (Féblot-Augustins' Carpathian obsidian 2); some mixing seems to have occurred

5. Püskaporos (latitude 48.13300/longitude 20.78300, Hungary):

Biró 1984, Féblot-Augustins 1997

Upper Palaeolithic rockshelter in the Bükk Mountains; a Szeletian lithic assemblage with leaf-points, scrapers, half-finished tools, blades and waste has been collected here; 2.3% of the artefacts are made of obsidian (10 out of 900) coming from both Slovakian and Hungarian sources

6. Diósgyőr-Tapolca (latitude 48.10000/longitude 20.68333, Hungary):

Biró 1984, Féblot-Augustins 1997, Otte 1998, Ringer & Moncel 2002

Upper Palaeolithic cave in the Bükk Mountains; a Magdalenian lithic assemblage including mainly points and microblades; obsidian is present in the assemblage but in a small quantity (36 from a total of 1300 artefacts); both Slovakian and Hungarian sources are used (Féblot-Augustins' Carpathian obsidian 1); some mixing seems to have occurred

7. Mexicóvölgy (latitude 48.08333/longitude 20.66667, Hungary):

Féblot-Augustins 1997

Upper Palaeolithic cave in the Bukk Mountains; very little obsidian has been recovered on-site deriving from Slovakian and Hungarian sources (Féblot-Augustins' Carpathian obsidian 1 and 2)

8. Nová Dědina I (latitude 49.21700/longitude 17.45000, Czech Republic):

Féblot-Augustins 1997

Upper Palaeolithic open-air site; very little obsidian has been recovered from an otherwise large lithic assemblage (10 from a total of 10514 artefacts); the raw material derives from a Hungarian source (Féblot-Augustins' Carpathian obsidian 2a)

9. Barca I (latitude 48.68300/longitude 21.26700, Slovakia):

Williams-Thorpe *et al.* 1984, Féblot-Augustins 1997

Upper Palaeolithic open-air site; a small Aurignacian lithic assemblage has been unearthed on-site; 120 artefacts have been collected from horizon I of which 7 are made of obsidian of an unknown source; a little obsidian (0.9%) is also present in horizon II, again from an unknown source

9. Barca II (latitude 48.36700/longitude 20.23300, Slovakia):

Williams-Thorpe *et al.* 1984, Féblot-Augustins 1997

Upper Palaeolithic open-air site; an Aurignacian lithic assemblage comprising of 1800 artefacts; some obsidian is present on-site but very rare (30 specimens); macroscopic analysis of the raw material has not succeeded in identifying the source of the obsidian

10. Kechnec I (latitude 48.55000/longitude 21.26700, Slovakia):

Féblot-Augustins 1997

Upper Palaeolithic open-air site; lithic assemblage consisting of 4300 artefacts of which 16 are made of obsidian (0.37%); the source from which the raw material derives is not known

11. Tibana (latitude 48.71700/longitude 21.25000, Slovakia);

Biró 1984, Williams-Thorpe *et al.* 1984, Féblot-Augustins 1997

Upper Palaeolithic open-air site; a Late Aurignacian-Early Gravettian lithic assemblage dominated by cores, half-made and completed retouched tools has been collected here; 164 from a total of 866 artefacts are made of obsidian (19%) originating from a Hungarian source (Féblot-Augustins' Carpathian obsidian 2a)

12. Istállóskö (latitude 48.06700/longitude 20.43300, Hungary):

Biró 1984, Féblot-Augustins 1997, Adams 2002, Ringer 2002

Upper Palaeolithic cave in the Bükk Mountains dating between 33-28kyr; a small Aurignacian lithic assemblage with little obsidian (<10 out of 324 artefacts) from Slovakian and Hungarian sources

13. Kraków-Zwierzyniec I (latitude 53.11667/longitude 21.13333, Poland):

Biró 1984, Féblot-Augustins 1997

Upper Palaeolithic open-air site; a small Aurignacian lithic assemblage with 184 specimens has been unearthed here; a single obsidian artefact has been found on-site; it comes from a Slovakian source (Féblot-Augustins' Carpathian obsidian 1)

14. Krems-Hundssteig (latitude 48.41700/longitude 15.60000, Austria):

Biró 1984, Féblot-Augustins 1997

Upper Palaeolithic open-air site; an Aurignacian lithic assemblage including one obsidian artefact has been found on-site; the source of the raw material has not been identified

15. Senftenberg (latitude 48.43300/longitude 15.55000, Austria):

Biró 1984, Féblot-Augustins 1997

Upper Palaeolithic open-air site; the Aurignacian lithic assemblage discovered here comprises of 1818 specimens of which only one artefact is made of obsidian; the source of the obsidian is not known

16. Bodrogkeresztúr (latitude 48.16667/longitude 21.36667, Hungary):

Personal observation-case study, Biró 1984, Simán 1989, Dobosi 1994, Féblot-Augustins 1997, Otte 1998

Upper Palaeolithic open-air site in the Zemplén Mountains region dating at approximately 29kyr (28700±3000 BP); a Late Aurignacian-Early Gravettian lithic assemblage has been collected here for which more information is given in the relevant chapter of this thesis; the obsidian utilised on site originates from both Slovakian and Hungarian sources (Féblot-Augustins' Carpathian obsidian 1 and 2)

17. Aggsbach, station B (latitude 48.28333/longitude 15.40000, Austria):

Biró 1984, Féblot-Augustins 1997, Otte 1981

Upper Palaeolithic open-air site; the Aurignacian lithic assemblage recovered here consists of 1480 specimens of which a single obsidian artefact; the source of the raw material is not known

18. Předmosti (latitude 49.46700/longitude 17.45000, Czech Republic):

Féblot-Augustins 1997

Upper Palaeolithic open-air site; not much information is available for the lithic assemblage collected here; Féblot-Augustins (1997) mentions that some obsidian has been found on-site but its geological source is not known

19. Dolni Věstonice I (latitude 48.88300/longitude 16.65000, Czech Republic):

Biró 1984, Montet-White 1994, Féblot-Augustins 1997, Simán 1989, Otte 1981

Upper Palaeolithic open-air site dating at 23kyr; very little obsidian is included in the Gravettian lithic assemblage discovered here; the raw material comes from a Slovakian source (Féblot-Augustins' Carpathian obsidian 1)

20. Pavlov I (latitude 48.86700/longitude 16.66700, Czech Republic):

Biró 1984, Féblot-Augustins 1997, Simán 1989

Upper Palaeolithic open-air site dating at 26kyr; <1% obsidian is included in the Pavlovian lithic assemblage recovered in this location; the raw material comes from a Slovakian source (Féblot-Augustins' Carpathian obsidian 1)

21. Cejkov I (latitude 48.46700/longitude 21.76700, Slovakia):

Otte 1981, Biró 1984, Féblot-Augustins 1997, Kaminskă & Tomášková 2004

Upper Palaeolithic open-air site in the Tokaj Mountains dating at approximately 25kyr; a Late Aurignacian-Early Gravettian lithic assemblage has been collected; in total 617 lithics (11 cores, 57 blades, 6 microblades, 518 flakes, 2 burin spalls, 23 retouched tools) belong to this assemblage of which 537 are made of obsidian (~90%); the raw material comes from a Slovakian source (Féblot-Augustins' Carpathian obsidian 1)

22. Stránská Skála IV (latitude 49.43300/longitude 17.98300, Czech Republic):

Féblot-Augustins 1997

Upper Palaeolithic open-air site; Féblot-Augustins mentions that obsidian is present on-site but she does not provide any further information with regards to the lithic assemblage

23. Kašov (latitude 48.48300/longitude 21.75000, Slovakia):

Biró 1984, Montet-White 1994, Féblot-Augustins 1997, Otte 1981

Upper Palaeolithic open-air site in the Zemplen Mountains region dating at 20kyr; a Late Aurignacian-Early Gravettian lithic assemblage has been discovered characterised by a low tool count and high debris density; 33% of the lithics are made of obsidian deriving from a Slovakian source (Féblot-Augustins' Carpathian obsidian 1); a superior Upper Palaeolithic horizon dating at approximately 19kyr with the same characteristics has also been unearthed here; obsidian is much more abundant (80%) and comes from a Slovakian source (Féblot-Augustins' Carpathian obsidian 1)

24. Arka (latitude 48.35000/longitude 21.25000, Hungary):

Biró 1984, Dobosi 1994; 1999, Montet-White 1994, Féblot-Augustins 1997, Otte 1998, Simán 1989, Vértes 1964/65

Upper Palaeolithic open-air site in the Tokaj Mountains dating at approximately 17kyr; a Magdalenian lithic assemblage including blades, retouched tools, microliths and waste; obsidian contributes by 4.11% in the lithic assemblage with 351 specimens from a total of 8543; both Slovakian and Hungarian sources are utilised (Féblot-Augustins' Carpathian obsidian 1 and 2)

25. Hidasnémeti (latitude 48.50000/longitude 21.23300, Hungary):

Simán 1989, Dobosi 1994, Montet-White 1994, Féblot-Augustins 1997

Upper Palaeolithic open-air site in the Tokaj Mountains region; an Early Gravettian lithic assemblage with high density of tool-making debris (60%) but low counts of retouched tools; obsidian is present on-site in the form of small cores, flakes, blade fragments and tools; in total 3993 artefacts comprise the assemblage of which 11 are made of obsidian (0.27%) coming from both Slovakian and Hungarian sources (Féblot-Augustins' Carpathian obsidian 1 and 2)

26. Szob (latitude 47.81700/longitude 18.86700, Hungary):

Biró 1984, Montet-White 1994, Dobosi 1996, Féblot-Augustins 1997, Otte 1998

Upper Palaeolithic open-air site in the Danube bend region; a Gravettian lithic assemblage has been unearthed here dominated by blades and scrapers and characterised by imperfectly worked rough artefact types; little obsidian (6 specimens), deriving from a Slovakian source (Féblot-Augustins' Carpathian obsidian 1) belongs to this assemblage

27. Dömös (latitude 47.76700/longitude 18.91700, Hungary):

Biró 1984, Dobosi 1996, Féblot-Augustins 1997, Otte 1998

Upper Palaeolithic open-air site in the Danube bend region; a Gravettian lithic assemblage with retouched tools, waste and chunks has been discovered here; 427 specimens comprise this assemblage of which 47 (10%) are made of obsidian; the raw material originates from more than one sources, both Slovakian and Hungarian (Féblot-Augustins' Carpathian obsidian 1); local production of exotic obsidian

28. Pilismarót-Díos (latitude 47.78300/longitude 18.88300, Hungary):

Biró 1984, Dobosi 1994, Féblot-Augustins 1997, Otte 1998, Simán 1989

Upper Palaeolithic open-air site in the Danube bend region dating at 17kyr; a Young Gravettian lithic assemblage consisting of retouched tools, waste and chunk; from the 1257 artefacts collected on-site 32 are made of obsidian (2.5%) deriving from both Slovakian and Hungarian sources (Féblot-Augustins' Carpathian obsidian 1); local production of exotic obsidian

29. Mogyorósbánya (latitude 47.73300/longitude 18.60000, Hungary):

Dobosi 1994; 1996; 2002, Féblot-Augustins 1997, Otte 1998

Upper Palaeolithic open-air site in the Danube bend dating at ~20kyr; a Gravettian lithic assemblage has been collected here (Dobosi calls it pebble Gravettian); obsidian is present in moderate quantities with 228 specimens from a total of 6108; the raw material comes from a Slovakian source (Féblot-Augustins' Carpathian obsidian 1)

30. Nógrádveröce (latitude 47.83300/longitude 19.03300, Hungary):

Biró 1984, Féblot-Augustins 1997

Upper Palaeolithic open-air site in the Danube bend region; a Gravettian lithic assemblage has been unearthed in this location; obsidian forms <10% of the total assemblage and it derives from a Slovakian source (Féblot-Augustins' Carpathian obsidian 1); local production of exotic obsidian

31. Esztergom-Gyurgyalag (latitude 47.80000/longitude 18.75000, Hungary):

Dobosi 1994; 1996, Féblot-Augustins 1997, Otte 1998, Dobosi & Kŏvecses-Varga 1991

Upper Palaeolithic open-air site in the Danube bend with an approximate date at 17kyr; a Young Gravettian lithic assemblage has been discovered here; 1100 artefacts form this assemblage of which one specimen is made of obsidian (0.1%); the raw material is of Slovakian origin(Féblot-Augustins' Carpathian obsidian 1)

32. Ságvár (latitude 46.83300/longitude 18.11700, Hungary):

Biró 1984, Dobosi 1994, Féblot-Augustins 1997, Otte 1998

Upper Palaeolithic open-air site in the Lake Balaton region dating at approximately 18-17kyr; a lithic assemblage of imperfectly worked, rough Gravettian artefact types, including burins and scrapers, has been recovered; a small amount (<1%) of Slovakian obsidian is present in the assemblage (totally 10 obsidian specimens)

33. Kůlna, c.5 (latitude 49.41096/longitude 16.74448, Czech Republic):

Biró 1984, Boeda 1995, Féblot-Augustins 1997, Oliva 2005

Upper Palaeolithic cave; a Magdalenian/Epigravettian lithic assemblage (209 specimens) has been collected from this location; a single obsidian artefact (0.48%, flake) of Slovakian origin is included in the assemblage (Féblot-Augustins' Carpathian obsidian 1)

34. Sajóbábony (latitude 48.16700/longitude 20.73300, Hungary):

Ringer 2002

Middle Palaeolithic open-air site in the Bükk Mountains; a single obsidian artefact has been recovered from this site and it derives from a Slovakian source (Féblot-Augustins' Carpathian obsidian 1)

35. Ballavölgyi (latitude 47.98300/longitude 20.03300, Hungary):

Biró 1984, Allsworth-Jones 1986, Féblot-Augustins 1997

Middle Palaeolithic rockshelter in the Bükk Mountains; the lithic assemblage consists of only 9 artefacts all of which made of obsidian; Allsworth-Jones mentions 3 obsidian denticulates, 2 points, a sidescraper, an end-scraper, a possible burin and a blade fragment; Biró mentions Mousterian flakes and waste from re-sharpening; the obsidian used comes from a Slovakian source (Féblot-Augustins' Carpathian obsidian 1); Biró also suggests that obsidian enters the site as blanks and it gets modified locally according to the arising needs; the modification involves the re-juvenation of the specimens using a levalloisoid technique (Biró 1984)

36. Büdöspest (latitude 48.05290/longitude 20.54281, Hungary):

Biró 1984, Mester 1995, Féblot-Augustins 1997

Middle Palaeolithic cave in the Bükk Mountains; the lithic assemblage comprises of flakes, blades, retouched tools and waste from re-sharpening; according to Biró (1984) obsidian enters the site in blank form and is modified according to special needs locally; 36 from a total of 9368 artefacts (0.38%) are made of obsidian; based on macroscopic criteria, two different types of obsidian are used, Féblot-Augustins' Carpathian 1 and 2, deriving from Slovakian and Hungarian sources; some mixing has occurred

37. Farkaskö (latitude 47.95000/longitude 20.61700, Hungary):

Biró 1984, Féblot-Augustins 1997

Middle Palaeolithic cave in the Bükk Mountains; the lithic assemblage comprises of completed and fragmented Mousterian retouched tools; one obsidian artefact has been unearthed on-site too; according to its physical characteristics it comes from a Slovakian source (Féblot-Augustins' Carpathian obsidian 1)

38. Subalyuk (latitude 47.93300/longitude 20.53300, Hungary):

Biró 1984, Féblot-Augustins 1997

Middle Palaeolithic cave in the Bükk Mountains; the lithic assemblage consists of flakes, blades, retouched tools and waste; the assemblage was previously mixed with that of Büdöspest but it has since been sorted; according to Biró (1984) 14 obsidian artefacts belong to the Subalyuk material; however, Féblot-Augustins (1997) mentions 28 (2.3%) & 4 (0.1%) obsidian artefacts that from the two Middle Palaeolithic horizons respectively; both Slovakian and Hungarian obsidian sources are utilised (Féblot-Augustins' Carpathian obsidian 1 and 2)

39. Jászfelsőszentgyörgy (two sites 200m distance) (latitude 47.50000/longitude 19.80000, Hungary):

Dobosi 1994; 1999; 2001, Otte 1998

Upper Palaeolithic open-air site dating at ~18kyr; a Gravettian lithic assemblage has been unearthed here; both localities combined produced 2223 artefacts of which 104 specimens are made of Slovakian and Hungarian obsidian (4.7%)

40. Bacho Kiro (latitude 42.93300/longitude 25.41700, Bulgaria):

Kozlowski 1982

Upper Palaeolithic cave dating at ~29 kyr; an Aurignacian assemblage has been unearthed from layer 7 (a total of 654 lithics) including a single obsidian artefact; based on its morphological features (Kozlowski) the source of the raw material is the Aegean Islands

41. Amaliada 13 (latitude 37.80000/longitude 21.35000, Greece):

Kourtessi-Philippakis 1986

Middle Palaeolithic open-air site; few surface findings were collected from this location, including one Levallois core; a single obsidian artefact (a blade) has been found here, its importance lying on the fact that the nearest obsidian source is several hundred kilometres away in the island of Melos

42. Görömböly-Tapolca (latitude 48.06700/longitude 20.75000, Hungary):

Personal communication with György Lengyel (Herman Ottó Museum)

Upper Palaeolithic open-air site dating at 30.3kyr; what is known for its lithic assemblage is that there is some obsidian which comes from a Hungarian source

43. Sajószentpéter-Nagykorcsolas (latitude 48.21700/longitude 20.71700, Hungary):

Simán 1982

Middle Palaeolithic open-air site; the lithic assemblage consists of surface findings of the Baboyian industry; 6.98% of the artefacts are made of obsidian from both Slovakian and Hungarian sources; an Upper Palaeolithic horizon has also been recovered at the site with lithics of the Gravettian tradition; in this horizon the obsidian ratio is increased (7.68%) but still Slovakian and Hungarian sources are in use

44. Ëger (latitude 47.71667/longitude 20.46667, Hungary):

Dobosi 1995, Zandler 2006

Upper Palaeolithic open-air site; a Szeletian lithic assemblage has been unearthed here; 5 obsidian artefacts (from a total of 357) are included in the assemblage of which 1 retouched tool and 4 flakes; Slovakian and Hungarian obsidian sources are in use

45. Malyj Rakovets (latitude 48.26700/longitude 23.20000, Ukraine):

Sitlivyj & Ryzov 1992

Late Middle Palaeolithic open-air site; a rich obsidian assemblage has been recovered in this location; a full reduction sequence is present but retouched tools dominate; 85.5% of the formal tools are made on obsidian and in general 95% of the lithics are of the specific raw material

46. Pilisszántó II (latitude 47.66700/longitude 18.90000, Hungary):

Dobosi & Vörös 1986, Biró 1984, Otte 1998

Middle Palaeolithic (Würm I/II) rockshelter; only two retouched flakes (possibly Jankovichian) have been discovered in this location; one of them is of Slovakian obsidian

Finally, archaeological obsidian has been unearthed from a number of Hungarian sites (Kasztovszky & Biró 2004): Galgagyörk-Csonká-hegy (Palaeolithic), Hont-Molnárhegy (Upper Palaeolithic), Kálló-Pusztahegy (Upper Palaeolithic-Gravettian) and Legénd-Káldy-tanya (Palaeolithic). However, their lithic assemblages have not been inventorised yet and so they were not chosen for further analysis.

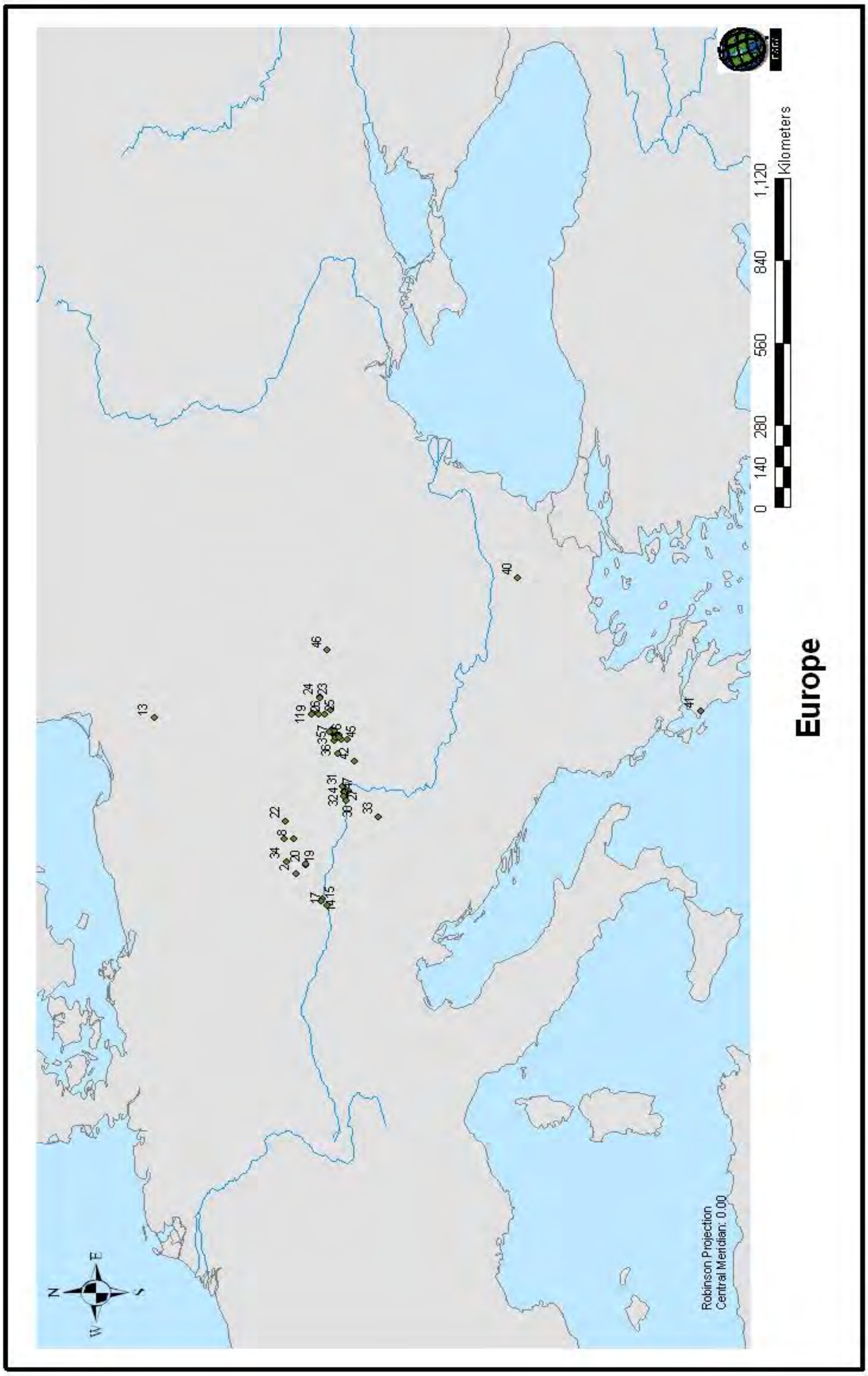


Figure 5.6. Map indicating the location of European obsidian-bearing sites dating to the Palaeolithic. Barca I and II have the same number (9) because they are two horizons of the same site.

2.3. Near East

2.3.1. Tectonic Evolution and Obsidian Sources in Turkey

A discussion of the geological history of Turkey is not an easy matter. The numerous, multiple and in many instances interrelated tectonic events that characterise it prohibit the generation of a clear, coherent model for its geological evolution.

Geologically, Turkey is part of the great Alpine belt that extends from the Atlantic Ocean to the Himalaya Mountains. Its sedimentological base is primarily confined to the limits of the minor continental Anatolian plate (with the exception of a small portion along the Syrian border that is a continuation of the Arabian platform); however, this country is highly affected by the motion of two other major tectonic plates, the African and Arabian plates as it is located at the junction of the three lithospheric units mentioned earlier. Convergence between these three plates began in mid-Cretaceous at approximately 100 Myr (Dhont *et al.* 1998). Not surprisingly, Turkey's position on the specific region resulted in it being subjected to intense tectonic and volcanic activity throughout this period. Yürür & Chorowicz (1998) discuss in details the recent tectonic and volcanic events in the region so they will not be repeated here. Summarising their conclusions, the following picture emerges: the triple junction zone has first suffered from a north-south compression, followed by the extrusion movement of the Anatolian block and the formation of the East Anatolian fault (dated at ~1.9 Myr) accompanied by the westward crustal displacements resulting in extensional and strike-slip faulting. This last event opened the older faults and joints which allowed magma to escape leading to extensive volcanism (mainly alkaline) dating to the Quaternary and more recent times (until 0.4 Myr).

Central Anatolia has undoubtedly been the part of the Turkish peninsula that suffered from these tectonic events the most. Nevertheless, it is also the region where the majority of obsidian outcrops have been formed. Brinkmann (1976), Druitt *et al.* (1995) and Deniel *et al.* (1998) offer a background of the pre-Quaternary geological evolution of the region, the volcanic events and the characteristic chemical composition of the released magma which in the case of, for example, the Acigöl complex and the Hasan Dag volcano resulted in the production of obsidian outcrops. In particular the late Quaternary rhyolitic eruptions of the Acigöl volcano complex are responsible for an extensive obsidian occurrence in the area, varying in shape, size and chemical composition from sub-source to sub-source.

In the western and eastern part of Turkey calc-alkaline magmas were also produced during the Late Oligocene-Early Miocene and Pliocene respectively. However, these deposits were later (Middle Miocene for the West and Quaternary for the East) covered by alkaline magmas (Deniel *et al.* 1998). South-eastern Turkey has also been an area of extensive volcanic activity dating to the Neogene (19-15 Myr) and Quaternary (2.3-0.6 Myr) and resulting in the production of basaltic magma (Arger *et al.* 2000). Finally, in the North East Black Sea part of the peninsula an eruptive event that took place sometime between 1.93±0.15 and 1.73±0.10 Myr resulted in the infilling of Pliocene neotectonic faults with obsidian. Despite the fact that these obsidian exposures are differing in colour and structure they are geochemically homogeneous and the only ones in the Eastern Black Sea area that date back to the Plio-Pleistocene (Yeğingil *et al.* 2002).

The highly complex nature of the tectonic and volcanic evolution phenomena that characterise Turkey makes the identification of distinct eruptive events and their correlation to specific obsidian outcrops/sources extremely difficult. Despite the efforts of a great number of researchers, many events still remain unknown or poorly understood. It is this limiting factor that poses problems in the study of obsidian in Turkey, particularly with regards to the identification and segregation of individual obsidian sources. Given that obsidian beds were being produced from 25 Myr onwards (for a summary of the available data see Ercan *et al.* 1994) it becomes apparent that putting the pieces of this puzzle in the correct order is not an easy task.

The intense volcanic activity that characterised Turkey throughout its geological history has bequeathed the region with an impressive number of obsidian sources. These occupy a large part of the country making Turkey one of the most interesting areas for obsidian oriented studies.

Renfrew and his colleagues were the first to turn their attention to the Turkish obsidian; from the early sixties they recognised the potential of the region in systematising the research on volcanic glass provenance (Cann & Renfrew 1964, Renfrew *et al.* 1966; 1968, Hallam *et al.* 1976). Despite the fact that their research was based on material from Neolithic contexts, the importance of their pioneering research has been catalytic as it permitted the determination of the natural (geological) sources of obsidian (trace-element analysis using optical spectrography) and the allocation of archaeological artefacts to specific sources initiating the discussion of raw material movement and trade (Renfrew 1969, Renfrew *et al.* 1965). Although, their work remains classic among studies on the correlation of obsidian artefacts to geological sources, additional and more recent investigation on the Turkish obsidian, undertaken by a number of researchers (e.g. Cauvin & Chataigner 1998, Mochizuki 1999, Oddone *et al.* 2003), led to a revision of those initial findings and allowed a more detailed dataset to be generated.

Turkish obsidian is found in flows or blocks, in a variety of sizes, and can be divided into two broad geochemical categories, calc-alkaline which is widespread throughout the country and peralkaline which is restricted to the Bingol and Nemrut Dag areas (Cauvin & Chataigner 1998). Nevertheless, given the complex tectonic history of the region these two different compositional groups can be found together rendering the assignment of an obsidian sample to a particular source problematic. With regard to its chromatic characteristics, Turkish obsidian can be black (occasionally with grey amygdules according to Renfrew *et al.* 1966), brown, laminated brown and black whereas the peralkaline varieties are usually green under transmitted light.

Almost every scientific technique aiming at the chemical characterisation or dating of volcanic glass has been applied to obsidian from Anatolia (taken to mean Turkey here): LA-ICP-MS/Laser Ablation Inductively Coupled Plasma Mass Spectometry (Gratuze 1999, Carter *et al.* 2006), PIXE/Proton Induced X-ray Emission (Le Bourdonnec *et al.* 2005), FT/Fission-Track (Bigazzi *et al.* 1997; 1998), PIGE/Proton Induced Gamma Ray Emission (Gratuze *et al.* 1991; 1993), INAA/Instrumental Neutron Activation Analysis (Oddone *et al.* 2003), X-Ray Fluorescence Analysis (Mochizuki 1999), ESR/Electron Spin Resonance and TL/Thermoluminescence (Bulur *et al.* 1994). Based on the results of each of these techniques various scholars proposed their own models for the identification and division of obsidian sources in Turkey creating a fair amount of confusion. In my opinion, Keller & Seifried (1990) manage to deal very effectively with this issue and provide a clarifying model of obsidian sources' discrimination putting together in the most successful manner all the available information.

It must be emphasised, and always recalled in any discussion concerning the Turkish obsidian, that the geological formations associated with the specific raw material are very different from those of the other two regions already examined. Compared to the well-distinguished, individually represented in space sources of East Africa and Central Europe, the obsidian bearing zones of Turkey cover hundreds of km² often encompassing multiple phases of volcanism that are not always distinguishable. Furthermore, apart from the two major zones of Eastern and Central Anatolia, smaller sources are scattered throughout the country, some sources have been completely used up whereas some others are buried under more recent alluviation or volcanism (Özdogan 1994).

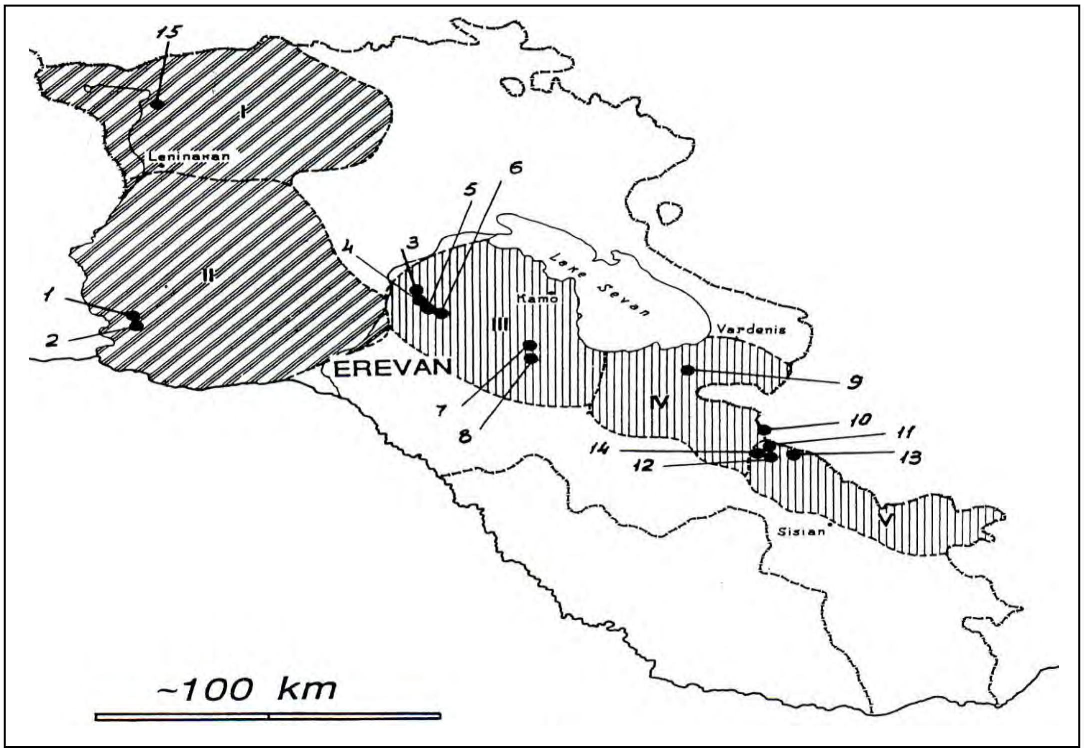
2.3.2. Tectonic Evolution and Obsidian Sources in the Caucasus

Administratively the Caucasus region comprises nine Eurasian nation-states and autonomous republics. In the context of this project the term «Caucasus» is confined to the countries where the eponymous mountain range occurs and where the presence of obsidian outcrops has been identified. Thus, «Caucasus» will stand for Armenia (and Karabagh), Georgia, Azerbaijan and the south-west part of Russia where a single obsidian source (no associated archaeology has been reported yet) exists.

As in the previous case, the geological history of the region is hard to reconstruct in detail, the main reason for this being the lack of research in the area and the peculiar position of the Caucasus Mountains with their division in several countries. Fortunately, the data that have been generated recently allow some useful inferences to be made with respect to the volcanic events and the related obsidian formation that characterised this particular spatial unit.

The obsidian bearing geological features in the region (figure 5.7) are associated with the prominent rhyolitic dome-shaped volcanoes dating to the Pliocene and Quaternary periods, from 2.5 Myr to present. Although geodynamic events linked to tectonic movement and volcanism have been taking place from early on in the geological history of the area, here I will only briefly discuss the Plio-Pleistocene phenomena (for a review and critique of the relevant literature see Mitchell & Westaway 1999). Obsidian is the product of acidic rhyolitic volcanism that took place during the Neogene-Quaternary spreading widely within the Caucasian part of the Eurasian plate (Adamia *et al.* 2002). At present there is a lack of agreement on the character of the events that resulted in this phenomenon; Mitchell & Westaway (1999) state that the uplift motion and its associated magmatism were caused by inflow of lower continental crust whereas Karapetian *et al.* (2001) put forward the theory of volcanic activity as a result of continental collision due to the convergence between the Eurasian and Arabian lithospheric plates.

The chronological framework of the events associated with the formation of obsidian is generally accepted and, as has already been mentioned, it is identified as Pliocene-Quaternary. With special reference to Armenia, Karapetian *et al*. (2001) recognise three stages of volcanism, 17-10 Myr, 7.5-4.5 Myr, and 2.8-0.1 Myr respectively, all of which produced rocks of rhyolitic composition. Using Armenia as their research focus, Mitchell & Westaway (1999) further determine the ages of recent volcanic events at 1.1-0.8 Myr in Greater Caucasus and ~1.5 Myr for the initiation of volcanism in the Lesser Caucasus. Keller *et al*. in their 1994 paper provide a useful outline of the obsidian bearing volcanoes in Armenia and its adjacent areas with information on dating conducted on obsidian samples using the FT (Fission-Track) technique that conforms to the above chronological scheme



The Caucasus sub-region is one of the less studied areas in relation to provenance studies of obsidian despite the presence of numerous volcanic complexes bearing this particular lithic material. Within the constrained field of Russian literature, obsidian from the Caucasus and Transcaucasus regions had received some attention in a petrological/petrographical framework, for example in the work of Abich (1882) or later in the work of Karapetian (1963), which however remained largely inaccessible to the wider scientific community.

Notwithstanding the delayed scientific interest in Caucasian obsidian the research undertaken succeeded in generating a sound, coherent picture of the obsidian bearing volcanic complexes with clearly defined limits and the assignment of obsidian to specific geological sources. Research conducted by Keller *et al*. (1994), Blackman *et al*. (1998) and most recently an INTAS (International Association for the Promotion of Co-operation from the New Independent States of the former Soviet Union) project (Badalian *et al*. 2001) has played a decisive role in filling many of the numerous gaps of the dataset concerning the characteristics and use of the particular region's obsidian. Emphasis has been mainly focused on Armenia, but this observation does in no way minimise the significance of the above studies in a better understanding of the Caucasian obsidian in general.

Although research in the area, both for geological and archaeological obsidian assemblages, is still ongoing the proposed models of Caucasian obsidian sources are in complete agreement, showing the exact same picture, and can thus be safely used in any study interested in the obsidian exploitation in the region. Figure 5.6 shows the volcanic complexes present in the Caucasus area. Chemical analysis conducted on samples of geological obsidian identified 19 chemical composition groups (all within the calc-alkaline family). 13 of them are uniquely associated with a single source, 2 sources appear to have more than one composition, probably due to multiple eruptive cycles on the same region, 2 composition groups seem to derive from multiple sources and 5 sources do not show any sign of prehistoric utilisation (and thus are not included in this project).

The obsidian sources identified for the purposes of this project in the Near East are (figure 5.8 and table 5.1 for coordinates evaluation):

1. **Yağlar:** (latitude 40.18029/longitude 45.02328, Turkey)
2. **Sakaeli:** (latitude 40.33276/longitude 44.73048, Turkey)
3. **Acigöl:** (latitude 40.40171/longitude 44.67214, Turkey)
4. **Nenezi Dag:** (latitude 40.51381/longitude 44.54628, Turkey)
5. **Hasan Dag:** (latitude 40.58921/longitude 44.55233, Turkey)
6. **Gollü Dag/Çiftlik:** (latitude 40.28886/longitude 43.76611, Turkey)
7. **Hotamis Dag:** (latitude 41.03972/longitude 43.85972, Turkey)
8. **Ikizdere:** (latitude 41.30000/longitude 40.91667, Turkey)

9. **Kars:** (latitude 40.75000/longitude 42.90000, Turkey)

10. **Sarikamiş:** (latitude 40.33188/longitude 42.59455, Turkey)

11. **Erzurum:** (latitude 39.91157/longitude 41.28977, Turkey)

12. **Bingöl:** (latitude 38.89029/longitude 40.49509, Turkey)

13. **Muş:** (latitude 38.72880/longitude 41.49831, Turkey)

14. **Meydan Dag:** (latitude 38.71117/longitude 41.53082, Turkey)

15. **Süphan Dağ:** (latitude 38.92000/longitude 42.82000, Turkey)

16. **Nemrut Dag:** (latitude 38.65000/longitude 42.23000, Turkey)

17. **Bartsratumb:** (latitude 39.55009/longitude 45.85181, Caucasus)

18. **Bazenk:** (latitude 39.76896/longitude 45.85686, Caucasus)

19. **Sevkar:** (latitude 39.79737/longitude 45.83969, Caucasus)

20. **Satanakar:** (latitude 39.82582/longitude 45.82814, Caucasus)

21. **Ketchaldag/Merkasar:** (latitude 39.58219/longitude 46.23664, Caucasus)

22. **Kelbadzhar:** (latitude 40.10667/longitude 46.03833, Caucasus)

23. **Khorapor:** (latitude 40.05480/longitude 45.62977, Caucasus)

24. **Geghasar:** (latitude 40.11450/longitude 44.99681, Caucasus)

25. **Spitaksar:** (latitude 40.18029/longitude 45.02328, Caucasus)

26. **Hatis:** (latitude 40.33276/longitude 44.73048, Caucasus)

27. **Gutansar:** (latitude 40.37046/longitude 44.68529, Caucasus)

28. **Alaphars:** (latitude 40.40171/longitude 44.67214, Caucasus)

29. **Kamakar:** (latitude 40.51381/longitude 44.54628, Caucasus)

30. **Hankavan:** (latitude 40.58921/longitude 44.55233, Caucasus)

31. **Arteni:** (latitude 40.28886/longitude 43.76611, Caucasus)

32. **Ashotsk:** (latitude 41.03972/longitude 43.85972, Caucasus)

33. **Chikiani:** (latitude 41.23105/longitude 43.82280, Caucasus)

34. **Baksan:** (latitude 43.68080/longitude 43.53406, Caucasus)

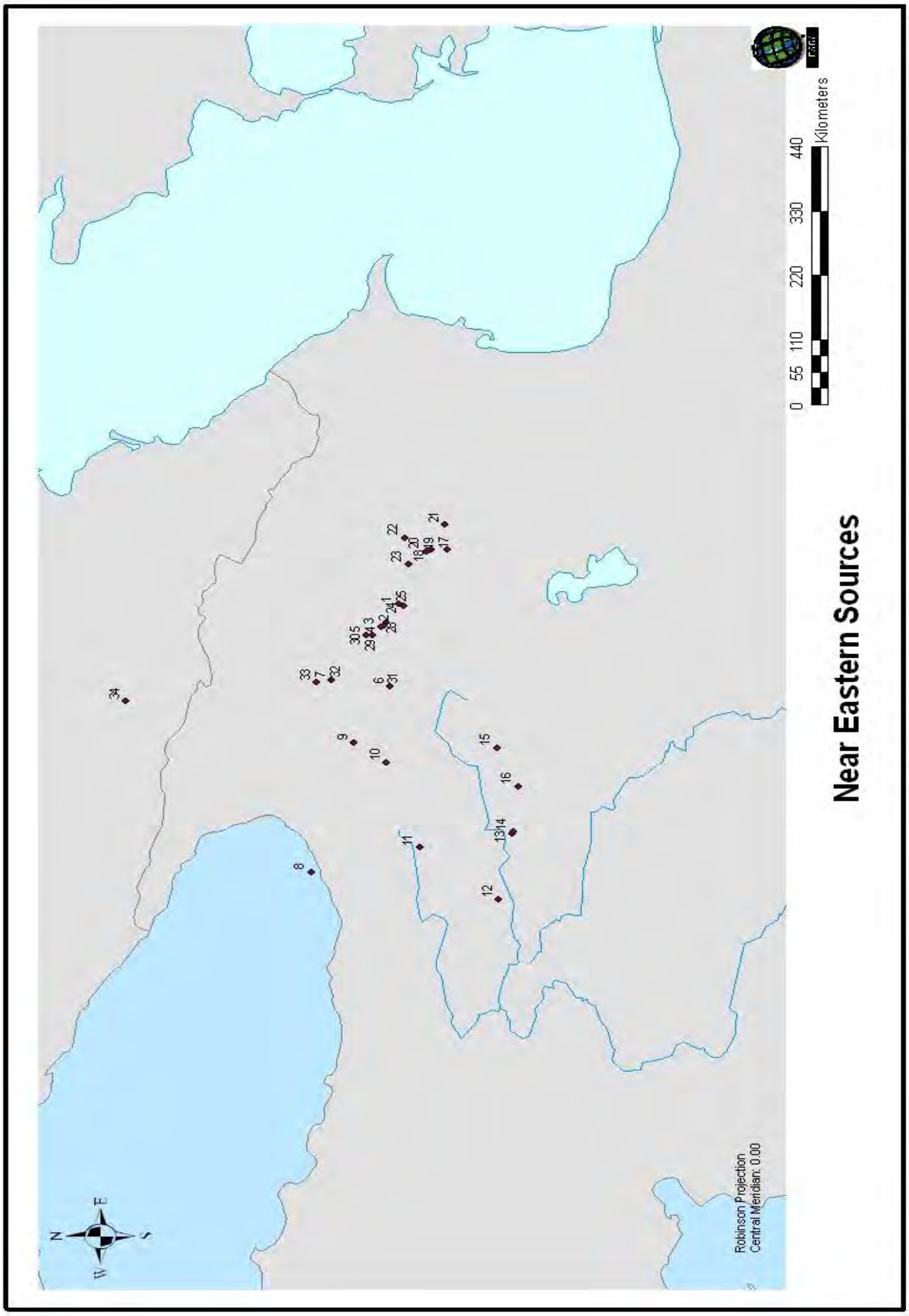


Figure 5.8. Map showing the distribution of obsidian sources in the Near East.

2.3.3. Gazetteer of Near Eastern Palaeolithic Obsidian-bearing Sites

In the Near East Palaeolithic sites using obsidian are found mainly in Turkey, undoubtedly a result of the numerous sources scattered in the region. Few obsidian-bearing sites have also been unearthed in Caucasus although future research is likely to increase their number (see below for information on these sites and figure 5.9). Table 5.2 gives an evaluation of the coordinates on which the map in figure 5.9 is based. As mentioned before, the site numbers are not in order as the gazetteer was generated following a chronological sequence. See table 5.3 for a summary of the information discussed in the gazetteer.

1. Ortvale Klde (latitude 42.29800/longitude 43.29900, Georgia):

Adler *et al.* 2006, Tushabramishvili *et al.* 2003

A long Middle and Upper Palaeolithic sequence has been established in this rockshelter; the Late Middle Palaeolithic horizon dates between 44-35kyr; a Typical Mousterian, non-Levallois, lithic assemblage has been unearthed here dominated by small débitage and heavily reduced tools and including 22051 specimens of which 93 (0.4%) are made of obsidian; an Early Upper Palaeolithic horizon is also present dating at approximately 35kyr; specimens resembling a full reduction sequence are present in this assemblage too; obsidian is more abundant here with 447 artefacts from the total of 11905 (4%); according to Adler et al. (2006) the raw material comes from an obsidian source located over 100 km away

2. Arzni (latitude 40.29600/longitude 44.59600, Armenia):

Klein 1966, Gábori 1976

Lower and Middle Palaeolithic open-air site; two lithic assemblages- a Late Acheulean and an Early Mousterian- have been unearthed here with full reduction sequences in both layers but, unfortunately, they have been lumped together; in total 350 artefacts comprise the lithic assemblage all of them made of obsidian

3. Dzhraber (latitude 40.35200/longitude 44.64500, Armenia):

Klein 1966

Lower Palaeolithic open-air site; the lithic assemblage follows the Late Acheulean tradition although some mixture with Mousterian features is possible; a full reduction sequence has been unearthed dominate by cores (105) including nucleiform lumps of obsidian as well; in total 200 artefacts comprise the assemblage all made of obsidian

4. Acigöl Etekleri (latitude 38.55028/longitude 34.50917, Central Anatolia):

TAY Project- The Archaeological Settlements of Turkey

Middle Palaeolithic findspot; the survey conducted in this location recovered Levallois tools and flakes made of obsidian; however, information with regards to the sampling strategy and artefact frequencies is not reported

5. Arapkir Çayi (latitude 39.03000/longitude 38.29000, Eastern Anatolia):

TAY Project- The Archaeological Settlements of Turkey

Upper Palaeolithic rockshelter; a test trench opened in this spot produced few lithics of which a single obsidian blade (excavations were discontinued after the first 50 cm because it was poor in cultural remains)

6. Domali-Alaçali (latitude 41.20000/longitude 29.40000, Marmara):

TAY Project- The Archaeological Settlements of Turkey

Upper Palaeolithic open-air site; a lithic assemblage dating to the end of the Upper Palaeolithic has been gathered in this location; the artefacts are mainly made of flint but a little obsidian has also been found

7. Erikli Deresi (latitude 39.45000/longitude 38.03333, Central Anatolia):

TAY Project-The Archaeological Settlements of Turkey

Lower Palaeolithic findspot; two obsidian handaxes have been collected in this location during a survey conducted near the obsidian sources of the region

8. Karatas Kaya Siginagi (latitude 38.83300/longitude 39.25000, Eastern Anatolia):

TAY Project- The Archaeological Settlements of Turkey

Upper Palaeolithic rockshelter; a lithic assemblage with Aurignacian features has been recovered here; some obsidian is included in the assemblage and according to the researcher (Kökten) it derives from the sources in the Bingöl-Soluhan district

9. Kisla Kadarak (latitude 37.58000/longitude 34.42000, Central Anatolia):

TAY Project- The Archaeological Settlements of Turkey

Middle Palaeolithic findspot; two handaxe-like obsidian tools have been discovered in this location but no further information is available

10. Liz (latitude 39.01639/longitude 42.05611, Eastern Anatolia):

TAY Project-The Archaeological Settlements of Turkey

Middle Palaeolithic findspot; a single obsidian chipped tool has been discovered here; the researcher who located the spot (Kökten 1947, 1952- mentioned in TAY) states that the specimen is of Levallois-Mousterian type; no other Palaeolithic sites have been discovered in the area (Mus province) possibly due to the fact that the climate in this period was too harsh for hunting and gathering (Rothman 1993)

11. Parganli-Kerpe Arasi (latitude 41.12400/longitude 30.01100, Marmara):

TAY Project-The Archaeological Settlements of Turkey

Middle Palaeolithic findspot; abundant cores and flakes have been collected in this location including a single specimen made of obsidian (scraper)

12. Pendik-Hacet Deresi (latitude 40.87750/longitude 29.25139, Marmara):

TAY Project-The Archaeological Settlements of Turkey

Middle Palaeolithic findpsot; a small lithic assemblage comprised of flakes and blades has been recovered in this location; the majority of them are made of flint but a few are of obsidian

13. Suvermez (latitude 38.36667/longitude 34.66667, Central Anatolia):

TAY Project-The Archaeological Settlements of Turkey

Middle Palaeolithic finspot; a small assemblage of 6 obsidian artefacts has been collected in this location; the researcher who discovered the spot (Kansu 1945-mentioned in TAY) describes the specimens as scrapers and scraper-points manufactured using the Levallois technique

14. Yazilikaya (latitude 39.20000/longitude 30.71700, Eastern Anatolia):

TAY Project- The Archaeological Settlements of Turkey

Upper Palaeolithic open-air site; some obsidian artefacts (burins) were collected in this location but further research is required

15. Yüksekova (latitude 37.35000/longitude 44.17000, Eastern Anatolia):

TAY Project-The Archaeological Settlements of Turkey, Nishiaki 1993

Middle Palaeolithic findspot; Kökten (1961-mentioned in TAY) discovered obsidian chipped stone tools in this location but no further information is available

16. Shanidar (latitude 36.80100/longitude 44.24300, Iraq):

Renfrew *et al.* 1966, Chataigner *et al*. 1998

Upper Palaeolithic cave; little obsidian (‘un dizaine de pieces’) is included in the site’s lithic assemblage; based on Renfrew’s (1966) opinion the raw material originates from the Nemrut Dag obsidian source

17. Karain (latitude 37.07280/longitude 30.55783, Southern Anatolia):

Renfrew *et al.* 1966, Demirci & Yalçinkaya 1994, Bahadir Alkim 1968, Otte *et al.* 1995; 1998, Yalçinkaya & Otte 2000

Upper Palaeolithic cave with two horizons, one dating at 120-110kyr and the second at 70-60kyr; the lithic assemblage discovered on-site is dominated by flakes and blades exhibiting Aurignacian features; little obsidian is present in the assemblage and according to Renfrew (1966) it comes from one of the obsidian sources in Çiftlik

18. Oküzini (latitude 37.05000/longitude 30.55000, Southern Anatolia):

Renfrew *et al*. 1966, Otte *et al.* 2003

Upper Palaeolithic cave; an Aurignacian lithic assemblage dominated by flakes and blades has been discovered in this site; little obsidian is included among the artefacts and according to Renfrew (1966) the raw material comes from one of the obsidian sources in Çiftlik

19. Erçis (latitude 39.02389/longitude 43.36167, Lake Van):

Renfrew *et al.* 1966, Nishiaki 1993

Middle Palaeolithic findspot; some obsidian artefacts have been collected from this location but no further information is known

20. Borluk (latitude 40.00000/longitude 43.00000, Eastern Anatolia):

Renfrew *et al*. 1966, Nishiaki 1993, TAY Project- The Archaeological Settlements of Turkey

Middle Palaeolithic cave; according to Renfrew (1966) very little obsidian has been collected from this location although Kökten (1944-mentioned in TAY) mentions only one Mousterian tool made of obsidian

21. Çarkini (latitude 37.05700/longitude 30.56200, Southern Anatolia):

Renfrew *et al.* 1966

Upper Palaeolithic findspot; little obsidian has been collected in this location but no further information is available

22. Zarzi (latitude 35.81194/longitude 45.01861, Iraq):

Renfrew *et al.* 1966

Late Upper Palaeolithic cave; two obsidian artefacts have been recovered from layer B but the author does not provide further information with regards to the lithic assemblage

23. Kaletepe Deresi 3 (latitude 38.28333/longitude 34.58333, Central Anatolia):

Slimak *et al.* 2004, TAY Project-The Archaeological Settlements of Turkey

Lower and Middle Palaeolithic open-air site; a rich lithic assemblage has been recovered from the Lower Palaeolithic horizon (levels IV-V) which dates at 160kyr and is dominated by handaxe production flakes; the main raw material utilised for the manufacture of the lithics is obsidian; the Middle Palaeolithic horizon (levels I-III) features a Levallois lithic assemblage characterised by discoid débitage and cores, denticulates and racloirs; obsidian comprises the majority of the lithics in this layer too

24. Trialeti (latitude 41.53900/longitude 44.10800, Georgia):

Gábori 1976

Middle Palaeolithic open-air site; the lithic assemblage includes Acheulean bifaces rejuvenated for MP use; the majority of the specimens are made of obsidian

25. Azych (latitude 39.01029/longitude 46.01647, Azerbaijan):

Roebroeks 1997, Panichina 1950, Klein 1966, Gábori 1976

Middle Pleistocene cave with Lower and Middle Palaeolithic horizons; a Middle Acheulean lithic assemblage has been unearthed in layer V consisting mainly of scrapers and other retouched tools; obsidian is present in this layer but very rare; a Late Acheulean-Early Mousterian lithic assemblage, with 3093 specimens, has been collected in layer III; obsidian is also present in this horizon with 14 artefacts made of obsidian

26. Kudaro I (latitude 42.52278/longitude 43.64222, Georgia):

Klein 1966, Roebroeks & van Kofschoten 1997, Baryshnikov 1999, Gábori 1976

Lower Palaeolithic cave dating at approximately 360kyr; an Acheulean lithic assemblage has been unearthed in layer 5v including handaxes, retouched tools, cores, flakes and waste; a single obsidian artefact (a limace) has also been discovered on-site

27. Tsalka (latitude 41.59139/longitude 44.08694, Georgia):

Gábori 1976

Middle Palaeolithic open-air site; a Mousterian lithic assemblage has been collected here with some obsidian but no further information is provided by the author

28. Satani-dar (latitude 40.91667/longitude 44.20000, Armenia):

Klein 1966, Gábori 1976, Panichina 1950

Lower Palaeolithic open-air site; a Late Acheulean lithic assemblage with 600 specimens has been discovered in the upper layer; cores, elongated blades, handaxes, Clactonian flakes, points, scrapers and obsidian fragments and nodules are included here; the bottom layer consists of 400 Chellean artefacts (nodules, choppers, scrapers, points, blades and nodules); the majority of lithics are made of obsidian

29. Erivan I (latitude 40.18100/longitude 44.51400, Armenia):

Gábori 1976

Middle Palaeolithic cave; a Mousterian lithic assemblage has been collected on-site including mainly retouched tools (such as points, burins and scrapers); the author mentions that the assemblage is totally made of obsidian but does not provide further information on the lithics

Finally, King et al. (2003) mention a cave at Tughlar, South-eastern Karabagh, with Upper Palaeolithic obsidian tools; as obsidian is not local to this site's region its presence may suggest networking between hominin groups. However, the lack of further information on the site's lithic assemblage does not permit its inclusion in the dataset.

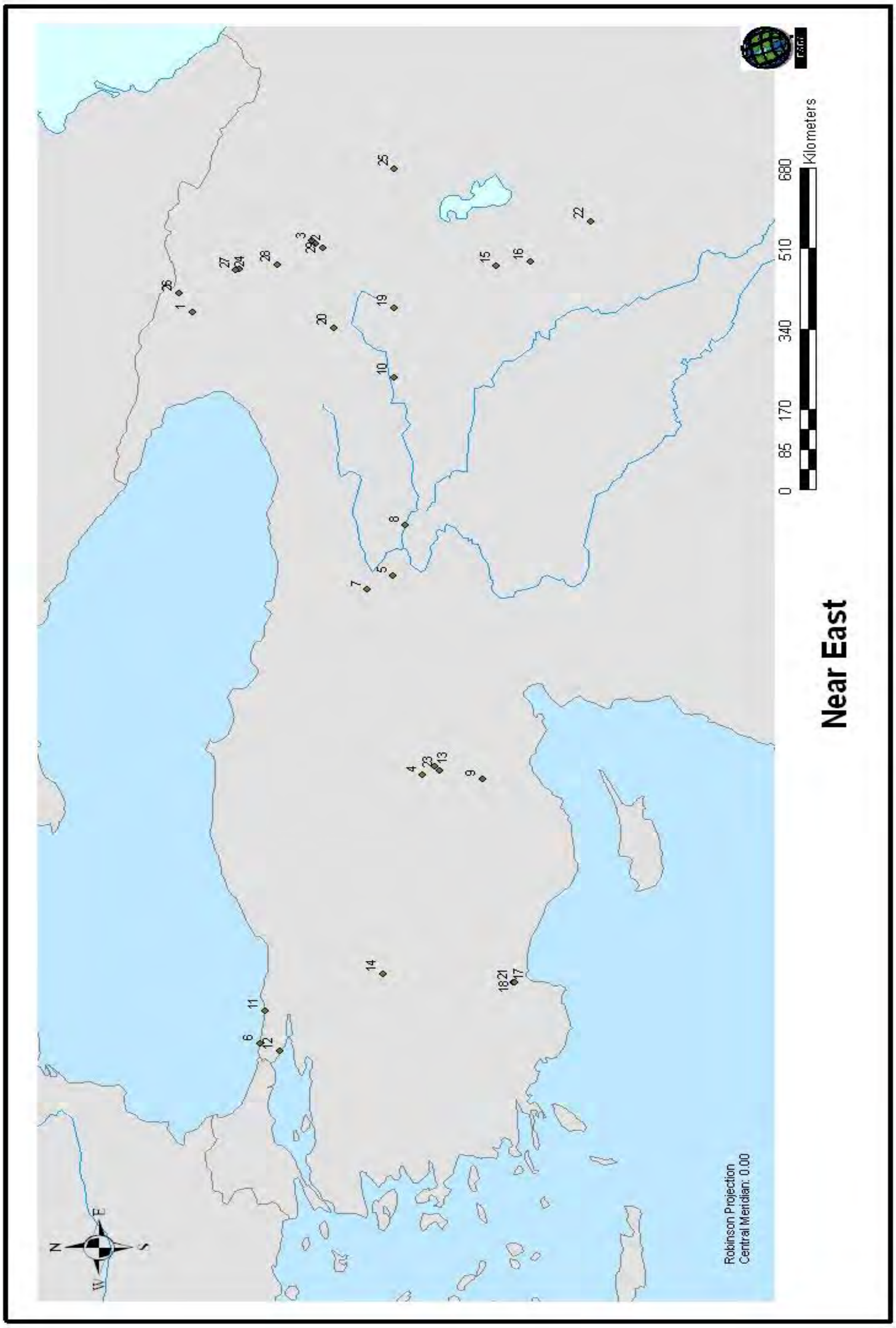


Figure 5.9. Map showing the location of obsidian-bearing Palaeolithic sites in the Near East.

SOURCE	LATITUDE	LONGITUDE	QUALITY
Suregei-Asille (mul. loc.)	4.17207	36.28358	3
Shin	3.76918	36.31568	3
Nasaken	1.65471	36.26365	3
Emuruangogolak	0.54823	35.72123	2
Salawa Hill	0.60000	36.01667	3
Kampi ya Samaki	0.56048	36.28551	1
Karau (mul.loc.)	0.15000	37.30000	3
Mt Kenya	-0.16667	35.60000	1
Londiani	-0.02102	35.95995	1
Kampi ya Moto	-0.43613	36.19348	2
Kisanana	0.48572	36.15989	1
McCall's Siding	-0.87725	36.26829	2
Menengai (mul.loc.)	-0.91942	36.32999	1
Masai Gorge	-0.97709	36.31218	3
Eburru	-0.98754	35.83967	2
Naivasha Scarp	-0.89449	37.21683	2
Ololerai	-9.58333	41.86667	2
Oserian no. 1&2	-38.67095	26.76095	3
Akira	-40.63504	33.11583	3
Olagirasha	-0.96750	35.83333	3
Suswa	-1.15000	36.35000	1
Kedong Escarpment	1.16667	36.41667	2
Gicheru (two loc.)	-1.20000	36.55000	1
Githuya	0.86667	36.96667	1
Gacharage	-0.93330	36.75000	1
Githumu	-0.81670	36.90000	1
Mangu	-1.00000	36.95000	3
Lukenya (mul.loc.)	-1.48194	37.07222	1
Ol Donyo Nyegi (mul.loc.)	-1.80000	36.36666	1
Mt Kilimanjaro (mul.loc.)	-3.07583	37.35333	1
Modjio	8.60000	39.11667	2
K'one	8.91667	39.66670	1
Fantale	8.97500	39.93000	1
Ayelu	10.13333	40.63333	1
Assabot	9.21667	40.76667	1
Afdem	9.46670	41.00000	1
Dire Dawa	9.58972	41.85972	1
Kibikoni	-0.83330	36.31667	1
Longonot	-0.83330	36.40000	1
Kinangop	-0.71700	36.65000	1
Opuru	-0.58330	36.25000	1
Gilgil Toll	-0.86252	36.36239	3
Njorowa Gorge South no.1	-39.42038	29.97566	3
Njorowa Gorge	-39.99347	31.69135	3

SOURCE (continued)	LATITUDE	LONGITUDE	QUALITY
Hell's Gate no.1	-40.68333	33.18333	1
Sonanchi	-0.78250	36.26194	1
Balchit	8.75444	38.63861	1
Kusrale	15.04200	39.82000	1
Yağlar	40.18029	45.02328	3
Sakaeli	40.33276	44.73048	1
Acigöl	40.40171	44.67214	1
Nenezi Dag	40.51381	44.54628	3
Hasan Dag	40.58921	44.55233	1
Gollü Dag	40.28886	43.76611	1
Hotamis Dag	41.03972	43.85972	2
Ikizdere	41.30000	40.91667	1
Kars	40.75000	42.90000	1
Sarikamiş	40.33188	42.59455	1
Bingöl	38.89029	40.49509	1
Muş	38.72880	41.49831	1
Meydan Dag	38.71117	41.53082	3
Süphan Dag	38.92000	42.82000	1
Nemrut Dag	38.65000	42.23000	1
Erzurum	39.91157	41.28977	1
Bartsratumb	39.55009	45.85181	3
Bazenk	39.76896	45.85686	1
Sevkar	39.79737	45.83969	1
Satanakar	39.82582	45.82814	1
Ketchaldag/Merkasar	39.58219	46.23664	1
Kelbadzhar	40.10667	46.03833	2
Khorapor	40.05480	45.62977	1
Geghasar	40.11450	44.99681	1
Spitaksar	40.18029	45.02328	1
Hatis	40.33276	44.73048	1
Gutansar	40.37046	44.68529	1
Alaphars	40.40171	44.67214	3
Kamakar	40.51381	44.54628	3
Hankavan	40.58921	44.55233	3
Arteni	40.28886	43.76611	1
Ashotsk	41.03972	43.85972	2
Chikiani	41.23105	43.82280	3
Baksan	43.68080	43.53406	1
Mád	48.20000	21.28300	1
Erdöbénye	48.26700	21.36700	1
Tolcsva	48.28333	21.45000	1
Csepegö Forrás	48.31700	21.43300	2
Kašov	48.48330	21.75000	1
Cejkov	48.46700	21.76700	1

SOURCE (continued)	LATITUDE	LONGITUDE	QUALITY
Szöllöske	48.40000	21.75000	1
Streda nad Bodrogom	48.36700	21.76700	1
Beregovo	48.21700	22.65000	1
Mukacevo	48.45000	22.71700	1
Gertsovtse-Fedeleshovtse	48.58300	22.65000	3
Khust	48.18100	23.29800	1
Olaszliszka	48.25000	21.43300	1
Malá Toroňa	48.45000	21.68300	1
Melos	36.68000	24.45000	1
Antiparos	37.03000	25.08000	1
Giali	36.67000	27.12000	1
Lipari	38.46700	14.95000	1
Palmarola	40.93300	12.85000	1
Pantelleria	36.83300	11.95000	1
Monte Arci (Sardinia)	39.75000	8.80000	1

SITE	LATITUDE	LONGITUDE	QUALITY
Gadeb 8E	**7.11670**	**39.36670**	**2**
Kariandusi bed 4	**-0.45000**	**36.28333**	**1**
Kilombe	**-0.10000**	**35.88333**	**1**
Olorgesailie	**-1.56667**	**36.45000**	**1**
Gamble's cave	**-0.28487**	**35.83155**	**3**
Magosi	**2.91700**	**34.51700**	**1**
Porc Epic	**9.58333**	**41.86667**	**2**
Prospect Farm	**-0.65139**	**36.00556**	**1**
Olduvai, Naisiusiu/HWK-E	**-2.99457**	**35.18396**	**2**
Little Gilgil	**-0.58333**	**36.35000**	**1**
Elmenteita	**-0.48300**	**36.15000**	**1**
Muguruk	**-0.15000**	**34.66667**	**1**
Songhor	**-0.03662**	**35.20828**	**1**
Cartwright's	**-0.59722**	**36.45833**	**1**
Wetherall's	**-0.70277**	**36.68752**	**3**
Gombore	**8.68300**	**37.63300**	**1**
Garba	**8.68300**	**37.63300**	**1**
Wofi II	**8.68300**	**37.63300**	**1**
Kella	**8.68300**	**37.63300**	**1**
GtJi12(Enkapune Ya Muto)	**-0.83333**	**36.16389**	**1**
GnJm1(Shurmai)	**-0.50833**	**37.21518**	**1**
GnJm2(Kakwa Lelash)	**-0.55278**	**37.17083**	**1**
GrJi11(Prolonged Drift)	**-0.48472**	**37.06667**	**1**
GsJi53 (Ol Tepesi)	**-0.69194**	**36.20667**	**1**
Isenya	**-1.85000**	**36.78300**	**3**
GnJi16(Kaptabuya)	**0.72507**	**35.82009**	**3**
GnJi15(Kapthurin 'A')	**0.60000**	**36.01700**	**3**
Nasera	**-2.73694**	**35.35806**	**1**
Mumba Höhle	**-3.53779**	**35.29929**	**1**
GvJm46	**-1.48194**	**37.07222**	**1**
GvJm19	**-1.48194**	**37.07222**	**1**
GvJm62	**-1.47361**	**37.07500**	**1**
KFR-A5 (Kisima Farm)	**0.48333**	**36.75000**	**1**
ETH-72-1	**7.92972**	**38.71000**	**2**
ETH-72-8B	**7.92972**	**38.71000**	**2**
ETH-72-7B	**7.92972**	**38.71000**	**2**
ETH-72-6	**7.92972**	**38.71000**	**2**
ETH-72-5	**7.92972**	**38.71000**	**2**
ETH-72-9	**7.92972**	**38.71000**	**2**
GvJm22	**-1.48194**	**37.07222**	**1**
GvJm16	**-1.48194**	**37.07222**	**1**
GvJh12	**-1.01528**	**35.89167**	**1**
GtJi15	**-0.75278**	**36.17500**	**1**
GvJh11(Ntumot)	**-1.34361**	**35.91306**	**1**

SITE (continued)	LATITUDE	LONGITUDE	QUALITY
Aladi Springs	9.50380	42.05598	3
Lake Besaka	9.56667	41.38333	2
K'one	8.86700	39.66700	1
Aduma	10.02500	40.03100	1
Modjio	8.60000	39.11667	1
Ortvale Klde	42.29800	43.29900	1
Arzni	40.29600	44.59600	1
Dzhraber	40.35200	44.64500	1
Acigöl Etekleri	38.55028	34.50917	1
Domali-Alacali	41.20000	29.40000	1
Erikli Deresi	39.45000	38.03333	2
Arapkar Çayi	39.03000	38.29000	2
Karatas Kaya Siginagi	38.83300	39.25000	1
Kisla Kadarak	37.58000	34.42000	1
Liz	39.01639	42.05611	1
Parganli-Kerpe Arasi	41.12400	30.01100	1
Pendik-Hacet Deresi	40.87750	29.25139	1
Suvermez	38.36667	34.66667	1
Yazilikaya	39.20000	30.71700	1
Yüksekova	37.35000	44.17000	1
Shanidar	36.80100	44.24300	1
Karain	37.07280	30.55783	3
Okuzini	37.05000	30.55000	3
Erçis	39.02389	43.36167	1
Borluk	40.00000	43.00000	1
Çarkini	37.05700	30.56200	3
Zarzi	35.81194	45.01861	1
Kaletepe Deresi 3	38.28333	34.58333	1
Trialeti	41.53900	44.10800	1
Azych	39.01029	46.01647	1
Kudaro I	42.52278	43.64222	1
Tsalka	41.59139	44.08694	2
Satani-dar	40.91667	44.20000	3
Erivan I	40.18100	44.51400	1
Kecskésgalya	47.88212	20.48152	3
Neslovice	49.15000	16.38300	1
Széléta, c.4	48.10000	20.63300	3
Herman Ottó	47.78300	18.75000	3
Püskaporos	48.13300	20.78300	1
Diósgyőr-Tapolca	48.10000	20.68333	2
Mexicóvölgy	48.08333	20.66667	1
Nová Dědina I	49.21700	17.45000	2
Barca I	48.68300	21.26700	1
Barca II	48.36700	20.23300	1

SITE (continued)	LATITUDE	LONGITUDE	QUALITY
Kechnec I	48.55000	21.26700	1
Tibana	48.71700	21.25000	3
Istállóskö	48.06700	20.43300	2
Kraków-Zwierzyniec I	53.11667	21.13333	3
Krems-Hundssteig	48.41700	15.60000	1
Senftenberg	48.43300	15.55000	1
Bodrogkeresztúr	48.16667	21.36667	2
Aggsbach, station B	48.28333	15.40000	3
Předmosti	49.46700	17.45000	1
Dolni Věstonice I	48.88300	16.65000	1
Pavlov I	48.86700	16.66700	1
Cejkov I	48.46700	21.76700	1
Stránská Skála IV	49.43300	17.98300	2
Kašov	48.48300	21.75000	1
Arka	48.35000	21.25000	1
Hidasnémeti	48.50000	21.23300	1
Szob	47.81700	18.86700	1
Pilismarót-Díos	47.78300	18.88300	2
Mogyorósbánya	47.73300	18.60000	1
Nógrádveröce	47.83300	19.03300	1
Esztergom-Gyurgyalag	47.80000	18.75000	2
Ságvár	46.83300	18.11700	1
Kůlna, c.5	49.41096	16.74448	2
Sajóbábony	48.16700	20.73300	1
Ballavölgyi	47.98300	20.03300	3
Büdöspest	48.05290	20.54281	3
Farkaskö	47.95000	20.61700	3
Subalyuk	47.93300	20.53300	3
Dömös	47.76700	18.91700	1
Pilisszántó II	47.66700	18.90000	3
Sajószentpéter-Nagykorcsolas	48.21700	20.21700	1
Jászfelsőszentgyörgy	47.50000	19.80000	1
Malyj Rakovets	48.26700	23.20000	1
Görömböly-Tapolca	48.06700	20.75000	1
Ëger	47.71667	20.46667	1
Bacho Kiro	42.93300	25.41700	1
Amaliada 13	37.80000	21.35000	1

SITE	AGE	DATE	REGION	TYPE SITE	QUANTITY	SOURCE
Gadeb 8E	lower	1.5Myr	Ethiopia	open	<1%	Clark 1980
Kariandusi	lower	>780kyr	Kenya	rockshelter	15%	Merrick et al. 1994
Kilombe	lower		Kenya	open	2	Merrick et al. 1994
Olorgesailie	lower		Kenya	open	3	Ambrose 2004
Gamble's cave	upper		Kenya	cave	100%	Merrick & Brown 1984
Magosi	upper		Uganda	rock cistern	few	Merrick & Brown 1984
Porc Epic	middle	>70kyr	Ethiopia	cave	5.50%	Pleurdeau 2006
Prospect Farm	middle	119-106kyr	Kenya	open	90%-99.5%	Merrick et al. 1994
Naisiusiu beds, Olduvai	upper	~17kyr	Tanzania	open	5%	Leakey et al. 1972
Little Gilgil	middle		Kenya	open	?	Wymer 1982
Elmenteita	middle		Kenya	open	?	Wymer 1982
Muguruk	middle		Kenya	open	<1%	McBrearty 1988
Songhor	middle		Kenya	open	<1%	McBrearty 1988
Cartwright's	middle	440kyr	Kenya	open	100%	Merrick et al. 1994
Wetherall's	middle	557kyr	Kenya	open	100%	Merrick et al. 1994
Gombore	lower		Ethiopia	open	minor	Chavaillon & Piperno 2004
Garba	lower	1.6Myr	Ethiopia	open	frequent	Chavaillon & Piperno 2004
Wofi II	middle		Ethiopia	open	majority	Chavaillon & Piperno 2004
Kella	upper		Ethiopia	open	100%	Chavaillon & Piperno 2004
GtJi12(Enkapune Ya Muto)	transitional middle to upper	>46kyr	Kenya		majority	Clark 1988
GnJm1(Shurmai)	middle	45kyr	Kenya	rockshelter	few	Dickson & Gang 2002
GnJm1(Shurmai)	upper		Kenya	rockshelter	few	Dickson & Gang 2002
GnJm2(Kakwa Lelash)	upper	<40kyr	Kenya	rockshelter	few	Dickson & Gang 2002
GrJi11(Prolonged Drift)	middle	~35kyr	Kenya	open	majority	Clark 1988
GsJi53 (Ol Tepesi)	upper	14kyr	Kenya	rockshelter	?	Ambrose 2004
Isenya	lower		Kenya	open	1	Merrick et al. 1994
GnJi16(Kaptabuya)	lower		Kenya	open	1	Merrick et al. 1994
GnJi15(Kapthurin 'A')	lower	230kyr	Kenya	open	1	Merrick et al. 1994
Nasera	middle	56-26kyr	Tanzania	rockshelter	little	Merrick et al. 1994
Mumba Höhle	middle	130-109kyr	Tanzania	rockshelter	little	Merrick et al. 1994
GvJm46	upper	30kyr	Kenya	open	<1%	Barut 1996
GvJm19	upper	~14kyr	Kenya	rock overhang	<1%	Barut 1996
GvJm62	upper	~21kyr	Kenya	rock overhang	<1%	Barut 1996

KFR-A5 (Kisima Farm)	upper		Kenya	rockshelter	10-15%	Merrick & Brown 1984
ETH-72-1	middle	235kyr	Ethiopia	open	2000	Wendorf & Schild 1974
ETH-72-8B	middle	235kyr	Ethiopia	concavity	9188	Wendorf & Schild 1974
ETH-72-7B	middle	235kyr	Ethiopia	open	few	Wendorf & Schild 1974
ETH-72-6	middle	235kyr	Ethiopia	open	1459	Wendorf & Schild 1974
ETH-72-5	middle	235kyr	Ethiopia	open	1699	Wendorf & Schild 1974
ETH-72-9	middle	235kyr	Ethiopia	open	5787	Wendorf & Schild 1974
GvJm22	upper	<22kyr	Kenya	rock overhang	6.7-13.8%	Gramly 1976
GvJm16	transitional middle to upper	>40kyr	Kenya	rockshelter	6%	Barut 1996
GvJh12 (Ntuka River 4)	transitional middle to upper	>60kyr	Kenya	open	44.50%	Ambrose 2004
GtJi15 (Marmonet Drift)	middle	205-100kyr	Kenya	open	?	Fieldwork
GvJh11(Ntumot-Ntuka River 3)	transitional middle	>50kyr	Kenya	open	64%	Ambrose 2004
GvJh11(Ntumot-Ntuka River 3)	upper		Kenya	open	16%	Ambrose 2004
Aladi Springs	upper	11kyr	Ethiopia	open	majority	Clark et al. 1984
Lake Besaka/Erer	upper	~18kyr	Ethiopia	open	few	Clark et al. 1984
K'one	middle		Ethiopia	open	?	Clark 1988
Modjio	middle		Ethiopia	open	?	Clark 1988
HWK-East	lower		Tanzania	open	2	Leakey 1971
Aduma	middle	>70kyr	Ethiopia	open	10%	Yellen et al. 2005
Acigöl Etekleri	middle		Anatolia	surface	?	TAY
Arapkir Çayi	upper		Anatolia	rockshelter	1	TAY
Domali-Alaçali	upper		Anatolia	open	some	TAY
Erikli Deresi	lower		Anatolia	surface	2	TAY
Karatas Kaya Siginagi	upper		Anatolia	rockshelter	some	TAY
Kisla Kadarak	middle		Anatolia	surface	2	TAY
Liz	middle		Anatolia	surface	1	TAY
Parganli-Kerpe Arasi	middle		Anatolia	surface	1	TAY
Pendik-Hacet Deresi	middle		Anatolia	surface	few	TAY
Suvermez	middle		Anatolia	surface	6	TAY
Yazilikaya	upper		Anatolia	open	?	TAY
Yüksekova	middle		Anatolia	surface	?	TAY
Shanidar	upper		Iraq	cave	<1%	Renfrew et al. 1966
Karain	upper	70-60kyr	Anatolia	cave	<1%	Renfrew et al. 1966
Okuzini	upper		Anatolia	cave	<1%	Renfrew et al. 1966
Erçis	middle		Anatolia	surface	<1%	Renfrew et al. 1966

Borluk	middle		Anatolia	cave	<1%	Renfrew et al. 1966
Çarkini	upper		Anatolia	surface	<1%	Renfrew et al. 1966
Zarzi	upper		Iraq	cave	2	Renfrew et al. 1966
Kaletepe Deresi 3	lower	160kyr	Anatolia	open	majority	Slimak et al. 2004
Kaletepe Deresi 3	middle		Anatolia	open	majority	Slimak et al. 2004
Trialeti	middle		Georgia	open	majority	Gábori 1976
Azych	lower		Azerbaijan	cave	<1%	Roebroeks et al. 2003
Azych	middle		Azerbaijan	cave	14	Roebroeks et al. 2003
Kudaro I	lower	~360kyr	Georgia	cave	1	Roebroeks et al. 2003
Tsalka	middle		Georgia	open	?	Gábori 1976
Satani-dar	lower		Armenia	open	majority	Gábori 1976
Erivan I	middle		Armenia	cave	all	Gábori 1976
Dzhraber	lower		Armenia	open	100%	Klein 1966
Arzni	lower		Armenia	open	100%	Klein 1966
Arzni	middle		Armenia	open		Klein 1966
Ortvale Klde	middle	50kyr	Georgia	rockshelter	0.40%	Adler et al. 2006
Ortvale Klde	upper	20kyr	Georgia	rockshelter	4%	Adler et al. 2006
Kecskésgalya	middle		Hungary	cave	<1%	Biró 1984
Neslovice	upper		Czech Republic	open	1	Oliva 1995
Széléta, c.4	upper	~40kyr	Hungary	cave	little	Biró 1984
Herman Ottó	upper		Hungary	cave	4.01%	Biró 1984
Püskaporos	upper		Hungary	rockshelter	2.30%	Biró 1984
Diósgyőr-Tapolca	upper		Hungary	cave	3%	Ringer & Moncel 2002
Mexicóvölgy	upper		Hungary	cave	little	Féblot-Augustins 1997
Nová Dědina I	upper		Czech Republic	open	0.10%	Féblot-Augustins 1997
Barca I	upper		Slovakia	open	0.9%-5.8%	Féblot-Augustins 1997
Barca II	upper		Slovakia	open	0.90%	Féblot-Augustins 1997
Kechnec I	upper		Slovakia	open	0.37%	Féblot-Augustins 1997
Tibana	upper		Slovakia	open	19%	Biró 1984
Istállóskö	upper	33-28kyr	Hungary	cave	0.30%	Biró 1984
Kraków-Zwierzyniec I	upper		Poland	open	<1%	Biró 1984
Krems-Hundssteig	upper		Austria	open	1	Féblot-Augustins 1997
Senftenberg	upper		Austria	open	1	Féblot-Augustins 1997
Bodrogkeresztúr	upper	29kyr	Hungary	open	4%-15%	Fieldwork
Aggsbach, station B	upper		Austria	open	<1%	Biró 1984
Předmosti	upper		Czech	open	little	Féblot-Augustins

			Republic			1997
Dolni Věstonice I	upper	23kyr	Czech Republic	open	little	Féblot-Augustins 1997
Pavlov I	upper	26kyr	Czech Republic	open	<1%	Féblot-Augustins 1997
Cejkov I	upper	~25kyr	Slovakia	open	90.20%	Biró 1984
Stránská Skála IV	upper		Czech Republic	open	?	Féblot-Augustins 1997
Kašov	upper	20kyr	Slovakia	open	33%-80%	Féblot-Augustins 1997
Arka	upper	~17kyr	Hungary	open	4.11%	Biró 1984
Hidasnémeti	upper		Hungary	open	0.27%	Dobosi 1994
Szob	upper		Hungary	open	6	Dobosi 1996
Dömös	upper		Hungary	open	10%	Dobosi 1996
Pilismarót-Díos	upper	17kyr	Hungary	open	2.50%	Dobosi 1994
Mogyorósbánya	upper	20kyr	Hungary	open	4%	Dobosi 1994
Nógrádveröce	upper		Hungary	open	<10%	Biró 1984
Esztergom-Gyurgyalag	upper	~17kyr	Hungary	open	0.10%	Dobosi 1996
Ságvár	upper	~18kyr	Hungary	open	<1%	Dobosi 1994
Kůlna, c.5	upper		Czech Republic	cave	0.48%	Oliva 2005
Sajóbábony	middle		Hungary	open	1	Ringer 2002
Ballavölgyi	middle		Hungary	rockshelter	100%	Allsworth-Jones 1986
Büdöspest	middle		Hungary	cave	0.38%	Biró 1984
Farkaskö	middle		Hungary	cave	<1%	Biró 1984
Subalyuk	middle		Hungary	cave	0.1%-2.3%	Biró 1984
Jászfelsőszentgyörgy	upper	18kyr	Hungary	open	4.70%	Dobosi 2001
Görömböly-Tapolca	upper	30kyr	Hungary	open	?	pers.com. György Lengyel
Ëger	upper		Hungary	open	1%	Dobosi 1995
Sajószentpéter-Nagykorcsolas	middle		Hungary	open	6.98%	Simán 1982
Sajószentpéter-Nagykorcsolas	upper		Hungary	open	7.68%	Simán 1982
Pilisszántó II	middle		Hungary	rockshelter	50%	Dobosi & Vörös 1986
Malyj Rakovets	middle		Ukraine	open	95%	Sitlivyj & Ryzov 1992
Bacho Kiro	upper	40kyr	Bulgaria	cave	1	Kozlowski 1982
Amaliada 13	middle		Greece	surface	1	Kourtessi-Philippakis 1986

Chapter 6

Regional Case Studies

1. INTRODUCTION

Chapter 5 concentrated on a detailed presentation of all the known obsidian-bearing Palaeolithic sites from two broad regions, Africa and Eurasia (central Europe and the Near East). The issue of spatial scale becomes, thus, crucial in the investigation of source-to-site obsidian distribution. In this thesis, scale is approached through the proxy of latitude and a division between high (Northern) and low (Southern) latitudinal regions. With this approach, my aim is to detect variation in obsidian use and movement between high and low latitude areas. In this chapter my focus is to identify raw material variation at a site level by comparing the technological/typological features of obsidian distribution in a site from high latitude with a site from low latitude regions. In chapter 7 I will expand the regional context of my analysis in order to discuss raw material variation in all the Palaeolithic periods and a wider territory (Africa versus Europe).

Specifically, the Upper Palaeolithic site of Bodrogkeresztúr in Hungary and the Middle Stone Age Kenyan site of Marmonet Drift, or GtJi15 as it is more commonly known in the African reference system, were chosen to serve as the reference point for the purposes of the regional perspective of this project. These two occurrences were chosen as the core of the analytical procedure because they meet the requirements set for this project:

- The obsidian assemblages come from secure stratigraphic horizons
- Both sites exhibit long sequences of obsidian use (lithic assemblages dominated by obsidian)
- Derive from a time frame that corresponds to a period when substantial changes in the overall Palaeolithic record occurred (for an overview see McBrearty & Brooks 2000)
- Both sites are located in the vicinity of obsidian sources, i.e. ~10 km
- Both sites preserve the complete chaîne opératoire of obsidian tool manufacture

Furthermore, the obsidian assemblage of Bodrogkeresztúr is compared to three other Carpathian basin sites: Subalyuk, Ballavölgyi and Pilismarót-Diós. It must be emphasised that in this chapter I only present the data of the latitude-obsidian distribution analysis; the behavioural implications of the effect of latitude on obsidian movement will be discussed in chapter 7.

2. BODROGKERESZTÚR, HUNGARY (48°10'0''N 21°22'0''E, 198 m asl)

The Upper Palaeolithic site of Bodrogkeresztúr is located on the top of the Henye Hill, part of a row of steep sided hills, in the Hungarian section of the Carpathian Basin (figure 6.1). The main features of the surface morphology of the Carpathian Basin, which extends over an area of 3 million km², were already established by the end of the Tertiary period and are associated with the intensive volcanic activity experienced in the region (discussed in chapter 5). The Carpathian basin is closed on three sides and its interior is dominated by topographic features, including the Carpathians and an interior volcanic arch modified by elevation and depression on a local scale.

To the East of the Danube bend, Hungary is dominated by the Northern Mid-Mountain Range. Its easternmost member is the Eperjes (Presov)-Tokaj Mountains (known also as Zemplén Mountains). This mountain range belongs to the innermost volcanic range of the young folded mountain system of the Carpathians. This area forms a transition between the High Carpathians and the Lowland (Alfold) which intrudes deep into the river valleys. The Tokaj-Presov Mountains were formed as a result of several volcanic eruptions in the Miocene/Sarmatian period. It has different strike from that of other members of the Northern Mid-Mountain range, directed roughly north-south. Eruption centres, lying ~10 km from each other and following the main strike of the mountain in a zig-zag line, can still be recognised. The most ancient member of the mountain range is the eponymous Tokaj. It stands separately to the south of the main body of the mountains; an irregular volcanic cone of 512 m altitude dissected by several dry valleys. It is separated from the main body of the mountains by a 5-6 km wide strip of hills. The highest point of these hills is Bodrogkeresztúr-Henye at 198 m altitude (Dobosi 2000). The Henye hill, on which the site of Bodrogkeresztúr lies, is surrounded by the mountains (north and south), river Bodrog (east), and the flatlands of the stream Takta (west).

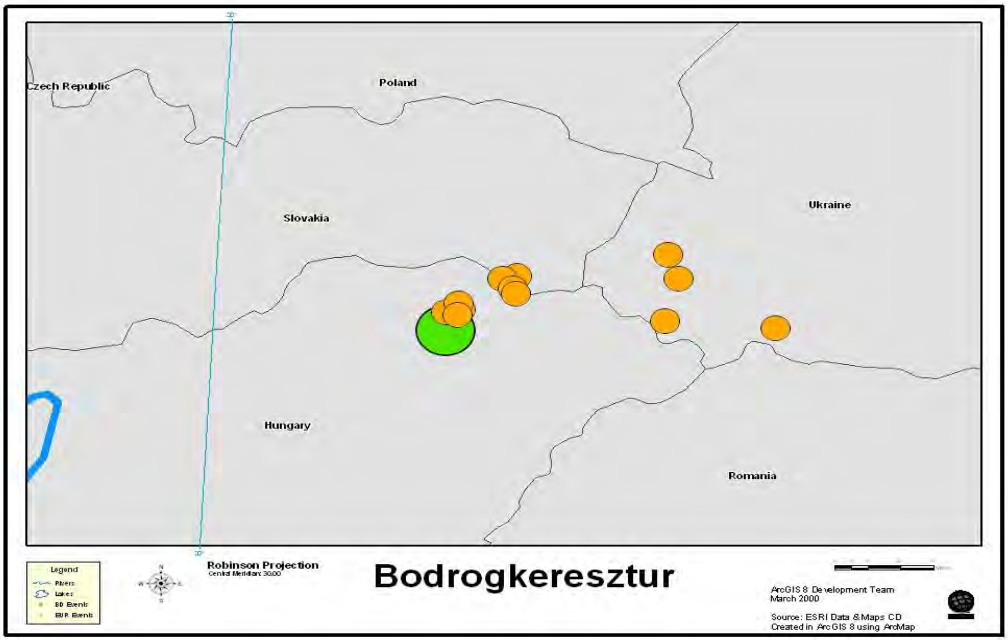


Figure 6.1. Location of Bodrogkeresztúr (green circle) and the obsidian sources available in Pleistocene Central Europe (orange circles).

One of the main geological features in the Carpathian basin and mountain range are the numerous obsidian sources that are mainly located in the interior of the volcanic arch. Specifically, they are located in a volcanic district covering a relatively wide area (~2000 km²) across the Hungarian-Slovakian border within the Tokaj-Presov mountain range. On the Hungarian side, volcanic activity started in the Late Badenian and continued through the whole Sarmatian (both Middle Miocene stages: 15.97-11.60 Ma) till Upper Miocene times. Several eruptions from different centres produced large amounts of rhyodacite ash flow tuff and a wide variety of volcanic rocks of acid and intermediate composition (Perlaky 1972, Gyarmati 1977). In the adjacent Slovakian area, the acid volcanism lasted for millions of years, from Middle-Late Badenian up to Middle-Late Sarmatian times. The Carpathian sources yielded relatively small amount of volcanic glass useful for tool-making. Still they are the only natural sources of obsidian present in Central Europe and unique in continental Europe. They can be divided into two regional/chemical groups (see chapter 5, section 2.2.3.): the first in the south part of the Tokaj Mountains (Mad, Erdöbénye, Tolscva) and the second to the north of the Hungarian/Slovakian border (Vinicky, Cejkov). This initial distinction was followed by the discovery of further sub-groups within the Hungarian (Biró *et al.* 1986) and possibly the Slovakian (Tóth *et al.* 1999) material. However, for the purposes of this project the primary separation of the central European obsidian sources into two groups is sufficient. Usually obsidian occurs in association with rhyolite flows (rhyodacites). Two main rhyolite bodies, which extend south of the Telkibanya-Nagyboszva line and north of the Erdöbénye-Tolscva line respectively, were recognised in the Tokaj Mountains. Several smaller rhyolite occurrences are scattered through the region. Mád, the richest and most accessible source within Carpathian II obsidians, is the source nearest to Bodrogkeresztúr (Williams & Nandris 1977, Thorpe 1978, Biró 1981, Williams-Thorpe 1984, Bigazzi *et al.* 2000).

According to Ringer (2000) the stratigraphic sequence of Bodrogkeresztúr is divided into the following layers (figure 6.2):

1. recent soil: 0.0-0.25 m shallow skeletal soil of brownish grey colour with anthropogenic interferences
2. loess: 0.25-0.40 m greyish yellow, slightly loamy sandy loess. Concretions of calcium-magnesium carbonate (large upper parts of the loess were eroded prior to recent soil formation processes)
3. three-layered sedimentary palaeocomplex: 0.4-1.0 m palaeocomplex comprising of several members. Only the first soil horizon is suitable for sampling: light brownish grey soil (this is the archaeological cultural layer) formed on a loess horizon containing more clay than the recent soil and less sand than its cover. Under this layer, over the volcanic bedrock and partly in its fissures, remains of a darker grey and a reddish brown soil could be observed

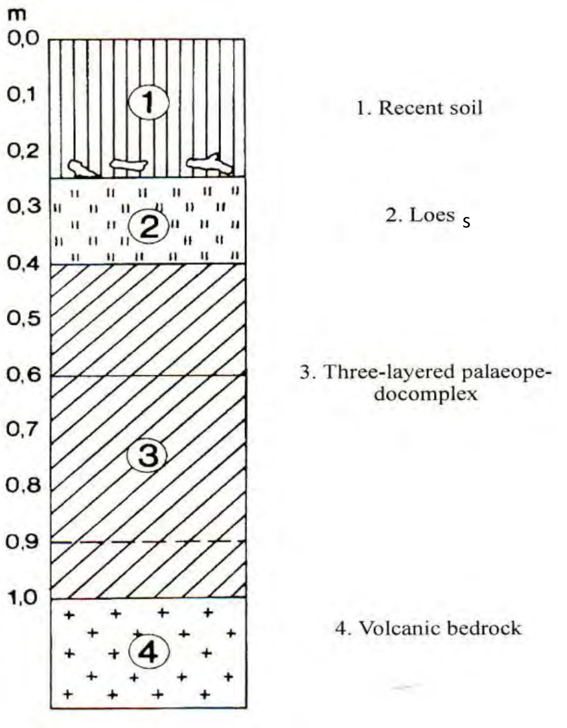


Figure 6.2. Stratigraphic sequence of Bodrogkeresztúr. After Ringer (2000).

The available paleostratigraphic data suggest that the Henye hill experienced considerable surface transformation (erosion) especially from the Late Pleistocene onwards. The bedrock of the Henye hill is volcanic (Upper Sarmatian rhyolite) in origin, followed by an andesite layer (which had already been levelled by erosion at the time of the Upper Palaeolithic habitation), a loess layer and a recent Holocene soil layer. Extended loess accumulation and denudation had a great effect on the overall picture of the locality. Extensive loess layers were deposited and sedimented in the flanks of the Henye hill even before the existence of the settlement. Loess was accumulated in larger quantities on the south-east side whereas the covering loess was thicker on the north side. The east, south and west foothill regions were the most severely affected sections of the hill but the horizon with the cultural layer remained undisturbed and indicates that the original hill-side used to be much steeper in all directions. In modern times, intensive cultivation and deep ploughing (figure 6.3) resulted in an even greater transformation of the hill and especially its top where the Bodrogkeresztúr site is located (figure 6.4).

Figure 6.3. View of the Bodrogkeresztúr Upper Palaeolithic site (photo T. Moutsiou).

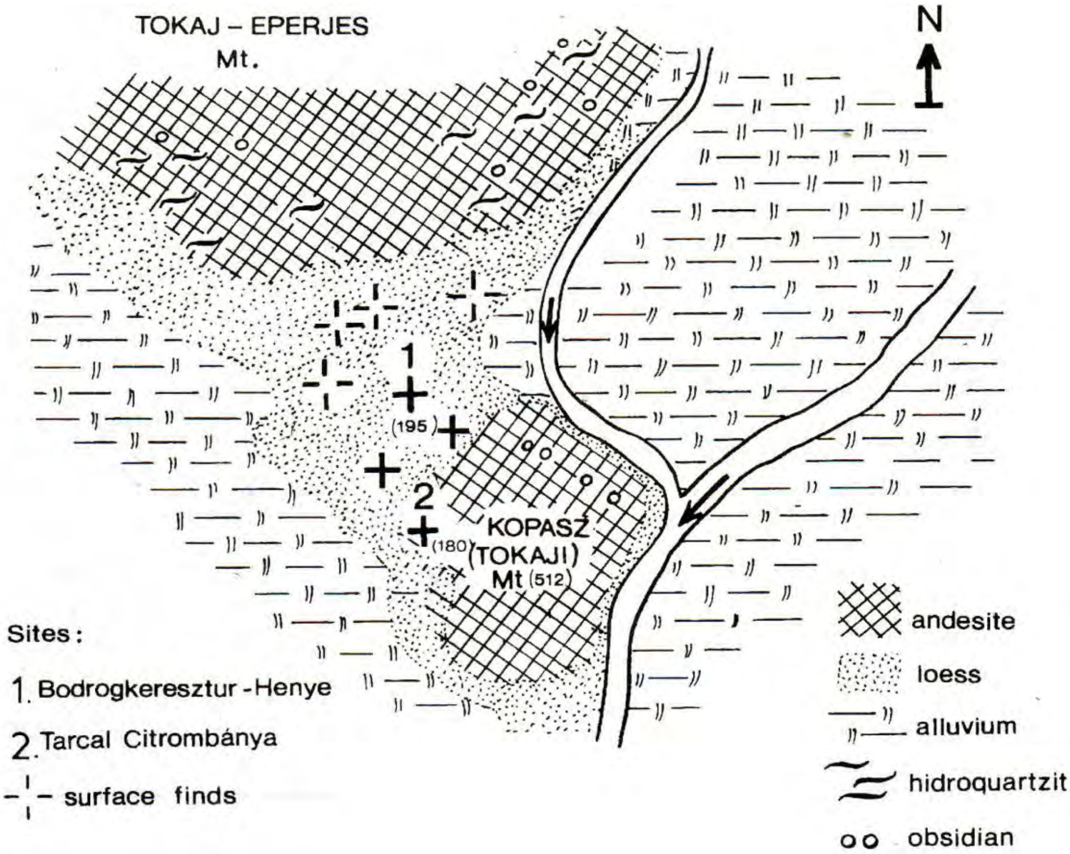


Figure 6.4. The Bodrogkeresztúr-Henye hill. After Dobosi (2000).

Charcoal and faunal analyses of the stratigraphic layers associated with the archaeological horizon provided enough information with regards to the environment of the Henye plateau during its occupation by Pleistocene hominins (Sümegi *et al.* 2000). A steppe-taiga seems to have been the dominating regional ecotone at the time of the formation of the cultural horizons. Arboreal plants of *Picea* type were the most characteristic element of the vegetation indicating cold climatic conditions but more humid and milder than those under which loess formation took place. Today, members of the *Picea* genus are spread in temperate and cold climatic zones (northern hemisphere) but also in the plains and the mountainous regions in north and central Europe respectively. In the Carpathians, these species are found at altitudes ranging from 600 to 1900 m and occasionally up to 1500 m. Present *Picea* type forests are able to tolerate long and cold winters and live in short but long day-lit vegetation periods and it is not unreasonable to assume a similar situation for the Late Pleistocene.

The faunal data (Vörös 2000) also indicates a mosaic-like environmental pattern. In Bodrogkeresztúr the following animal species have been reported: *Equus*, *Alces*, *Cervus*, *Bison*, *Mammuthus*, *Leo* and *Lepus*. Horse is indicative of a steppe environment, bison characterises steppe and forest-steppe environments, red deer is a forest element, mammuthus can be found in association with a wide range of environments and, finally, alces is indicative of a marshland environment. Although horse and elk almost completely dominate the Bodrogkeresztúr faunal assemblage, the presence of all these species with their different ecological niches supports a mixed ecological environment during the site's Late Pleistocene occupation.

A detailed record of the research history of the site is provided by Dobosi (2000) and this section provides a brief review of the work undertaken at the Henye hill based on the above information. Archaeological research was conducted in the region over several fieldwork seasons and by a number of researchers. Trial excavations were initially performed by Laszlo Vertes between 1 and 15 October 1963; the aim at that stage was to find the original camp site on the repeatedly ploughed, disturbed area of the Henye hill (see figure 6.3). Years later, in 1977, Dobosi performed a short field survey and collected surface material as part of a larger project focused on the investigation of the site Tiszaladány-Nagyhomokos, Ürgehát. In 1982 Vertes' excavations were continued by Hellebrandt (the 1963 and 1982 excavations combined opened up at the site covered a 425 m² surface). A sondage was carried out around the flat plateau of the Henye hill and three excavation trenches were opened (B-H stands for Bodrogkeresztúr-Henye):

- B-H I unit: to the north and east of the spot height (fix point)
- B-H II unit: about 80 m to the north-west from the spot height, 4 trenches 20 m long each, scattered settlement features, some in situ artefacts (bone, stone tools
- B-H III unit: 4 trenches to the west of Vertes' sections

Bodrogkeresztúr is not the only cultural unit identified in the region; on the contrary, Palaeolithic finds were collected from all the hill-tops around the Henye hill in a circle of some hundred metres. All these sites seem to form a group that fits well into the chain of Upper Palaeolithic sites which: a) follow the south margin of the Northern Mid-Mountain range which is rich in raw materials and, b) occupied the lowland-foothill surfaces intruding deep into river valleys from the Danube bend to Beregovo and Korolevo (Great Hungarian Plain).

On the basis of evidence provided by the sedimentary data from the Sajoszentpeter-Margit kapu site associated with ^{14}C dates, and the results of the lithic analysis from Bodrogkeresztúr-Henye (Dobosi 2000), the cultural layer in the top member of the three-layered sedimentary palaeocomplex can be dated to mid-Würm and Younger Dryas stadials (MIS 3 and 2). The age of the settlement can be placed with great certainty at the cooler climatic phase between these two stadials and archaeologically corresponds to an Early Gravettian horizon. In particular, scattered, marginal settlement features with in situ finds covered the whole surface of the hill in a circle of approximately 200 m. The centre of the campsite was probably settled immediately over the bedrock. The extension of the settlement reached or slightly exceeded 200 m diameter and incorporated the plateau-like hill top and a part of the south-east slope.

The available archaeological information, according to Dobosi (2000), results in the reliable reconstruction of four settlement units that form one cultural horizon. All finds from Bodrogkeresztúr (including several field surveys, collections and the 2 excavations) seem to belong to one cultural layer of one settlement dating to the Early Gravettian (classical blade industry) for reasons discussed in the previous paragraph. A large section of the obsidian assemblage recovered from this site was analysed during my fieldwork season in 2007 (National Hungarian Museum) and the results of this investigation will be presented later on in this chapter.

2.1. Description of the Obsidian Assemblage

In the lithic assemblage of Bodrogkeresztúr in Hungary obsidian is one of the preferred raw materials for the manufacture of the excavated tool kit. A local material, named 'stone marrow' by Dobosi (2000), is the most widely utilised stone in Bodrogkeresztúr but obsidian is also very popular (table 6.1). Lithic analysis was conducted on samples of this obsidian assemblage. Specifically, 187 obsidian specimens from Bodrogkeresztúr were examined corresponding to a 73% of the complete assemblage.

Szeletian felsitic porphyry	9	0.80%
Hydroquartzite	329	28.10%
Silex	74	6.30%
Radiolarite	54	4.60%
Obsidian	276	23.60%
Opal and Jasper	13	1.10%
Stone marrow	415	35.50%

Table 6.1. Raw materials present in the lithic assemblage of Bodrogkeresztúr. After Dobosi (2000).

As a qualitative evaluation of their condition, the analysed artefacts were classified into complete and fragmented (table 6.2). The majority of the obsidian specimens have been recovered complete or with minimum damage that did not impede crucial aspects of the analytical procedure. However, for a significant amount of tools (33.2%) this information is missing; their fragmented character did not allow measurements with regards to dimensions or the investigation of technological/typological parameters. Notwithstanding the above observation and the arbitrary choice of assemblages, these artefacts were included in the dataset as it is only by such means that an objective perception of the lithic assemblages can be generated (see methodology chapter for details on the recorded variables).

		Bodrogkeresztúr
complete	Count	125
	Column %	*66.8*
fragmented	Count	62
	Column %	*33.2*
Total	**Count**	**187**
	Column %	***100.0***

Table 6.2. Qualitative evaluation of the analysed obsidian artefacts from the Upper Palaeolithic site of Bodrogkeresztúr.

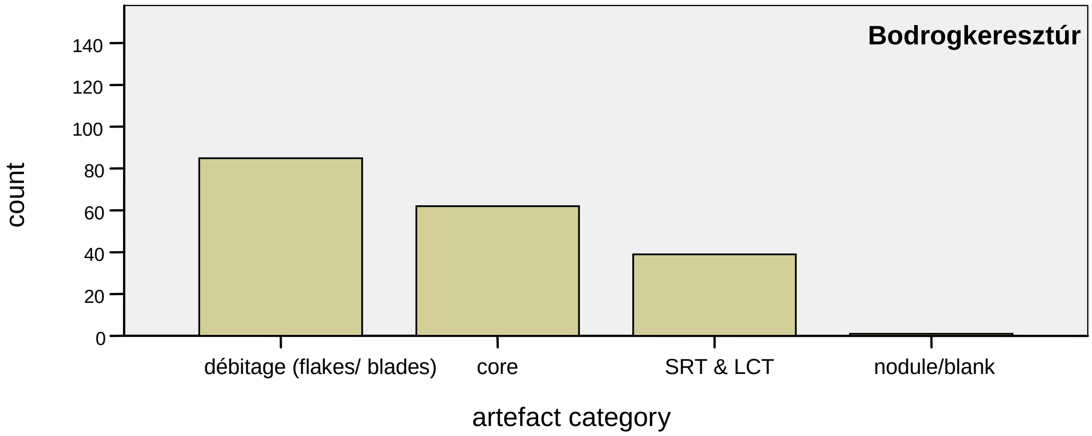


Figure 6.5. Recorded typological classes in Bodrogkeresztúr.

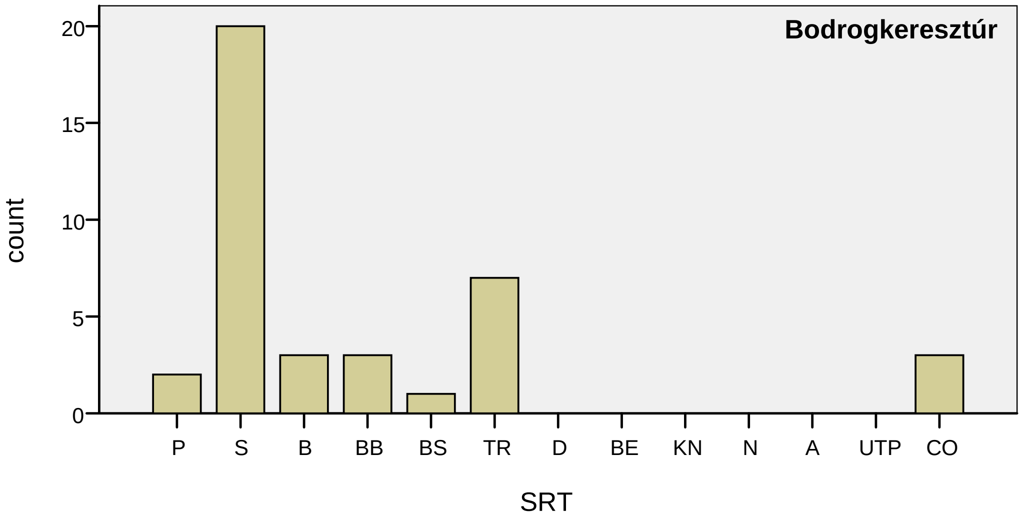


Figure 6.6. Distribution of small retouched tool (SRT) classes in the Bodrogkeresztúr assemblage. [P= point, S= scraper, B= burin, BB= burin blow, BS= burin spall, TR= truncation, D= denticulate, BE= bec, KN= knife, N= notch, A= awl, UTP= utilised piece, CO= composite].

Figures 6.5 and 6.6 show the obsidian tool types (general classes and specific tool types) identified and examined in Bodrogkeresztúr. Débitage, as defined by Tixier (1974), is the commonest category comprising the 45.5% of the overall assemblage, followed by cores (33.2%), small retouched tools (20.9%) and finally nodules/blanks. Bodrogkeresztúr yields a blade industry and although it is an atypical one compared to the other Upper Palaeolithic Central European techno-complexes (Dobosi 2000), blades form the most important part of its lithic assemblage. Flakes appear in an almost equal amount (42 flakes to 43 blades) of which whole and proximal ones are the most frequent flake types. Moreover, significant quantities of «technical pieces» have been identified. Technical pieces are artefacts that are directly linked to the procedure of tool manufacture. They are an important source of information with regards to raw material exploitation. Luckily, such artefacts have been recovered from Bodrogkeresztúr although restricted to a single tool type, namely decortications flakes. With regards to small retouch tools and as figure 6.6 indicates the majority of the analysed Bodrogkeresztúr obsidian specimens cluster in the «scraper» category with only a few examples deviating from this group. Furthermore, 3 of the other identified classes are associated with the production of burins (burin, burin blow, burin spall) suggesting that the typological variability is even more restricted than it appears on a first glance.

The analysis focused on parameters of the obsidian specimens that would provide an accurate description of the lithic assemblage. The aim is to use this information for a comparative analysis among Bodrogkeresztúr and the other selected sites. By doing so, it will possible to discern any patterns in the use of obsidian and answer the two questions set out at chapter 1: a) what is the effect of region and time in the formation of an obsidian assemblage when site-to-source distance is constant and, b) what is the effect of distance in the formation of an obsidian assemblage when region is kept constant.

The results of the dimensions' analysis of the Bodrogkeresztúr obsidian specimens are provided in the following tables (6.3- 6.8). As it is shown, the length of the artefacts ranges significantly between 20 and 70mm. However, the 20-50 mm group is the most abundant whereas examples of the lower limits of the range are totally lacking. In terms of width, the general trend is towards less wide specimens (no obsidian artefacts wider than 50 mm have been recorded) with the 10-40mm group being the commonest. In terms of thickness, all the identified classes are observed in Bodrogkeresztúr although a tendency towards the thicker classes is clear, especially when the 15-30 mm groups are taken into account. With regards to weight, the lighter categories (1-10 gr) dominate the obsidian assemblage with most cases falling within the first two groups (1-10 and 10-20 gr respectively). The tendency towards thinner specimens is further supported by the platform dimensions which were shown to be clustered within particular classes. Specifically, all the recorded specimens have been found to be <20 mm in width and <10 mm in thickness.

The examination of the technological parameters of the assemblage is indicative of the stage in the operational sequence to which the specimens are attributed. Obsidian artefacts with cortex are very abundant in the European obsidian assemblage (43.8%), mainly exhibiting medium-large percentages of cortex (25% - >100%). The non-cortical butt and partial dorsal group is the most frequent class in Bodrogkeresztúr and only few examples of fully or partially cortical platforms have been observed (tables 6.9 and 6.10).

Retouched specimens are frequent in the Bodrogkeresztúr assemblage but not dominant; 40 artefacts exhibit signs of secondary modification. Specifically, the majority of the artefacts show marginal secondary modification while specimens with long retouch are the second most numerous category. Artefacts with extensive retouch are also occasionally present but tools with retouch that covers their surfaces completely are totally lacking (table 6.11). Platforms with a single removal (flat) are the main feature of the assemblage whereas facetted platforms are the second most abundant class followed by the linear and cortical classes. Finally, the analysis has shown that all secondary flakes have been removed following a single system, that of direct flaking (table 6.12). A tendency towards specific retouch positions has also been observed; in particular, the majority of the Bodrogkeresztúr obsidian tools show evidence for secondary removals on their distal ends.

Length	Bodrogkeresztúr
1- 10mm	
10-20mm	
20-30mm	38
30-40mm	58
40-50mm	21
50-60mm	2
60-70mm	2
70-80mm	
Total	**121**

Table 6.3. Length ranges of the analysed obsidian artefacts from Bodrogkeresztúr.

Width	Bodrogkeresztúr
1-10mm	8
10-20mm	44
20-30mm	56
30-40mm	26
40-50mm	3
50-60mm	
60-70mm	
70-80mm	
Total	**137**

Table 6.4. Width ranges of the analysed obsidian artefacts from Bodrogkeresztúr.

Thickness	Bodrogkeresztúr
1-5mm	38
5-10mm	33
10-15mm	18
15-20mm	22
20-25mm	16
25-30mm	11
30-35mm	1
Total	**139**

Table 6.5. Thickness ranges of the analysed obsidian artefacts from Bodrogkeresztúr.

Weight	Bodrogkeresztúr
1-10gr	52
10-20gr	39
20-30gr	23
30-40gr	4
40-50gr	1
50-60gr	3
60-70gr	2
80-90gr	
90-100gr	
Total	**124**

Table 6.6. Weight ranges of the analysed obsidian artefacts from Bodrogkeresztúr.

Platform width	Bodrogkeresztúr
<1 mm	1
1-5 mm	20
5-10 mm	21
10-15 mm	10
15-20 mm	7
20-25 mm	
25-30 mm	
30-35 mm	
35-40 mm	
40-45 mm	
45-50 mm	
50-55 mm	
Total	**59**

Table 6.7. Platform width distribution in the Bodrogkeresztúr assemblage.

Platform thickness	Bodrogkeresztúr
<1 mm	25
1-5 mm	32
5-10 mm	2
10-15 mm	
15-20 mm	
Total	**59**

Table 6.8. Platform thickness distribution in the Bodrogkeresztúr assemblage.

Cortex %	Bodrogkeresztúr
0%	41
0-25%	22
25-50%	24
50-75%	16
75-100%	18
100%	2
Total	**123**

Table 6.9. Number of obsidian specimens separated according to cortex % in Bodrogkeresztúr.

Cortex distribution	Bodrogkeresztúr
cortical butt&100%dorsal	3
cortical butt&partial dorsal	7
cortical butt&0%dorsal	
non-cortical butt&100%dorsal	4
non-cortical butt&partial dorsal	18
non-cortical butt&0%dorsal	33
Total	**65**

Table 6.10. Number of obsidian specimens in Bodrogkeresztúr separated according to the distribution of cortex on their surfaces.

Retouch	Bodrogkeresztúr
short	25
long	13
invasive	2
covering	
Total	**40**

Table 6.11. Distribution of obsidian artefacts with retouch according to the extent of the secondary modification on their surfaces.

Retouch		Bodrogkeresztúr
direct	left	5
	distal	15
	right	9
	proximal	1
	left & right	3
	left & distal	1
	right & distal	2
	circular	4
	Total	**40**

Table 6.12. Distribution of the Bodrogkeresztúr obsidian artefacts based on the position of retouch on their surfaces.

2.2. Subalyuk

This site has evidence of obsidian exploitation from a Pleistocene stratigraphic horizon dated to >35 kyr BP (figure 6.7). Obsidian is found in this site in very small quantities deriving both from Hungarian and Slovakian sources. Given that Subalyuk is located a short distance, calculated at 68 km, from at least one obsidian source the above observations acquire special significance in the investigation of the effect of distance in the exploitation and use of obsidian during the Palaeolithic. The Subalyuk obsidian artefacts constitute only a small portion of the overall lithic assemblage recovered from the site's stratigraphic units; a total of 32 obsidian specimens have been identified from over 5000 lithics. For the purposes of this project, and according to the availability of material in the National Hungarian Museum, 14 (43.75%) of those obsidian implements were analysed.

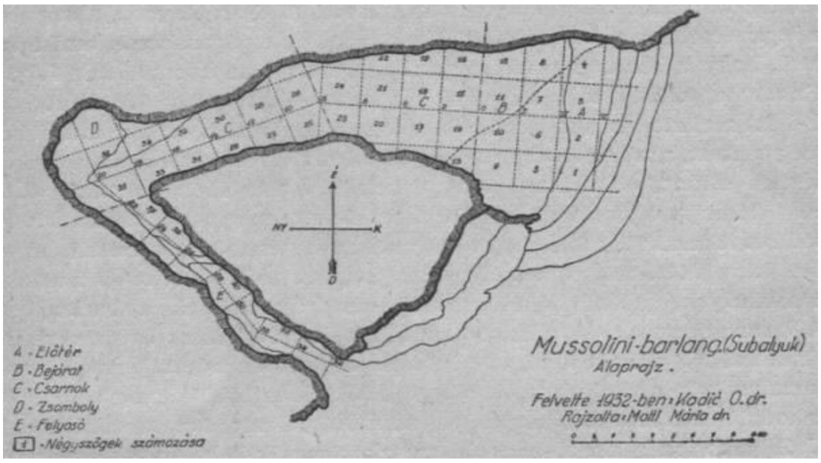


Figure 6.7. Schematic map of the Subalyuk cave after www.barlang.hu/pages/konyvek/suba/suba.htm (last visited 10/07/2208).

2.3. Ballavölgyi

This is a rock shelter dating to the Middle Palaeolithic with its lithic assemblage dominated by obsidian; the utilised raw material has been attributed to Slovakian sources resulting in a minimum distance of 106 km from the nearest obsidian source to the site. Given that only 8 obsidian specimens have been recovered from the site's stratigraphic units it is worth investigating to what extent is this number a result of distance and/or time and how it differs from the Upper Palaeolithic long obsidian sequence of Bodrogkeresztúr.

2.4. Pilismarót-Diós

This is an Upper Palaeolithic open site dating to ~17 kyr BP and located in the Hungarian section of the Carpathian basin (figure 6.8). In terms of age and region Pilismarót-Diós falls within the same context as Bodrogkeresztúr, thus, comprising the best candidate for the purposes of this analysis. The two sites differ in the quantities of obsidian included in their lithic assemblages, with Bodrogkeresztúr dominated by the specific raw material whereas in Pilismarót-Diós only a few obsidian specimens are represented. More importantly, they differ in their proximity to the obsidian source supplying them with the desired raw material; as it has already been discussed in the previous chapter Bodrogkeresztúr is located in the vicinity of the utilised obsidian source. However, the nearest Carpathian I obsidian source to the Pilismarót-Diós site lies a minimum distance of 204 km away. In Pilismarót-Diós 32 out of a total of 1257 lithic implements are made of obsidian comprising a small but significant section of the assemblage. From those 32 specimens I had the opportunity to analyse 8 (25%) that were held in the collections of the Hungarian National Museum.

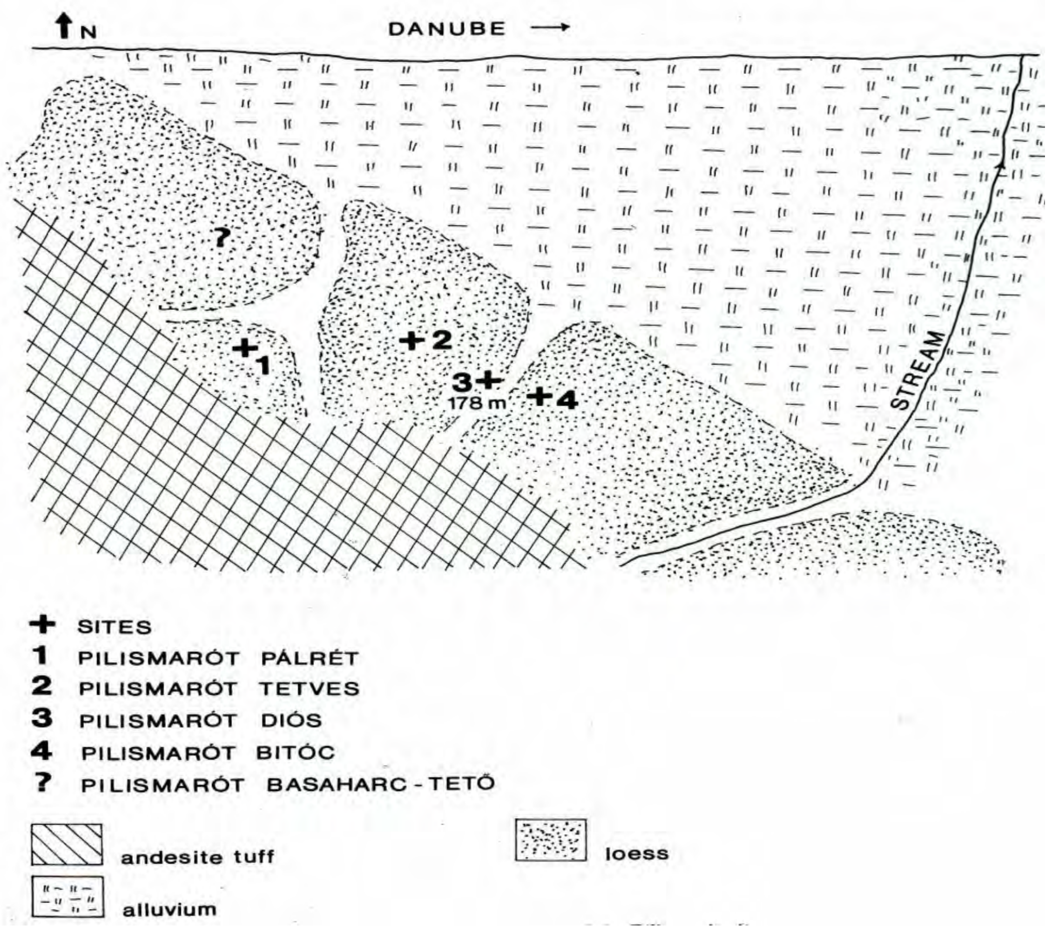


Figure 6.8. Location and general geological context of Pilismarót-Diós. After Dobosi (1994).

3. MARMONET DRIFT (GtJi15), KENYA (0°45’10’’S 36°10’30’’E, 2106 m asl)

Marmonet Drift, GtJi15, is situated in the South Narok district within the boundaries of the Kenyan sector of the Great Rift Valley. The central part of the Rift Valley is bordered by the Kinangop Plateau on the east and by the Mau Escarpment on the west, while the Naivasha and Nakuru-Elmenteita lake basins, divided by the Eburru Mountain, constitute its central section. Marmonet Drift itself is located at the base of the Mau Escarpment in the north-west corner of the Naivasha basin in close approximation to the west side of the Marmonet River valley and at an elevation of 2106 m at the top of the outcrop (figure 6.9).

A wealth of physiographic features characterised the general topographic context of Marmonet Drift; extensive tectonic activity resulted in the formation of several mountains such as Mt Kinangop, Mt Margaret, Mt Suswa, a large low volcano (caldera) 15 km south-west of Mt Margaret, Mt Longonot (caldera) in the north-west as well as the impressive Lake Sonachi crater to name just a few. Lake Naivasha reaches an elevation of ~1890 m (lake surface) while the basin itself is surrounded by the Mau Escarpment (3100 m asl) and Mt Eburru (2700 m asl) which form its western and north horizons respectively. Of great importance for this thesis is the fact that numerous obsidian sources are scattered all over the area described above (personal observation). Obsidian outcrops are identifiable throughout this part of the Rift Valley; Fisherman’s camp, Sonachi, Hell’s Gate are some of the sources enriching the topography of the region.

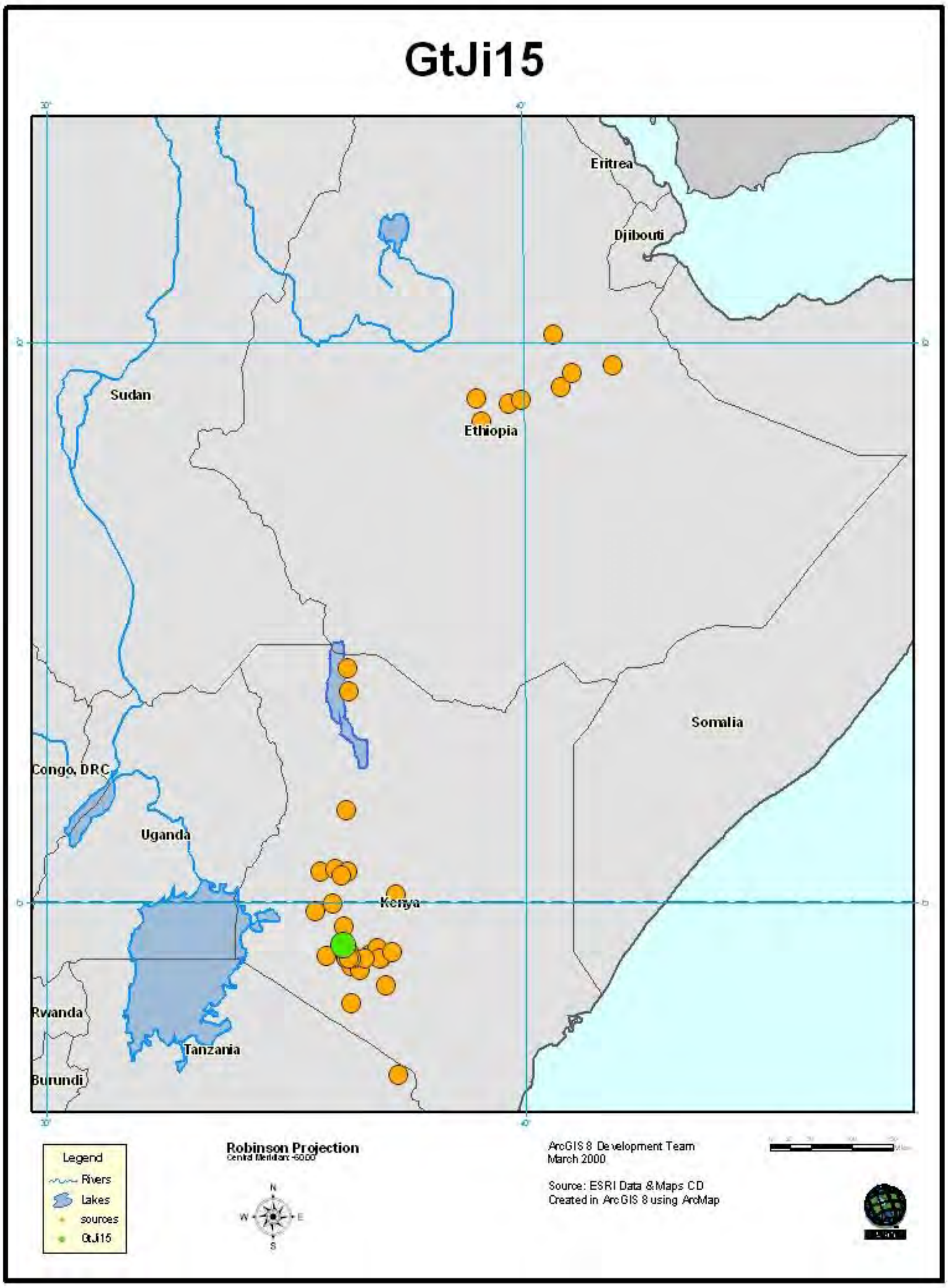


Figure 6.9. Location of Marmonet Drift/GtJi15 (green circle) and the available obsidian sources in Pleistocene East Africa (orange circles).

Figure 6.10. One of the excavated sections with some of the volcanic horizons (indicated by the orange arrow) clearly visible on the upper part of the trench (photo T. Moutsiou).

Figure 6.11. Close up of one of the volcanic horizons excavated during the 2006 field season in GtJi15 (photo T. Moutsiou).

The sedimentary sequence, which in the excavated section approximates 22 m in thickness, is rich in features, the most interesting of which are the volcanic ashes. These are found interstratified with weakly developed paleosols that formed in part on aggrading alluvial/colluvial sediments transported mainly from higher slopes of the Mau and in part on reworked volcanics. A detailed description of the stratigraphy of GtJi15 can be found in the Proceedings of the MSA of East Africa and modern human origins conference (2005). Here, I will concentrate on the volcanic ashes as they have a crucial effect on our understanding of the archaeological site under investigation. The number of volcanic horizons present at the site is impressive (figures 6.10 and 6.11). This fact in association with the same situation observed in other nearby areas facilitates stratigraphic correlations, date determinations and estimation of relative artefact densities. Beginning from near the base of the sequence, fifteen volcanic horizons have been identified (Ambrose 2005). These are:

- VA 0: dark grey-green pumiceous tuff with black pumice, thickness ~55 cm
- VA 1: light grey fine volcanic ash with micro-laminations and white ash at base, thickness 18 cm
- VA 2: light grey volcanic ash, well-sorted coarse silt/fine sand texture, thickness 17 cm
- VA 3: very dark grey volcanic ash, fine sand grading to coarse laminated silt near base, thickness 31 cm
- VA 4: light grey volcanic ash, well-sorted coarse silt texture with root marks & voids, thickness 21 cm
- VA 5: grey massive volcanic ash, coarse silt to fine sand texture, thickness 17 cm
- VA 6: grey volcanic ash, fine silt texture; platy mineral cementation at base, thickness 17 cm
- VA 7: gritty grey pumice fine gravel tuff, thickness 21 cm
- VA 8: grey-brown and greenish yellow platy laminated basaltic tuff, thickness 25-61 cm
- VA 9: black and white stratified pumice with interbedded ash and pumice layers, thickness ~170 cm
- VA 10: grey pumiceous coarse sand/fine gravel, thickness ~25 cm
- VA 11: dark yellow-brown massive, dense gritty soil with pumice gravel and root casts, thickness ~33 cm
- VA 12: dark yellow-brown massive sandy pumiceous loam, thickness ~20-33 cm

- VA 13: light grey pumice bed (young)
- VA 14: blue-grey fine-grained volcanic ash (young)

The most important features of this sequence are the fine gravel tuff (VA 7); Ar/Ar dating was applied to this layer and gave an argon isotope age of 205 kyr, and VA 9 that gives dates of 107 kyr and 100 kyr, which form the basis for the chronological sequence of the archaeology-bearing horizons.

Faunal and floral remains are absent or very poorly preserved at most Middle Stone Age sites especially in the Kenyan sector of the Rift Valley. Evidence for the presence of *Pelorovis,* an extinct buffalo species, in the central rift during that time exists at the Malewa River site but no further information with regards to the rest of the faunal assemblage of the site has been published. Faunal remains have been unearthed in the Marmonet Drift site but the results of their analysis are not yet known. Unanalysed remain faunal assemblages from other Middle Stone Age sites in the area, for example Prolonged Drift making it impossible to reconstruct a detailed picture of the Marmonet Drift environment at its time of occupation by the Palaeolithic hominins.

Research conducted by Isaac (1972) in the early 80s indicated a remarkable increase in artefact densities in the central Rift at elevations approximating 2000-2100 m. Further research (Bower *et al.* 1977 and more recently, Ambrose 2001) reinforced Isaac's observation and showed that Middle Stone Age sites tend to concentrate at high elevations (2000-2100 m). Using the Okiek hunter-gatherers of the montane regions of Kenya and northern Tanzania, this observation was used as evidence for a settlement preference for the montane forest-savanna ecotones by Middle Stone Age hominins. This ecotone is at present located at an elevation above 2300 m but the available palynological, archaeological and isotopic evidence indicates that it shifted to higher or lower altitudes in response to climate change (Richardson 1972, Ambrose & Sikes 1991).

Excavation in the form of a step trench in the area was initiated at 2001 as part of a multidisciplinary research program on the socio-ecology and geochronology of the Middle Stone Age in the Central Rift. In 2006, I accompanied Ambrose and his team in the Rift for another field season at Marmonet Drift. The 2006 brief fieldwork period concentrated on the removal of VA 7 (see above) in order to examine what lies directly beneath it, cleaning of the previously dug step trench and expansion of an older trench with the aim to gain a better understanding of the archaeological sequence. Excavation units were usually whole natural stratigraphic layers but when thicker strata were present, they were subdivided into 10-25 cm thick sections. All the soil that was removed was sieved using coarse and fine screens.

The assemblage collected during that year's field season was transferred to the National Museum of Kenya in Nairobi where it was cleaned and catalogued. Despite the number of artefacts gathered, I decided not to use this particular assemblage in my lithic analysis. Rather, I chose to adopt a model that would allow me to gain the fullest perception possible of the complete archaeological sequence/chronological span of the site. This is the reason that led me to the decision to examine small, but representative, samples from each of the four Middle Stone Age phases.

Marmonet Drift (GtJi15) is one of the components of a complex of Middle Stone Age Palaeolithic sites in the Central Rift Valley of Kenya, which include Prolonged Drift, Prospect Farm, Ntumot and Enkapune Ya Muto. In Marmonet Drift four main periods of occupation have been identified, all coinciding with the Middle Stone Age based on Ar/Ar data, ranging in date from older than 205 kyr and younger than 100 kyr. The separation of the archaeological strata to the aforementioned periods is in accordance with the following scheme:

- Earliest occupation phase (strata 41-44): older than 205 kyr (and most likely associated with MIS 7), the lithic assemblage so far is dominated by flakes with faceted platforms struck from radial cores. The raw materials are obsidian and lavas (an increase in the quantity of lavas is observed in contrast to younger horizons)

- Second occupation phase (strata 20-22): older than 205 kyr (MIS 6?), very low artefact densities but it is here that the highest diversity in obsidian sources use is recorded
- Third occupation phase (strata 10-11): older than 107-100 kyr (MIS 5?), very low artefact densities
- Fourth occupation phase (strata 2-7): younger than 100 kyr (within MIS 5?), flaking floors along the top of the outcrop

The archaeological sequence continues upslope with Holocene Later Stone Age and Neolithic horizons but no further reference will be made concerning them as here my interest is restricted to the four Middle Stone Age horizons. The obsidian assemblages examined for the purposes of this research come from level 42, level 22, level 10 and level 5. Respectively these cultural horizons correspond to the first occupation phase, the second, the third and the fourth occupation phase.

3.1. Description of the Obsidian Assemblage

In the lithic assemblage of Marmonet Drift (GtJi15) in Kenya, obsidian is the raw material the majority of the artefacts are made of. Flint, chert and quartz are the other identified materials but as they have not yet been analysed no further information can be provided regarding them. The site's obsidian sequence was sampled and analysis was conducted on 196 of those artefacts. Given that research in GtJi15 is ongoing, the ~200 specimens are only a small proportion of a yet unknown total lithic (obsidian) quantity.

Before embarking on a detailed description of the analysed assemblage it is necessary to comment on the quality of the selected artefacts. As it is clear from table 6.13 complete and fragmented specimens are equally represented in the sample. The large amount of broken pieces explains the lack of data in certain categories of the metrical and technological parameters of analysis.

		GtJi15
complete	Count	97
	Column %	*49.5*
fragmented	Count	99
	Column %	*50.5*
Total	**Count**	**196**
	Column %	***100.0***

Table 6.13. Qualitative evaluation of the analysed obsidian artefacts from the Middle Stone Age site of GtJi15.

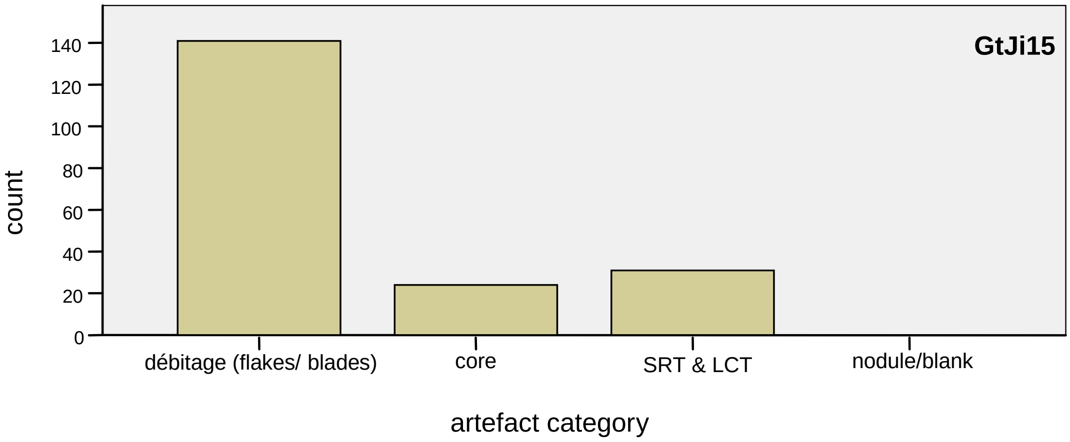


Figure 6.12. Recorded typological classes in GtJi15.

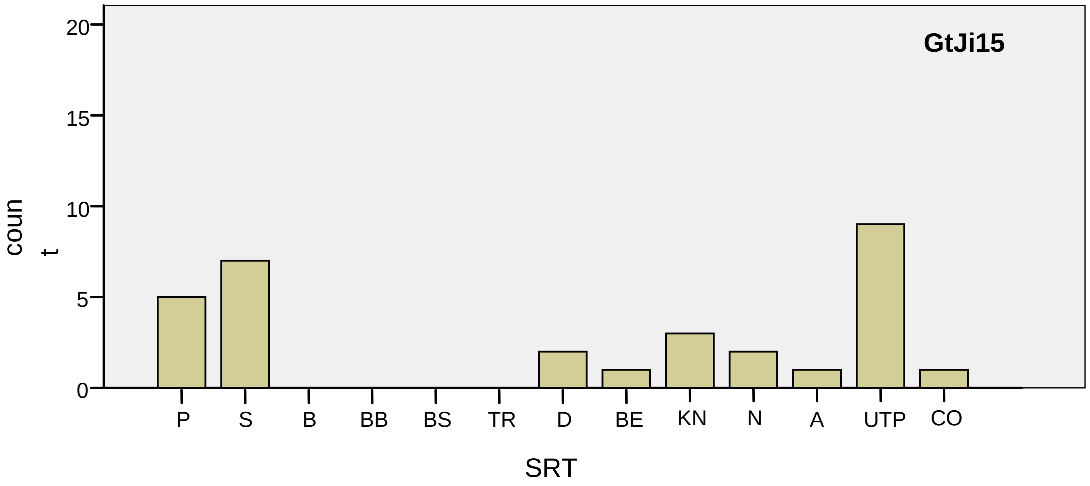


Figure 6.13. Distribution of small retouched tool (SRT) classes in the GtJi15 assemblage. [P= point, S= scraper, B= burin, BB= burin blow, BS= burin spall, TR= truncation, D= denticulate, BE= bec, KN= knife, N= notch, A= awl, UTP= utilised piece, CO= composite].

The general typological classes and specific tool types identified in the analysed obsidian assemblage of GtJi15 are presented in figures 6.12 and 6.13. Similarly to Bodrogkeresztúr, débitage forms the commonest category in GtJi15 comprising the 71.9% of the overall obsidian assemblage. Small retouched tools are the second most abundant tool class (15.8%), followed by cores (12.2%) whereas nodules/blanks are totally lacking. Specifically, flakes constitute a very important part of the GtJi15 assemblage with a 77% of the total débitage count. Significant quantities of «technical pieces» have also been unearthed, namely trimming and platform removal flakes. With regards to small retouched tools utilised pieces are the most frequently encountered class. Utilised pieces are included in the small retouched tools group but they are in fact flakes with evidence of utilisation and not specially designed tools (Débenath & Dibble 1994). Various «proper» tool types are also present in the assemblage (figure 6.13) of which scrapers form the most abundant category.

The above obsidian artefact groups from GtJi15 were examined and the results of the dimensions' analysis are provided in the following tables (6.14-6.19). With regards to length, specimens spanning the whole range of length classes have been observed. 13 cases of a maximum length >50 mm have been recorded although the 20-40 mm class comprises the commonest category. When maximum width is taken into account, the 10-40 mm range is the most frequent, although instances of specimens exceeding 50 mm are present in more than one occasion. In terms of thickness, all the identified classes have been recorded in GtJi15; however, there is a clear tendency towards the lower limit of the range with the majority of artefacts falling in the 5-10mm group. In terms of weight, the lighter categories clearly dominate the assemblage with the majority of specimens falling within the 1-10gr group. Nevertheless, examples of the heavier classes are also represented (80-100 gr). The analysis of the platform dimensions reveals a big range where small sizes dominate but an overall inclination towards larger sizes, with artefacts occasionally reaching 55 mm in width and 20 mm in thickness, cannot be disregarded.

Length	GtJi15
1- 10mm	1
10-20mm	18
20-30mm	28
30-40mm	24
40-50mm	13
50-60mm	5
60-70mm	7
70-80mm	1
Total	**97**

Table 6.14. Length ranges of the analysed obsidian artefacts from GtJi15.

Width	GtJi15
1-10mm	3
10-20mm	58
20-30mm	54
30-40mm	26
40-50mm	13
50-60mm	2
60-70mm	1
70-80mm	1
Total	**158**

Table 6.15. Width ranges of the analysed obsidian artefacts from GtJi15.

Thickness	GtJi15
1-5mm	53
5-10mm	74
10-15mm	24
15-20mm	3
20-25mm	2
25-30mm	1
30-35mm	1
Total	**158**

Table 6.16. Thickness ranges of the analysed obsidian artefacts from GtJi15.

Weight	GtJi15
1-10gr	76
10-20gr	11
20-30gr	5
30-40gr	1
40-50gr	
50-60gr	1
60-70gr	2
80-90gr	1
90-100gr	1
Total	**98**

Table 6.17. Weight ranges of the analysed obsidian artefacts from GtJi15.

Platform width	GtJi15
<1 mm	5
1-5 mm	6
5-10 mm	23
10-15 mm	34
15-20 mm	19
20-25 mm	18
25-30 mm	13
30-35 mm	7
35-40 mm	2
40-45 mm	2
45-50 mm	2
50-55 mm	1
Total	**132**

Table 6.18. Platform width distribution in the GtJi15 assemblage.

Platform thickness	GtJi15
<1 mm	16
1-5 mm	57
5-10 mm	49
10-15 mm	9
15-20 mm	1
Total	**132**

Table 6.19. Platform thickness distribution in the GtJi15 assemblage.

The examination of cortex quantity and position in the obsidian assemblage of GtJi15 showed that cortical pieces comprise only a small proportion (10.7%) of the GtJi15 assemblage. The 100% cortex category is represented in the African site but only rarely. On the other hand, specimens falling in the groups '0% cortex' and 'non-cortical butt&0% dorsal cortex' comprise the commonest group of the assemblage (tables 6.20 and 6.21).

Cortex %	GtJi15
0%	137
0-25%	6
25-50%	4
50-75%	2
75-100%	5
100%	4
Total	**158**

Table 6.20. Number of obsidian specimens separated according to cortex % in GtJi15.

Cortex distribution	GtJi15
cortical butt&100%dorsal	3
cortical butt&partial dorsal	
cortical butt&0%dorsal	1
non-cortical butt&100%dorsal	1
non-cortical butt&partial dorsal	16
non-cortical butt&0%dorsal	137
Total	**158**

Table 6.21. Number of obsidian specimens in GtJi15 separated according to the distribution of cortex on their surfaces.

Artefacts with evidence of retouch (table 6.22) are relatively frequent in the GtJi15 assemblage (37 specimens). Here, artefacts with long retouch are the most commonly encountered category followed by tools with short secondary modification. Examples of extensively retouched artefacts are very infrequent but in GtJi15 even the «covering» category is represented. The GtJi15 assemblage exhibits a clear preference towards a specific platform class and an overall greater variety in tool platform types. Facetted platforms are by far the commonest category followed by platforms with single removals. Punctiform, chapeau and cortical platforms are the remaining recorded types although they are represented by very small numbers. With regards to the direction of secondary flake removals, a big variety has been observed in the GtJi15 assemblage, with removals following either a direct or alternate pattern, although direct flaking is the most abundant category (table 6.23). Furthermore, the majority of retouched artefacts appear to have undergone secondary modification all around their surfaces (circular retouch). However, this class is numerically closely followed by artefacts with retouch on their left or right sides.

Retouch	GtJi15
short	15
long	19
invasive	2
covering	1
Total	**37**

Table 6.22. Distribution of obsidian artefacts with retouch according to the extent of the secondary modification on their surfaces.

Retouch		GtJi15
direct	left	7
	distal	2
	right	5
	proximal	3
	left & right	3
	left & distal	3
	right & distal	3
	circular	8
	Total	**34**
alternate	right	1
	left & right	1
	circular	1
	Total	**3**

Table 6.23. Distribution of the GtJi15 obsidian artefacts based on the position of retouch on their surfaces.

4. COMPARISON OF THE ASSEMBLAGES

A comparative analysis of the Bodrogkeresztúr and GtJi15 assemblages was undertaken and the results are discussed in the following paragraphs. The analysis concentrated solely on technological issues of the artefacts with the aim of investigating the degree of differential exploitation of obsidian on a micro-scale level. A comparative analysis of the dimensions of the two Palaeolithic industries was not attempted; artefact size depends on the raw material sources which are very different in the two regions under examination - large nodules in GtJi15 and small pebbles in Bodrogkeresztúr. Subsequently, the size of the available blanks is responsible for the patterns discussed in the previous sections and no behavioural significance can be attributed to those results.

Significant differences are observed in the technological aspects of the two industries. In GtJi15 a general abundance of technical pieces, especially trimming and platform removal flakes, combined with a paucity of cores, characterises the obsidian assemblage. A very different picture emerges when the Upper Palaeolithic Bodrogkeresztúr obsidian technical pieces, also supported by the core data, are taken into account. In this site, artefacts indicative of the procedure of tool manufacture are restricted to decortication flakes. Decortication is the term given to flakes that result from the transformation of a nodule to core and as such they are attributed to the initial stages at lithic reduction. This observation has particularly significant implications with regards to the initial obsidian appearance on site as the above pieces are directly associated with the initial stages of lithic production.

Furthermore, the cortex (figures 6.14-6.16) and retouch (6.17-6-19) data supports a tendency towards fewer cortical and more extensively retouched obsidian specimens in the African assemblage despite its early age compared to Bodrogkeresztúr. The same result is also generated when the obsidian tool platforms are analysed (figure 6.20). In Bodrogkeresztúr, obsidian enters the site either as a fully cortical nodule or very basically reduced blank/core, and undergoes most of the reduction procedure on site. The ratios of cortex on the respective artefacts, either on their platforms or any other part of their surface, do not allow a different interpretation. The ratio of cortical to non-cortical artefacts in GtJi15, on the other hand, strongly support a perception of obsidian exploitation highly deviating from the norm in Bodrogkeresztúr. In the African case, obsidian reaches the site in a more reduced form and it is then further modified into primary flakes that are utilised as they are or shaped into a more elaborate tool type. The quantities of cortical pieces found in each of the two sites suggest a more complete operational sequence in the exploitation of obsidian in the European assemblage with specimens representing each one of the manufacture stages contrary to GtJi15 where, although a few instances of a complete chaîne opératoire do exist, most of the obsidian appears on site after some initial modification elsewhere. Finally, the European obsidian débitage platforms indicate a very concise mode of production emphasising thinner and narrower proximal edges in accordance with an overall tendency for more elaborate and technologically succinct forms. This is in contrast to the African assemblage where a greater dimensional variation with plenty large artefacts has been observed.

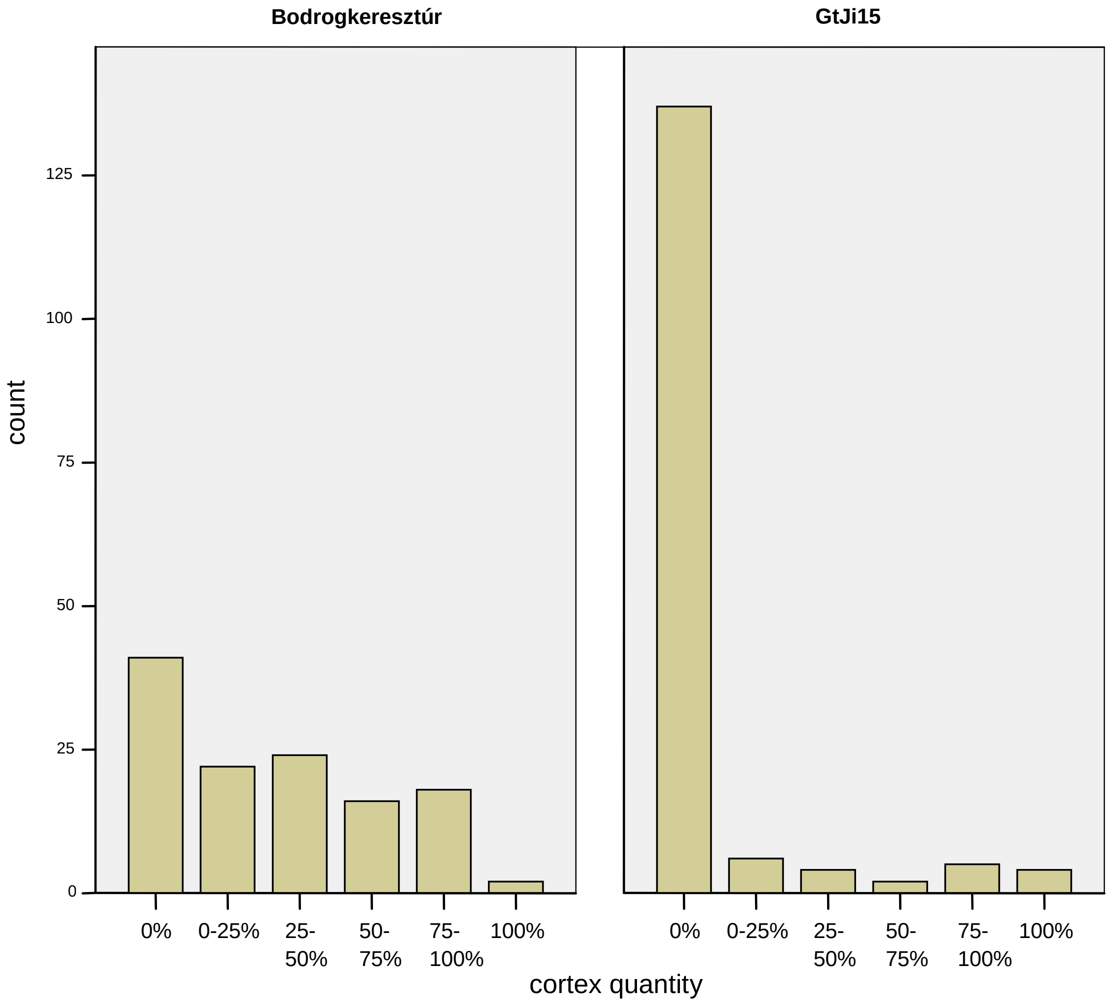


Figure 6.14. Graphic presentation of cortex distribution in the Bodrogkeresztúr and GtJi15.

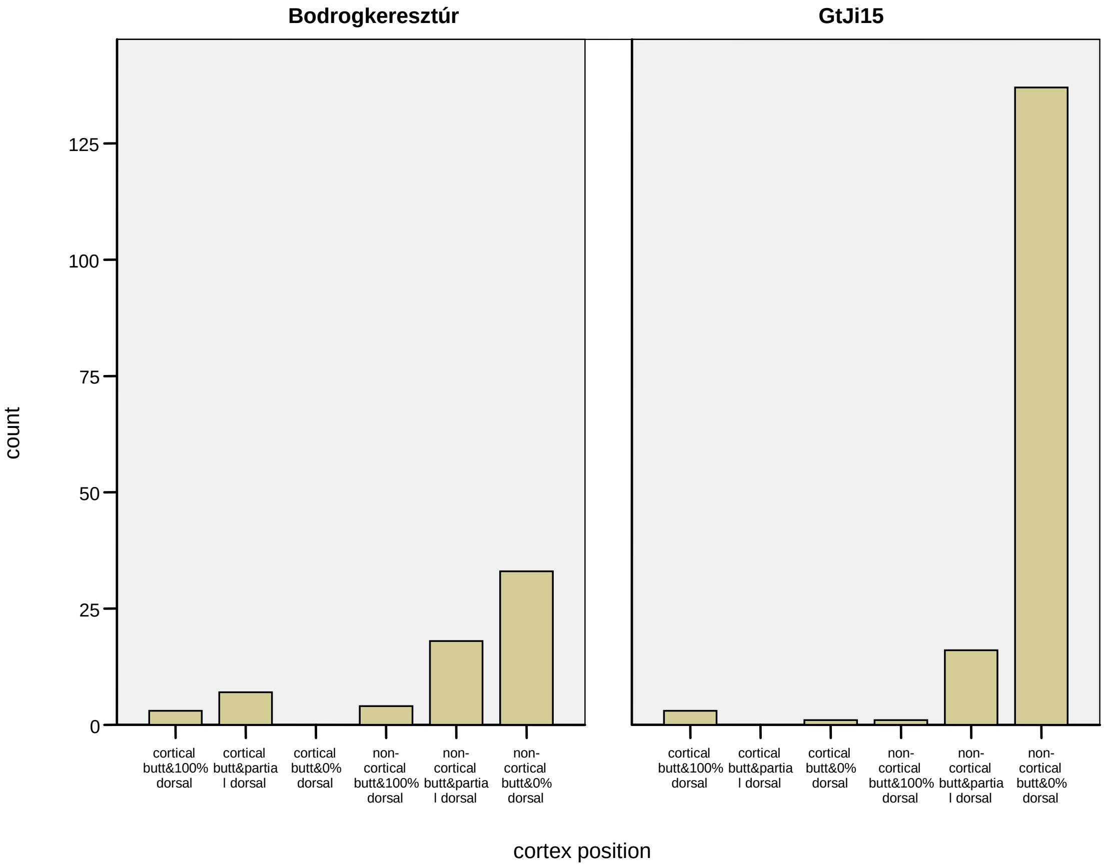


Figure 6.15. Graphic presentation of cortex position in the Bodrogkeresztúr and GtJi15 obsidian assemblages.

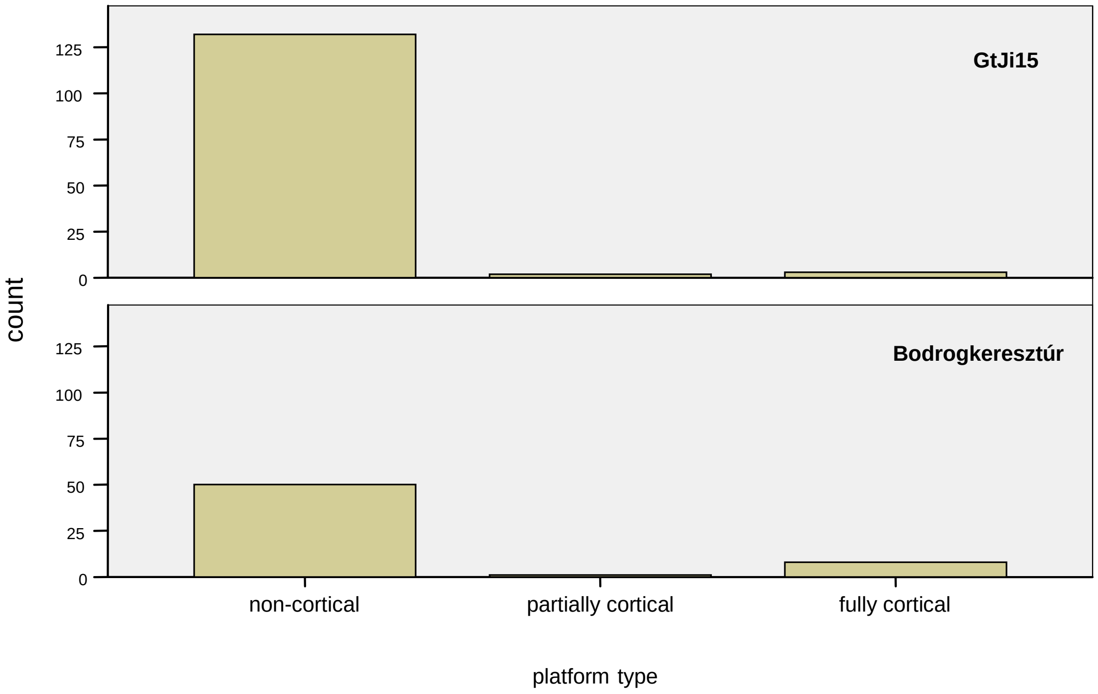


Figure 6.16. Distribution of platform types with emphasis on the extent of cortex in the two analysed assemblages.

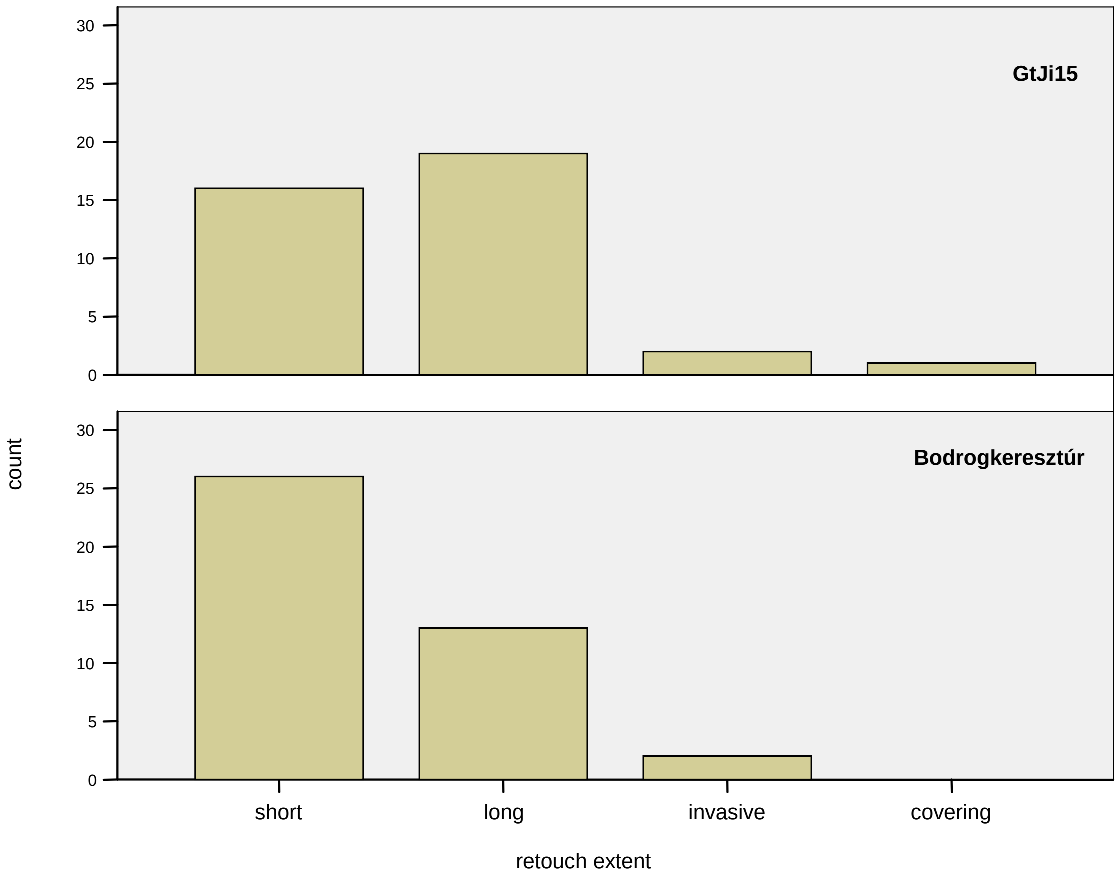


Figure 6.17. Graphic presentation of the distribution of the recorded retouch extent classes in the two analysed obsidian assemblages.

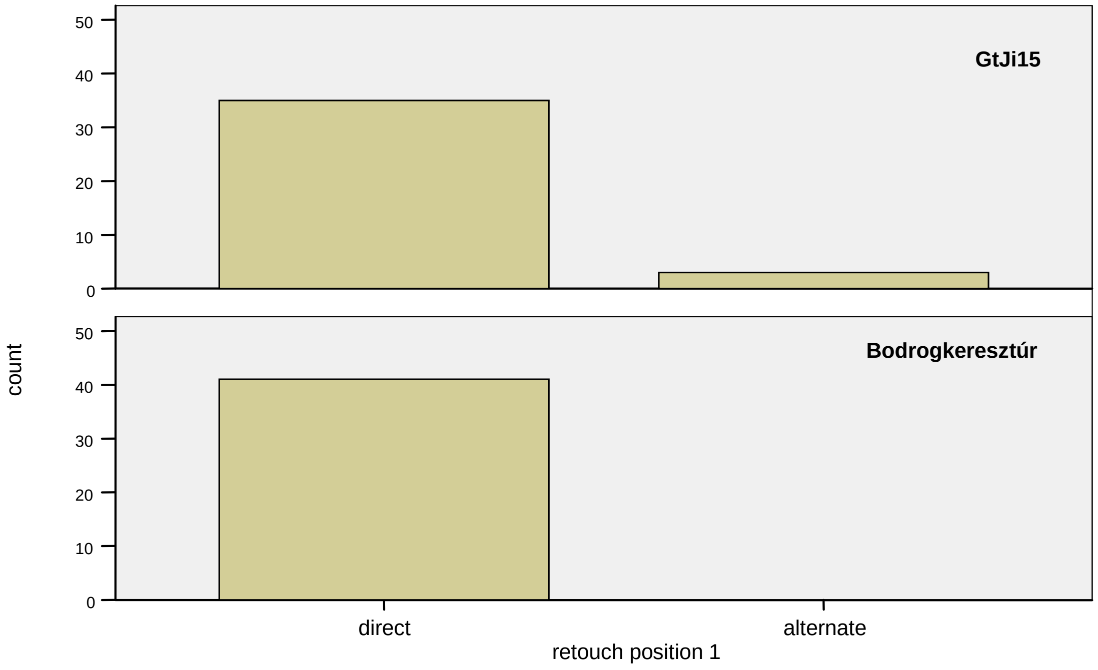


Figure 6.18. Graphic presentation of retouch position 1 classes in the Bodrogkeresztúr and GtJi15 obsidian assemblages

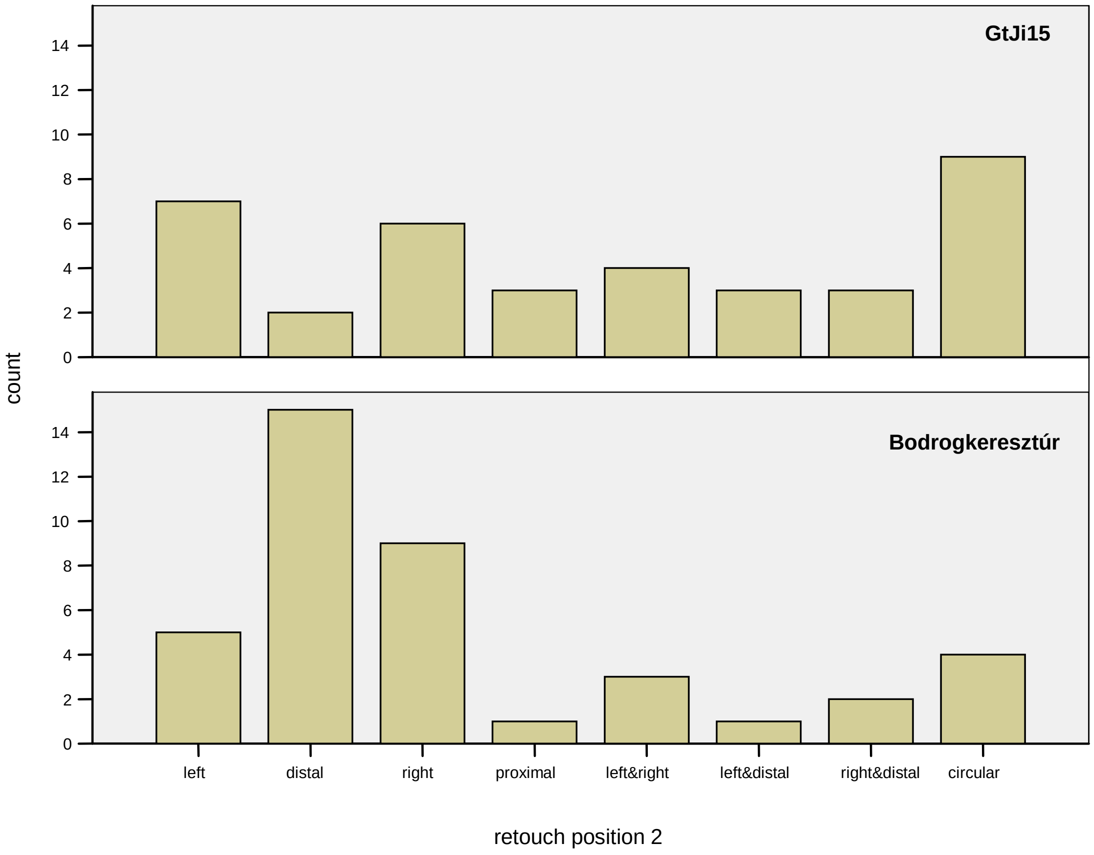


Figure 6.19. Graphic presentation of retouch position 2 classes in the Bodrogkeresztúr and GtJi15 obsidian assemblages.

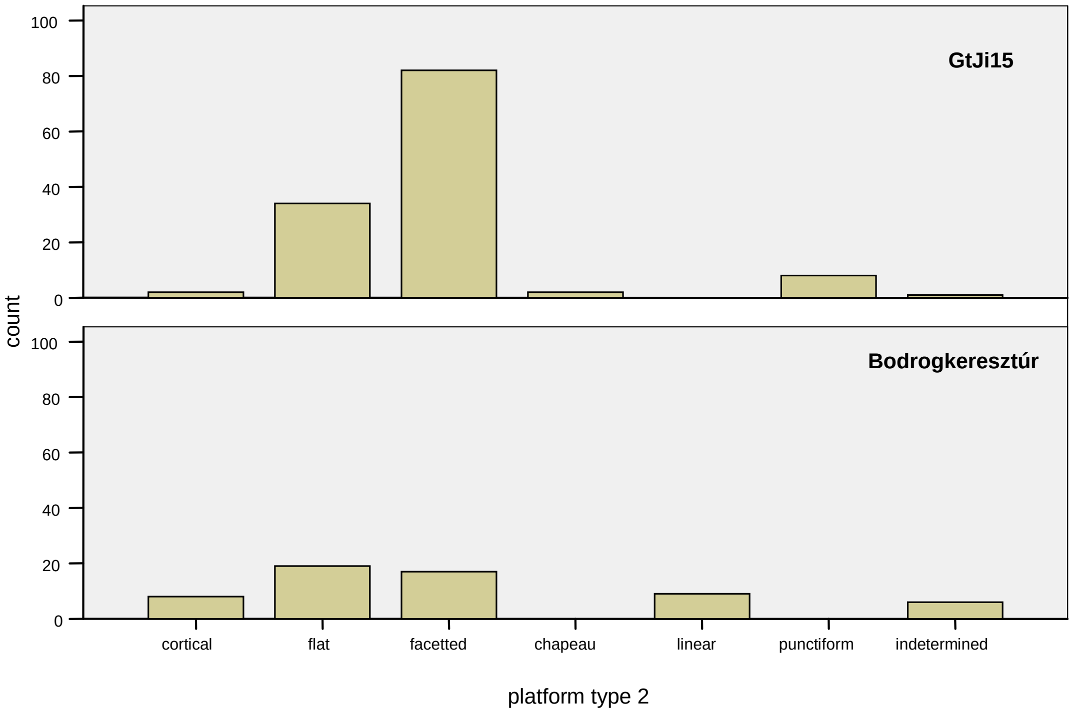


Figure 6.20. Distribution of platform types with emphasis on the typological characteristics/scar count (platform type 2) in the two analysed assemblages.

Therefore evidence exists to support a number of differences between the two analysed obsidian assemblages. Indeed, technologically the European assemblage exhibits signs of a more sophisticated level of tool manufacture expressed in a greater degree of retouch and more intensively worked platforms. However, the explanation lies in the chronological context of the two sites rather than anything else. The observations discussed in the previous paragraphs must be attributed to the earlier date of the GtJi15 site when compared to the late age of Bodrogkeresztúr and its more elaborate Upper Palaeolithic tool forms. Particularly with regards to the typologies present in each assemblage this factor constitutes the most plausible interpretation. The analysis of the features characterising obsidian in Bodrogkeresztúr and GtJi15 has revealed a major deviation between the two sites. Burins, truncations and blades are absent from the Middle Stone Age cultural horizon of GtJi15 whereas notches and knives have not been recovered from the Upper Palaeolithic layer of Bodrogkeresztúr. Based on the Palaeolithic classification scheme developed by Bordes (1961a; b) and revised by Débenath & Dibble (1994) the missing classes are in accordance with the general typological characteristics of the Middle Stone Age and Upper Palaeolithic technologies.

All the evidence supports the interpretation that obsidian entered the lithic records of the two sites at a different stage of production. The percentages of cores to flakes, the amount and type of technical pieces and the presence of at least one obsidian nodule in Bodrogkeresztúr support the entrance of obsidian to this site in an earlier, rougher form than at GtJi15. Specifically, in Bodrogkeresztúr obsidian appears in a very early stage and undergoes its major modification on site whereas in GtJi15 entrance at a later stage of exploitation is shown to be the case. The identified numbers of technical pieces, characteristic of the secondary phase of lithic reduction, are particularly informative to that respect. Technical pieces are associated with the final thinning and shaping of the tool or with the rejuvenation of the core after some initial knapping had occurred. The analysis has shown that such artefacts are more numerous in GtJi15 indicating a more advanced degree of modification at the time of obsidian entering the site. Information provided by the cortex and retouch data further support a perception according to which obsidian enters Bodrogkeresztúr in an earlier, more cortical, phase and undergoes most of the reduction procedure in situ. Conversely, in the African assemblage although such artefacts are present they do not constitute the commonest category implying a more advanced, in terms of reduction sequence, stage at the time of entry.

The differences that have been observed between Bodrogkeresztúr and GtJi15 are disparities associated with the overall differential patterns characterising the lithic technologies of two very different periods and regions. However, there is an underlying pattern common in both sites and the way they exploited obsidian. Located in the vicinity of at least one obsidian source both sites make the most out of this opportunity to manufacture the bulk of their lithic tool-kits out of this particular material. Obsidian is also present in great distances but such occurrences are rare and include only SRTs (small retouched tools). It is not possible to discern archaeologically whether the location for the Bodrogkeresztúr and GtJi15 sites was chosen based on their proximity to obsidian sources but once there, both Middle Stone Age and Upper Palaeolithic knappers relied on obsidian for their lithic tools. However, when distances like that of Ballavölgyi and Pilismarót-Diós are reached even by few obsidian artefacts we can confidently claim that obsidian got there because of a hominin’s desire for its acquisition.

In the previous sections the regional scale of the effect of latitude on the formation of two obsidian assemblages was examined. The analysis showed the ways in which region affects typological and technological aspects in the use of obsidian in two sites from two different regions but with the same source-to-site distance. In the following sections and in order to account for the effect distance exerts in the use of obsidian an intra-regional analysis of four central European sites was undertaken (figure 6.21). The typological, technological and dimensional parameters of the obsidian assemblages from Bodrogkeresztúr, Subalyuk, Ballavölgyi and Pilismarót-Diós (see sections 2.2-2.4 a description of the sites) were compared and patterns identified. With regards to the artefacts' dimensions metrical comparisons were deemed meaningful as the size of the blanks is the same in all European obsidian sources. Given that source size cannot account for any of the observed patterns and region is also kept constant, the effect distance exerts on obsidian assemblages can securely be identified.

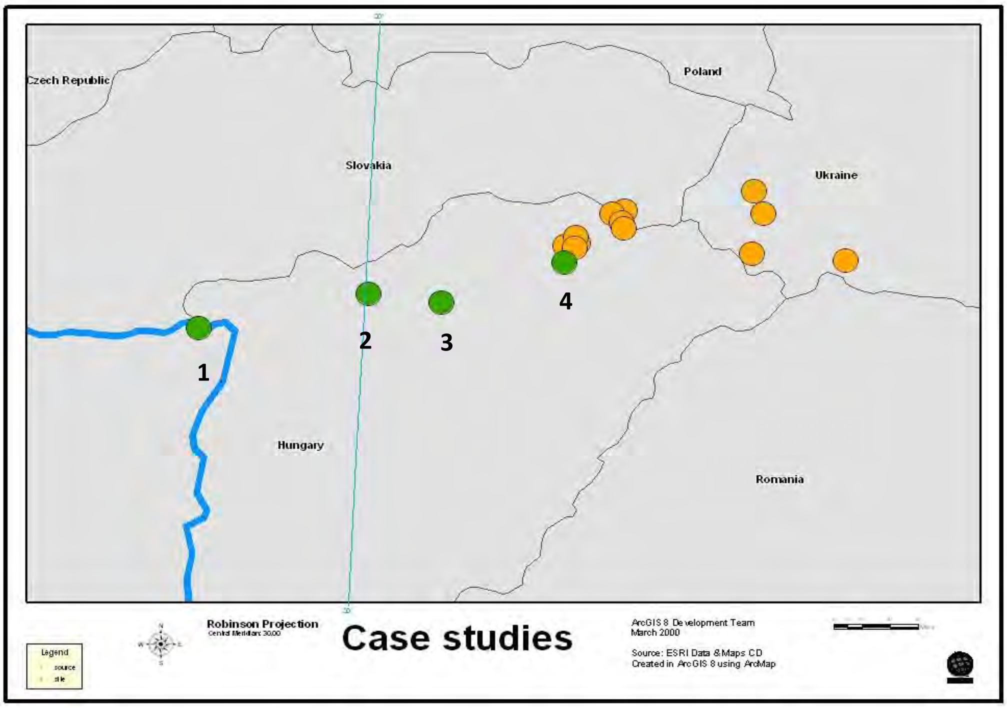


Figure 6.21. Map showing the location of the four case studies (green circles). Note: 1= Pilismarót-Diós, 2= Ballavölgyi, 3= Subalyuk and 4= Bodrogkeresztúr. The orange circles indicate the obsidian sources identified in Central Europe.

The comparative examination of the obsidian assemblages demonstrates the inversely correlated character of the distance-frequency relationship (table 6.24 and figure 6.22). The number of obsidian specimens present in each assemblage decreases as the source-to-site distance increases. Bodrogkeresztúr, which is located the shortest distance from an obsidian source, i.e. 1-50 km class, exhibits the highest obsidian artefact frequencies. Obsidian numbers substantially decline in Subalyuk which is located in a distance coinciding with the 50-100 km class and they are even further reduced in Ballavölgyi and Pilismarót-Diós, both sites located >100 km from their nearest obsidian source. 100 km seems to be a threshold as the comparison between the two later sites shows that the obsidian frequencies do not change despite the 100 km difference between Ballavölgyi and Pilismarót-Diós.

	Bodrogkeresztúr	**Subalyuk**	**Ballavölgyi**	**Pilismarót-Diós**
Km	7	64	107	204
No of specimens	187	14	8	9

Table 6.24. Number of obsidian artefacts in the four analysed assemblages and their distance from their nearest sources.

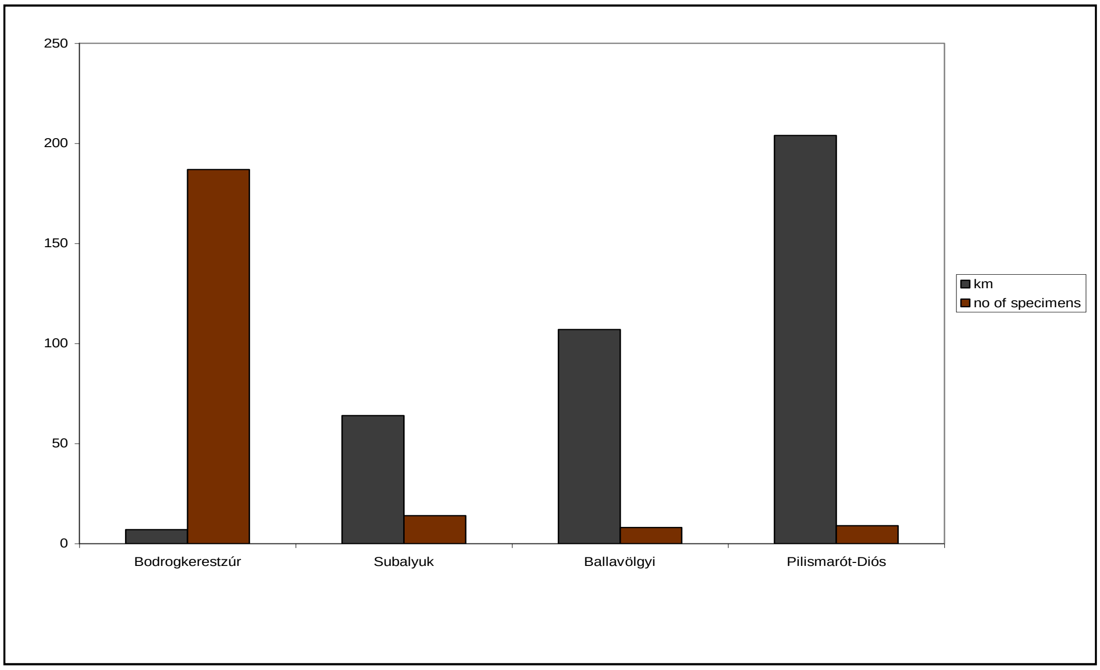


Figure 6.22. Graph illustrating the inversely correlated relationship between artefact quantities and source-to-site distance.

The analysis of the typological classes identified in the four obsidian assemblages under examination provides further support to the above observation (table 6.25). Bodrogkeresztúr exhibits the broadest typological variability encompassing the whole spectrum of tool types from nodules to retouched, i.e. «finished» products, artefacts. This is in accordance to the site's short distance from its nearest obsidian source which would have made the transport of raw material in its primary form (nodules, cores) easy. The remaining assemblages involve tool types in a highly modified state with unretouched flakes/blades and small retouched tools being the only represented classes. This pattern characterises any site located over a 50 km radius from its nearest obsidian source and no differences within the 50 - >200 km range have been identified. Tool size seems to have a strong effect on the tool types preferred for long distance transportation as all the recorded specimens, even the Pilismarót-Diós core, are small compared to many of the Bodrogkeresztúr artefacts.

Artefact class	**Bodrogkeresztúr** (7 km)	**Subalyuk** (64 km)	**Ballavölgyi** (107 km)	**Pilismarót-Diós** (204 km)
débitage (flakes,blades)	85	8		7
core	62			1
SRT&LCT	39	6	8	1
nodule/blank/pebble	1			
Total	**187**	**14**	**8**	**9**

Table 6.25. Typological classification of the obsidian artefacts recorded in each of the four analysed lithic assemblages.

The maximum dimensions of the obsidian artefacts from the four European case studies were recorded as a means of establishing the significance levels of the distance-tool size relationship identified in the above section (tables 6.26-6.29 and figures 6.23-6.26).

Tool weight is the dimension that is most affected by the scale of the source-to-site transports. Maximum weight figures decrease exponentially to increasing distance. The heaviest artefacts are included in the Bodrogkeresztúr assemblage which is located the shortest distance from an obsidian source. Subalyuk, located the second shortest distance from a source, has the second heavier artefacts in its assemblage. Similarly, Ballavölgyi and Pilismarót-Diós exhibit further reduced values in terms of maximum artefact weight. However, 100 km seem to be a threshold as despite their large kilometrical difference the two last sites fall within the same maximum weight class.

Thickness is the second dimension most intensively affected by the scale of movement. The maximum thickness values are associated with the shortest source-to-site distances and they gradually decrease as the distance increases. The Bodrogkeresztúr assemblage encompasses the thickest obsidian artefacts followed by Subalyuk, Pilismarót-Diós and finally Ballavölgyi. The fact that Pilismarót-Diós shows the same thickness range as Subalyuk despite their 43 km difference suggests that the ~60-100 km radius is a spatial unit within whose sub-units changes are not dramatic.

The same conclusion was reached by the analysis of the remaining two tool dimensions, namely maximum length and width. These attributes seem to be more dependent on the chosen technological industry than the source-to-site distance. Nevertheless, some connection between the scale of movement and maximum length-width has been observed when short and long distances are taken into account. The longest and widest obsidian artefacts are found in Bodrogkeresztúr, the site with the shortest distance from its source. Despite the fact that any clear patterns between medium distance sites, i.e. Subalyuk and Pilismarót-Diós (~60-100 km), are hard to discern the same cannot be argued for Ballavölgyi. It is in this site that the smallest artefacts have been identified; a result clearly associated with the site's long distance, >200 km, from its nearest source.

Length	**Bodrogkeresztúr** (7 km)	**Subalyuk** (64 km)	**Ballavölgyi** (107 km)	**Pilismarót-Diós** (204 km)
10-20 mm		1		1
20-30 mm	39	5	3	3
30-40 mm	60	4	2	2
40-50 mm	22			1
50-60 mm	2			
60-70 mm	2			
80-90 mm				

Table 6.26. Length distribution of the analysed obsidian artefacts in the four obsidian-bearing Hungarian sites.

Width	**Bodrogkeresztúr** (7 km)	**Subalyuk** (64 km)	**Ballavölgyi** (107 km)	**Pilismarót-Diós** (204 km)
1-10 mm	8			
10-20 mm	44	2	3	4
20-30 mm	56	2	2	3
30-40 mm	26			1
40-50 mm	3	2		
50-60 mm				
60-70 mm				
80-90 mm		1		

Table 6.27. Width distribution of the analysed obsidian artefacts in the four obsidian-bearing Hungarian sites.

Thickness	**Bodrogkeresztúr** (7 km)	**Subalyuk** (64 km)	**Ballavölgyi** (107 km)	**Pilismarót-Diós** (204 km)
1-5 mm	38	7		2
5-10 mm	33	3	5	3
10-15 mm	18	2		2
15-20 mm	22	1		1
20-25 mm	16			
25-30 mm	11			
30-35 mm	1			

Table 6.28. Thickness distribution of the analysed obsidian artefacts in the four obsidian-bearing Hungarian sites.

Weight	**Bodrogkeresztúr** (7 km)	**Subalyuk** (64 km)	**Ballavölgyi** (107 km)	**Pilismarót-Diós** (204 km)
1-10 gr	52	4	4	5
10-20 gr	40	2	1	2
20-30 gr	22			
30-40 gr	4	1		
40-50 gr	1			
50-60 gr	3			
60-70 gr	2			

Table 6.29. Weight distribution of the analysed obsidian artefacts in the four obsidian-bearing Hungarian sites.

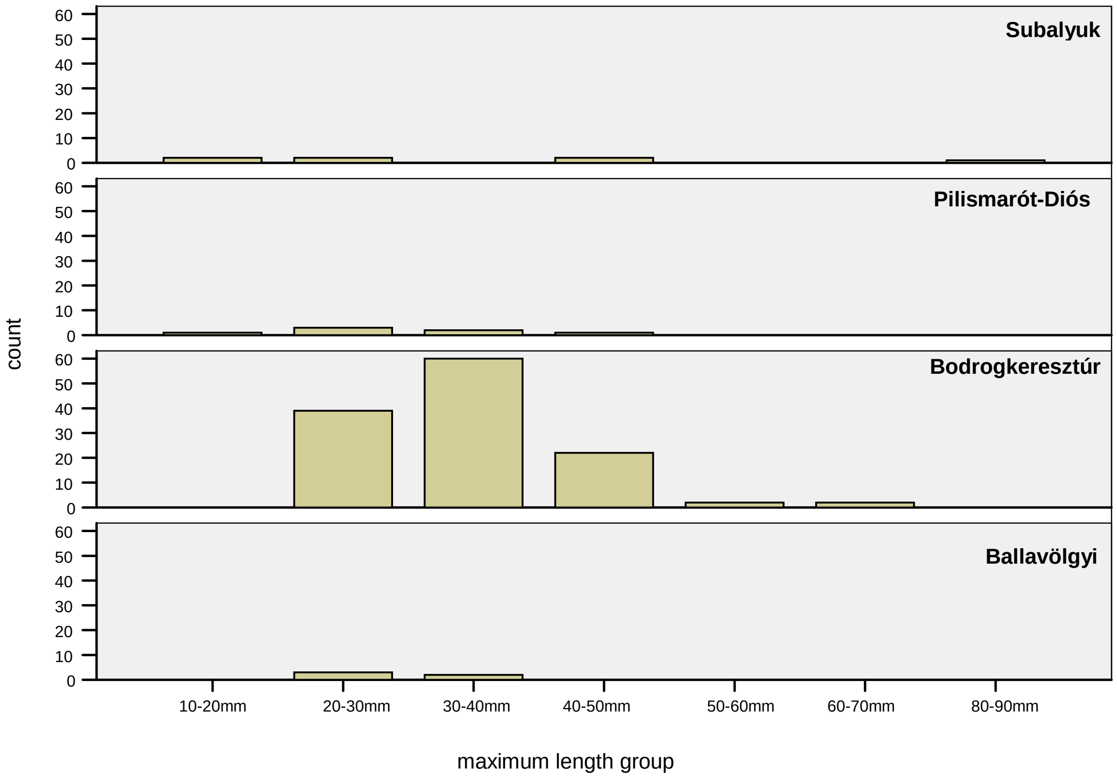


Figure 6.23. Range of maximum lengths recorded in the four analysed obsidian assemblages.

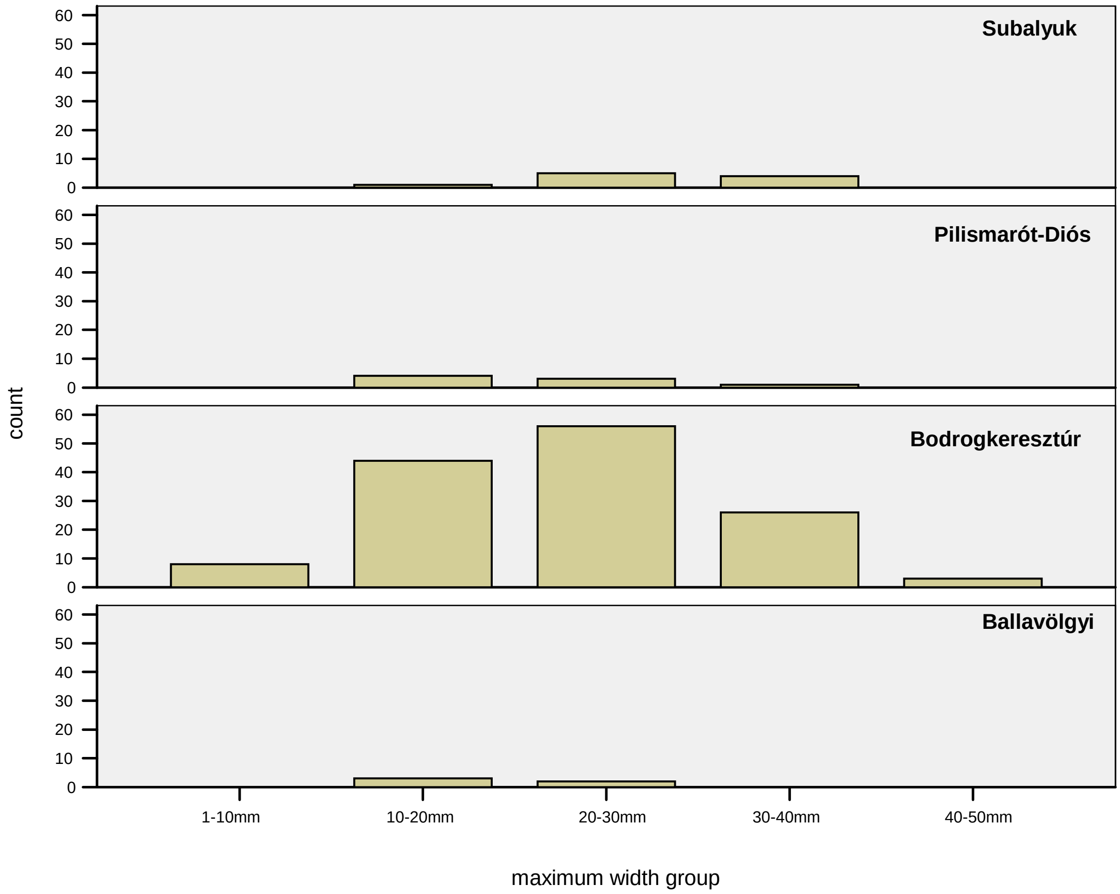


Figure 6.24. Range of maximum widths recorded in the four analysed obsidian assemblages.

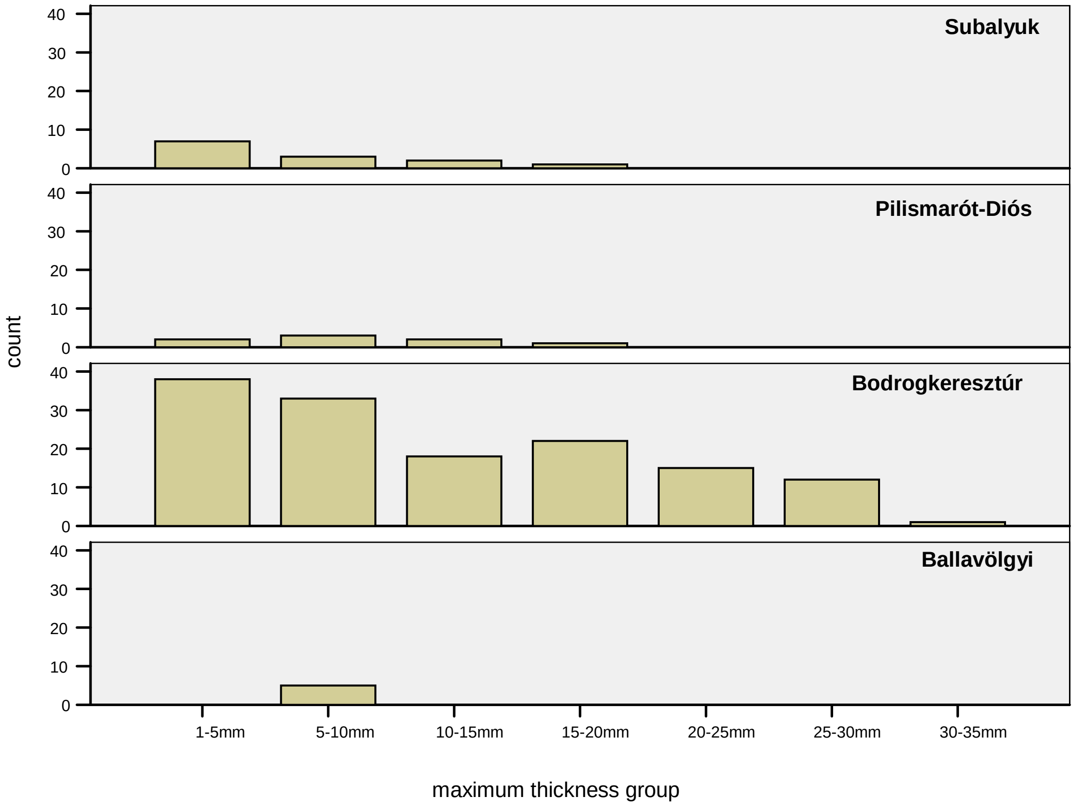


Figure 6.25. Range of maximum thicknesses recorded in the four analysed obsidian assemblages.

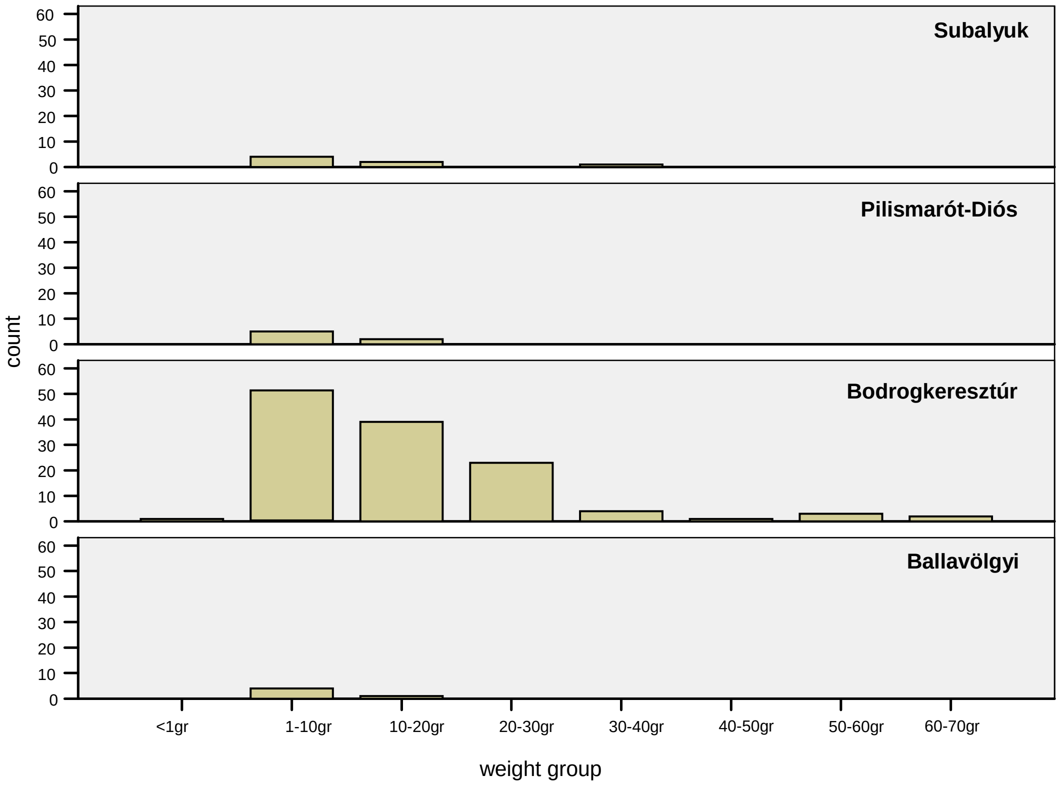


Figure 6.26. Graph illustrating the weight classes recorded in the four analysed obsidian assemblages.

Technological issues, in particular cortex and retouch, need to be addressed in association with distance and in a comparative manner in order to examine the extent of this attribute's effect on the formation of obsidian assemblages.

The analysis of the respective data from the four sites under examination has established a strong correlation between distance, the numbers of cortical pieces present in an assemblage and the extent of cortex on their surfaces (tables 6.30-6.32 and figures 6.27-6.29).

Cortex extent is directly and strongly affected by circulation distances in an inversely correlated mode: cortex percentages decrease as the source-to-site distance increases. The majority of cortical pieces have been recovered from the site with the shortest, i.e. <10 km, distance from its source (Bodrogkeresztúr). Furthermore, in the Bodrogkeresztúr artefacts the extent of cortex is the greatest with several examples exhibiting over 50%, and occasionally reaching even 100%, cortex coverage. The number of cortical specimens and the extent of cortex decreases substantially in assemblages located a medium distance from a source, i.e. ~60-100 km, as the Subalyuk and Ballavölgyi data suggest. The respective values reach their lowest limits in assemblages associated with the longest source-to-site distances. The lithic assemblage of Pilismarót-Diós, a site located >200 km from its nearest source, comprises of the smallest numbers of obsidian artefacts which, furthermore, have minimal cortex coverage.

The position of cortex on the relevant artefacts (cortical débitage and small retouched tools) points to the same patterns. Fully cortical platforms, indicative of initial reduction stages, have only been recorded in Bodrogkeresztúr, suggesting a strong relation between such implements and short source-to-site distance. Furthermore, artefacts with partially cortical platforms are most abundant in assemblages from sites near the supplying source (Bodrogkeresztúr) and their quantities decline with increasing distance (Subalyuk and Ballavölgyi), before completely disappearing from long distance assemblages (Pilismarót-Diós). Cortical platforms, suggesting a primary manufacture stage, are more numerous in assemblages located a short source-to-site distance and they gradually decrease in quantity as the distance increases.

Cortex extent	Bodrogkeresztúr	Subalyuk	Ballavölgyi	Pilismarót-Diós
0%	41	4	5	4
0-25%	22	1		
25-50%	24			2
50-75%	16	1		
75-100%	18	1		1
100%	2			
Total	**123**	**7**	**5**	**7**

Table 6.30. Cortex extent in the Bodrogkeresztúr, Subalyuk, Ballavölgyi and Pilismarót-Diós obsidian artefacts.

Cortex position	Bodrogkeresztúr	Subalyuk	Ballavölgyi	Pilismarót-Diós
cortical butt&100%dorsal	3			
cortical butt&partial dorsal	7	2		2
non-cortical butt&100%dorsal	4			
non-cortical butt&partial dorsal	18	1		
non-cortical butt&0%dorsal	33	4	5	4
Total	**65**	**7**	**5**	**6**

Table 6.31. Cortex position, in the Bodrogkeresztúr, Subalyuk, Ballavölgyi and Pilismarót-Diós obsidian artefacts.

Platform type 1	Bodrogkeresztúr	Subalyuk	Ballavölgyi	Pilismarót-Diós	**Total**
non-cortical	50	8	3	4	**65**
partially cortical	1				**1**
fully cortical	8			2	**2**
Total	**59**	**8**	**3**	**6**	**68**

Table 6.32. Platform type distribution in Bodrogkeresztúr, Subalyuk, Ballavölgyi and Pilismarót-Diós respectively.

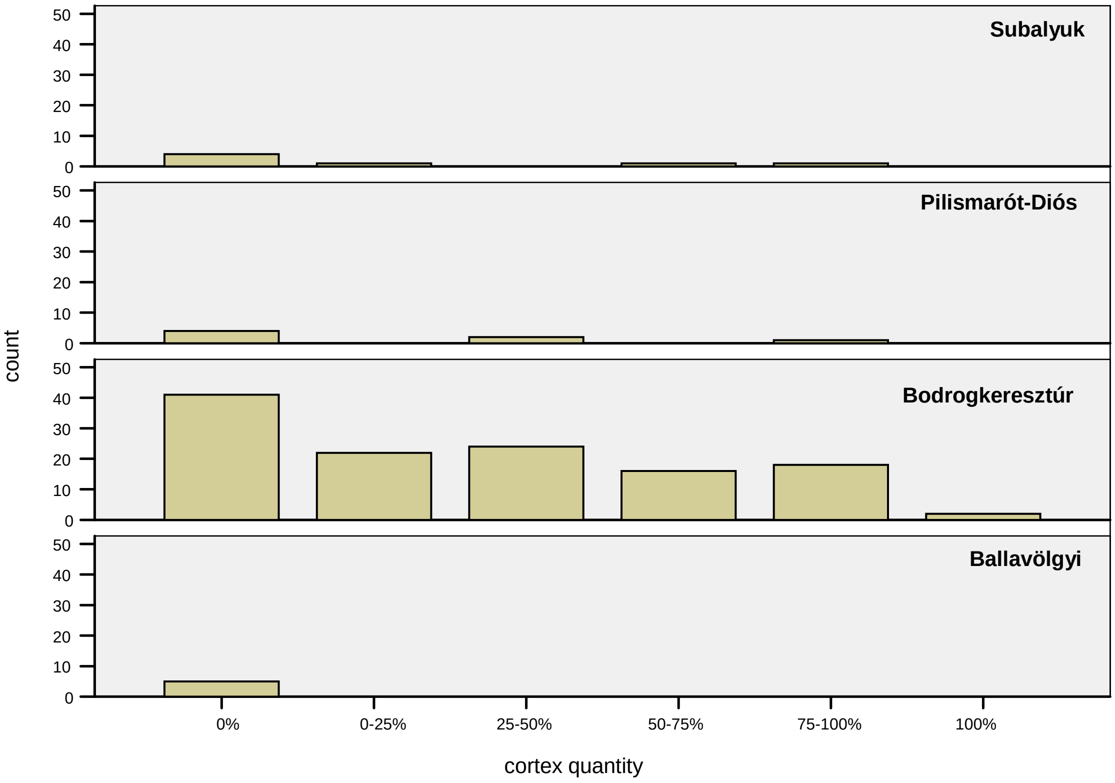


Figure 6.27. Distribution of cortex extent classes in the four examined obsidian assemblages.

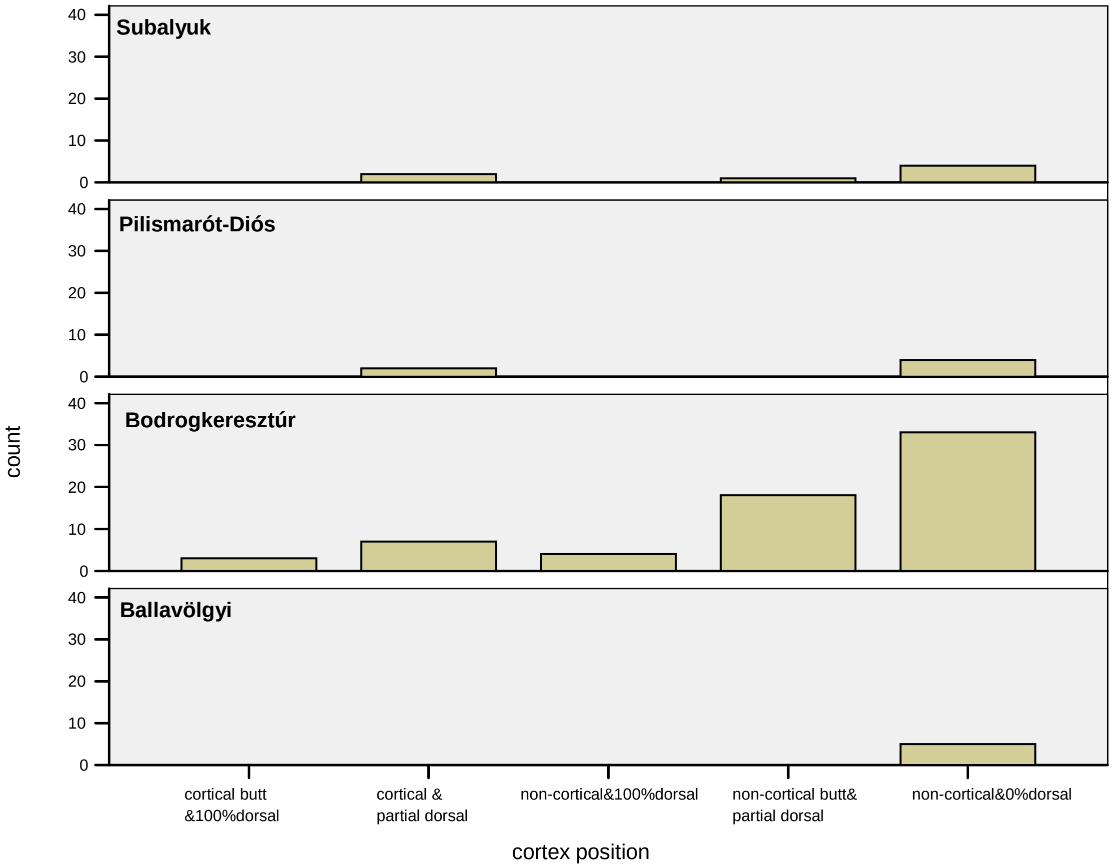


Figure 6.28. Distribution of cortex position classes in the four obsidian assemblages under investigation.

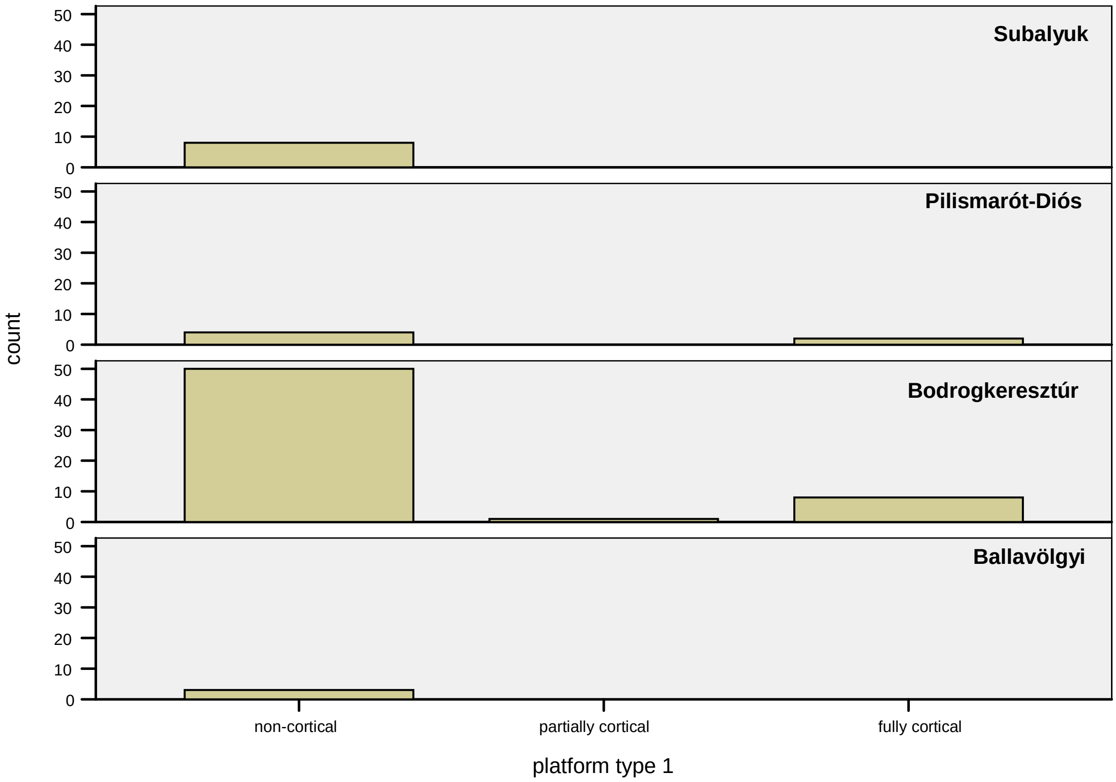


Figure 6.29. Graph illustrating the frequencies of platform types in each of the examined obsidian assemblages.

A strong correlation underlies the relationship between retouch and source-to-site distance according to the results of the respective analysis (tables 6.33-6.35 and figures 6.30-6.32). Specifically, the extent of retouch is affected by the scale of raw material movement. Most classes are represented in each of the four examined assemblages but their percentages change similarly to the changes on the source-to-site distances. Short retouch is most abundant in Bodrogkeresztúr, i.e. within a <10 km radius, and it is completely lacking in assemblages with long, i.e. >200 km, source-to-site distances (e.g. Pilismarót-Diós). Additionally, more extensively retouched artefacts (long, invasive and covering retouch classes) become more common as the source-to-site distance increases.

The examination of the retouch position with respect to distance suggests some degree of relation between the two attributes although conclusive evidence associating the two features could not be demonstrated. With regards to retouch position 1 no patterns connecting either direct or alternate retouch with certain spatial units have been discerned. In all the obsidian assemblages under investigation «direct» is the chosen technique for retouch irrespectively of the sites' distances from their sources. A stronger connection exists between distance and retouch position 2. According to the analysed data the assemblages located over 100 km, exhibit retouch that extends to more than one tool sides. Despite the fact that categories combining more than one retouched sides are present in sites <65 and even <10 km from a source, they are the only classes dominating in distances greater than the above values.

Similarly, platform type 2 is affected by distance by means of more retouch scars on the platforms of the longest transported artefacts (table 6.36 and figure 6.33). In assemblages near a source, i.e. <10 km, all the types are represented (e.g. Bodrogkeresztúr) although simpler forms dominate. However, as the distance increases so do the numbers of removals (retouch scars) on the tools' platforms, for example compare Pilismarót-Diós and Subalyuk.

Retouch extent	Bodrogkeresztúr	Subalyuk	Ballavölgyi	Pilismarót-Diós	**Total**
Short	26	1	1		**28**
Long	13	3	5	1	**22**
Invasive	2				**2**
Covering		1			**1**
Total	**41**	**5**	**6**	**1**	**53**

Table 6.33. Retouch extent on the obsidian artefacts examined from the Bodrogkeresztúr, Subalyuk, Ballavölgyi and Pilismarót-Diós obsidian assemblages.

Retouch position 1	Bodrogkeresztúr	Subalyuk	Ballavölgyi	Pilismarót-Diós	**Total**
Direct	41	5	5	1	**52**
Alternate			1		**1**
Total	**41**	**5**	**6**	**1**	**53**

Table 6.34. Retouch position 1 on the obsidian artefacts examined from the Bodrogkeresztúr, Subalyuk, Ballavölgyi and Pilismarót-Diós obsidian assemblages.

Retouch position 2	Bodrogkeresztúr	Subalyuk	Ballavölgyi	Pilismarót-Diós	**Total**
Left	5	1			**6**
Distal	16				**15**
Right	9		2		**11**
Proximal	1				**1**
left & right	3				**3**
left & distal	1	2			**3**
right & distal	2	1	1		**4**
Circular	4	1	3	1	**9**
Total	**41**	**5**	**6**	**1**	**53**

Table 6.35. Retouch position 2 on the obsidian artefacts examined from the Bodrogkeresztúr, Subalyuk, Ballavölgyi and Pilismarót-Diós obsidian assemblages.

Platform type 2	Bodrogkeresztúr	Subalyuk	Ballavölgyi	Pilismarót-Diós	**Total**
Cortical	8			1	**9**
plain	19	5		2	**26**
Facetted	17	3	3	1	**24**
Linear	9			1	**10**
indetermined	6			1	**7**
Total	**59**	**8**	**3**	**6**	**76**

Table 6.36. Platform types distribution in Bodrogkeresztúr, Subalyuk, Ballavölgyi and Pilismarót-Diós respectively.

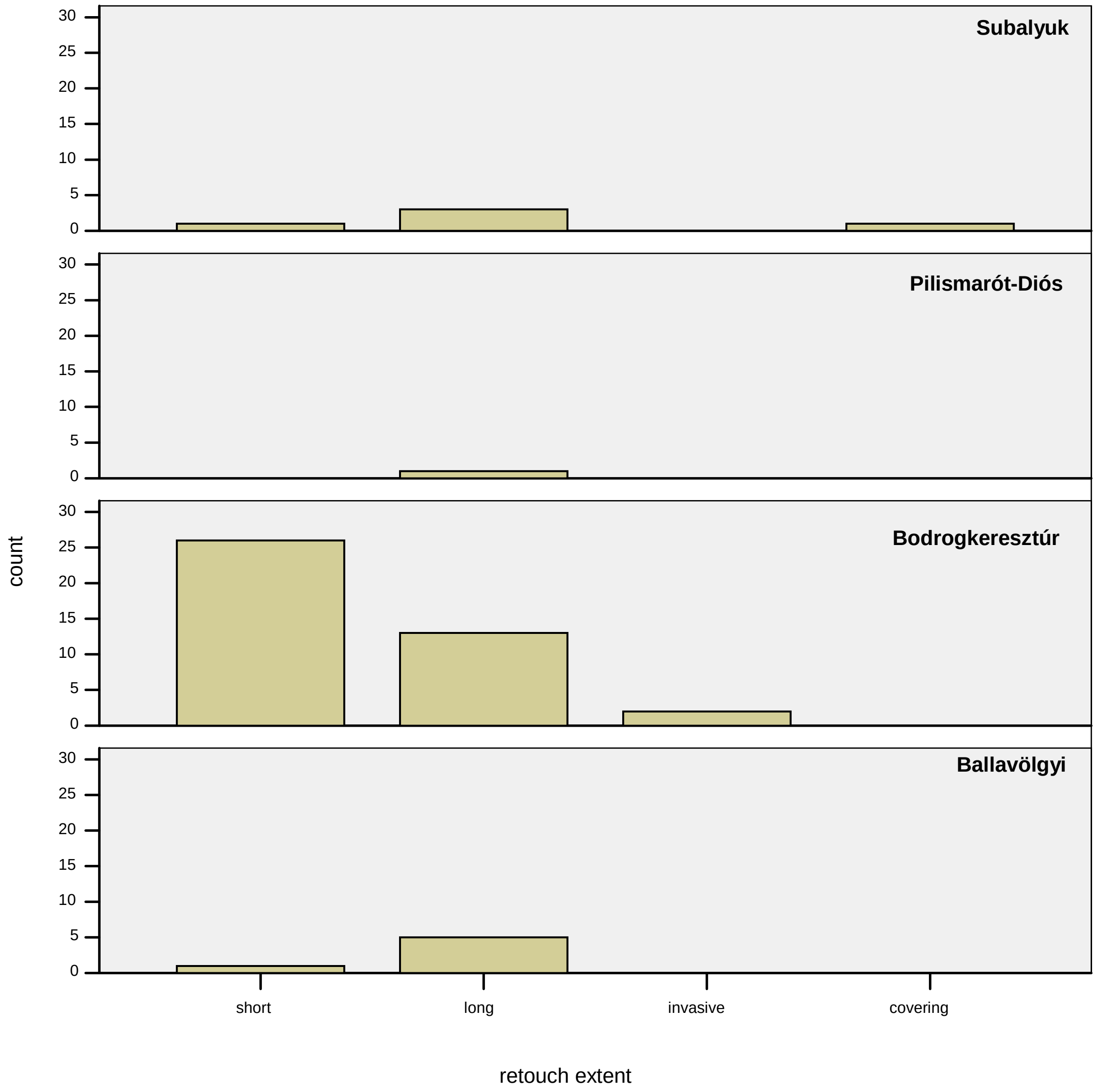


Figure 6.30. Illustration of the extent with which retouch appears in each of the four analysed assemblages.

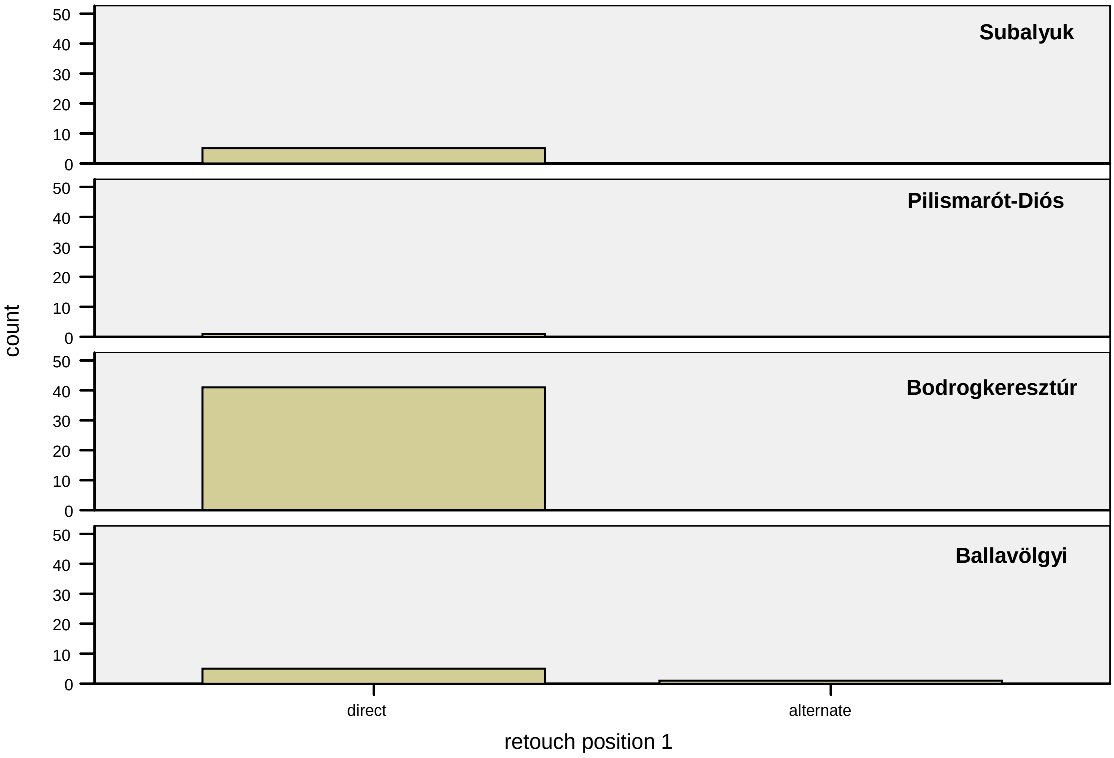


Figure 6.31. Graphic presentation of retouch position classes (retouch position 1) and their frequencies in each of the analysed assemblages.

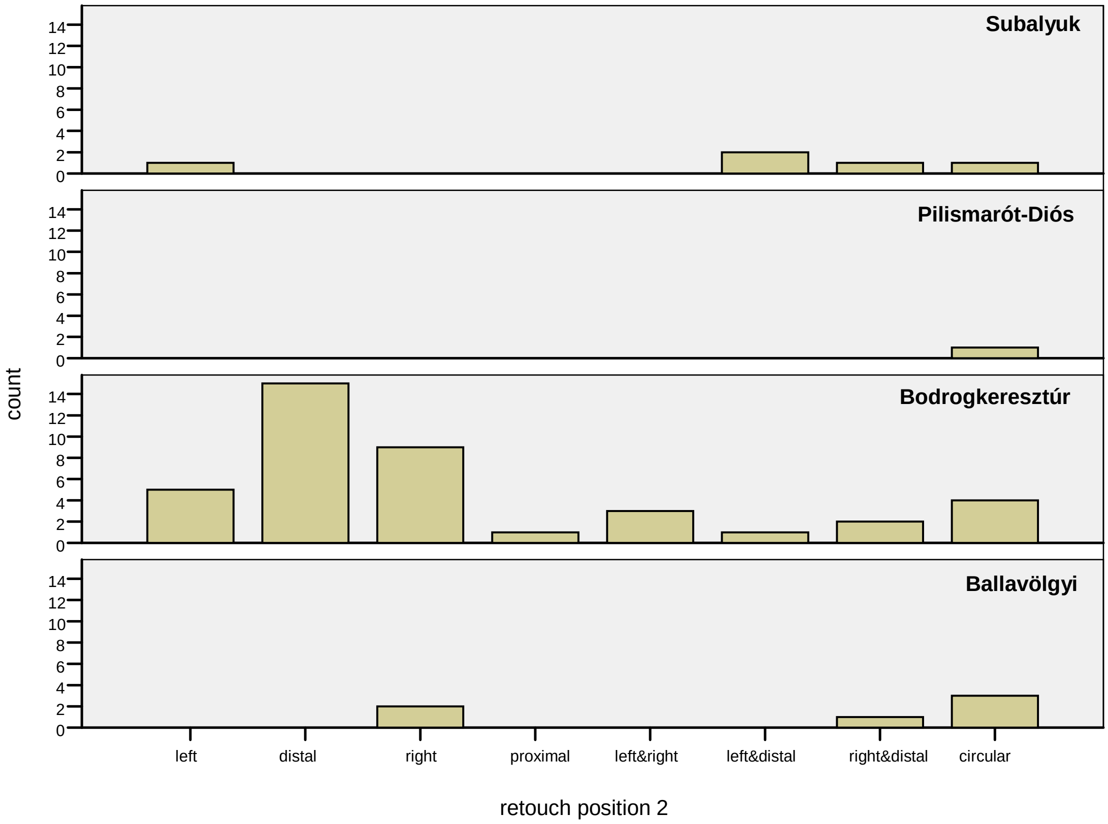


Figure 6.32. Graphic presentation of retouch position classes (retouch position 2) and their frequencies in each of the analysed assemblages.

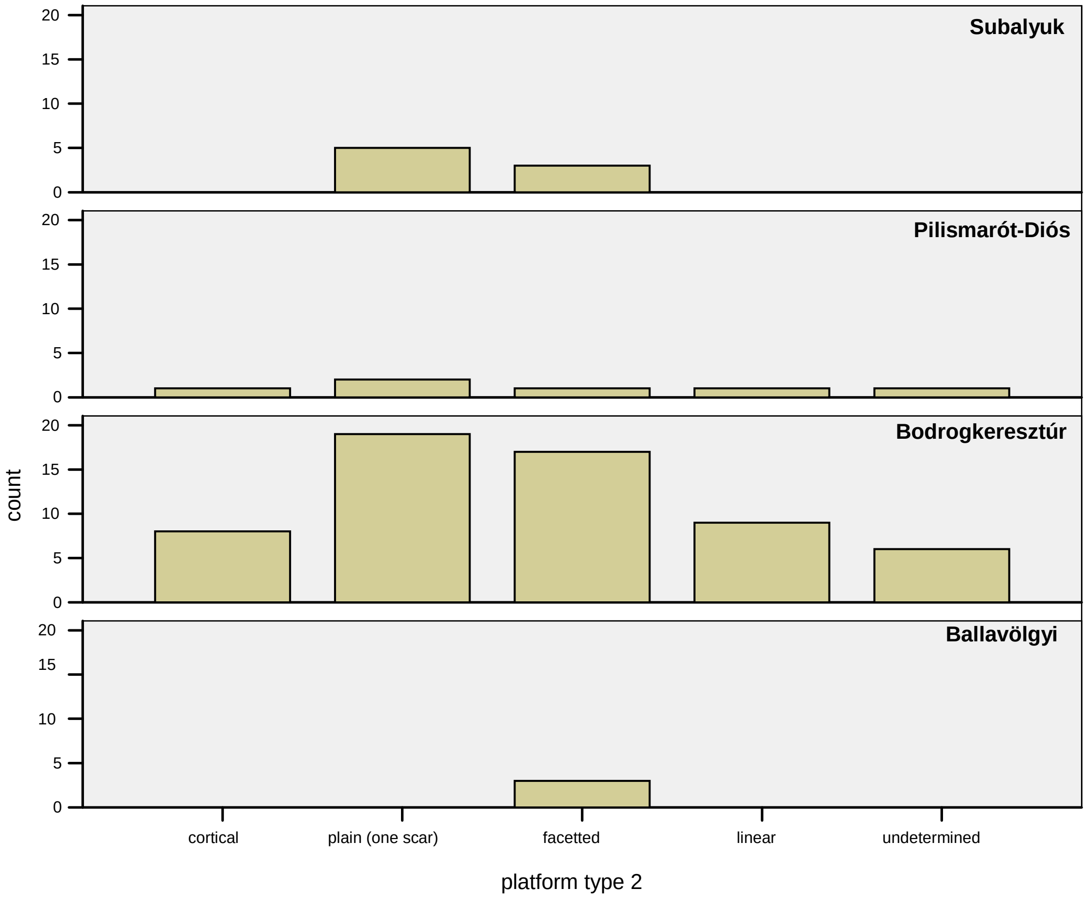


Figure 6 33. Graph illustrating the frequencies of platform types in each of the examined obsidian assemblages.

5. SUMMARY

This chapter has focused on the upper Palaeolithic European site of Bodrogkeresztúr and the Middle Stone Age African site of GtJi15 and provided information on their topography, stratigraphy, environmental and research history. Particular emphasis was placed on presenting their lithic assemblages, to the extent the available information allowed to do so, and describing the obsidian artefacts using the basic parameters included in any lithic analysis (size, cortex, retouch). By doing so the regional scale effect of region and period in the use of obsidian can be evaluated and the emerging patterns satisfactorily explained. Finally, the precedence of distance as a critical factor in the formation of obsidian assemblages was identified in the comparative analysis of sites differing in their regional and temporal context but similar in their site-to-source distances.

Chapter 7

Data Analysis

1. INTRODUCTION

In chapter 6 I identified distance as the primary factor controlling the formation of obsidian assemblages. The effect of distance from a global perspective on obsidian movement will be addressed in this chapter in order to evaluate the validity of this observation on a macro-scale level of the archaeological record. The first section begins with a presentation of the source-to-site distances recorded in each of this project's three regions and sub-phases of the Palaeolithic. Then, the typological and technological patterns of the obsidian use are examined in association to obsidian circulation distances before the discussion turns to more traditional exploratory means, namely climatic cycles and latitude. In the final section of this chapter, an evaluation of the six hypotheses presented in chapter 1 will take place.

2. ANALYSIS OF OBSIDIAN USE BY PALAEOLITHIC PERIOD AND INDUSTRY

In order to satisfactorily understand the patterns underlying obsidian use, the quantitative, typological and technological parameters of the recorded Palaeolithic assemblages must be taken into account. The analysis will deal with each Palaeolithic period individually and examine how the use of obsidian alters from the Lower to the Upper Palaeolithic African and European industries.

Minor (1-10%) and extremely large (90-100%) obsidian quantities are the most commonly encountered classes when the dataset is taken as a whole. Furthermore, these two classes remain the most numerous in each individual region and during each of the three Palaeolithic sub-phases. On the contrary, the remaining identified classes undergo a number of changes with regards to region and time (table 7.1).

In Africa, obsidian is most often found in small quantities during the Earlier Stone Age and under no circumstances does it comprise more than the 50% of the total lithic assemblage (one case of «frequent», i.e. 30-50%). This picture alters in the Middle Stone Age when percentages over 50% are recorded for the first time and an overall increase in the quantitative range in which obsidian enters the Palaeolithic record is observed. Additionally, it is during this period that obsidian is the dominant (90-100%) raw material in a lithic assemblage for the first time. In the Later Stone Age the number of classes is reduced from five to four with the «frequent» class totally lacking; however, the broad pattern is similar to that seen in the Middle Stone Age.

In Central & South-eastern Europe obsidian makes its initial appearance in Palaeolithic sites dating to the Middle Palaeolithic in frequencies that are clustered in the «minor» class. Small quantities (1-10%) constitute the most commonly encountered class on the European landscape with 7 examples whilst the only other recorded class is «all» with 2 examples. A substantial increase in the variety of frequency classes characterises the Upper Palaeolithic when all the quantitative categories are represented. The «minor» class remains the most dominant category during this period with 32 examples, 25 more than what was observed for the Middle Palaeolithic.

In the Near East obsidian is equally represented by small («minor») and large («all») quantities in Lower Palaeolithic assemblages whereas the single other identified category is associated with obsidian percentages >50%. The same picture characterises the Middle Palaeolithic, the only difference being the number of examples that fall into the «minor» class that are more numerous (9) at this phase than the preceding one (3). Contrary to the previous periods, the Upper Palaeolithic exhibits a substantial decrease in the quantitative classes in which obsidian is found in the Near East (3 classes in Lower and Middle Palaeolithic; only 1 in the Upper Palaeolithic). All the obsidian transports fall within the «minor» class and no other categories are represented in the record of this period. However, no changes occur with regards to this specific group as the number of examples that was recorded from the Middle Palaeolithic remains constant during the Upper Palaeolithic too (9 examples each).

	East Africa				Central & Southern-eastern Europe			Near East			
	ESA	MSA	LSA	**Total**	MP	UP	**Total**	LP	MP	UP	**Total**
minor (1-10%)	8	8	8	**24**	7	32	**39**	3	9	9	**21**
moderate (10-30%)	1	3	2	**6**		2	**2**				
frequent (30-50%)	1	2		**3**		1	**1**				
majority (50-90%)		4	1	**5**		1	**1**	1	1		**2**
all (90-100%)		5	2	**7**	2	1	**3**	3	3		**6**
not specified		5	2	**7**	1	3	**4**		3	1	**4**
Total	**10**	**27**	**15**	**52**	**10**	**40**	**50**	**7**	**16**	**10**	**33**

Table 7.1. Distribution of the various frequency classes in time and space.

Obsidian assemblages enter the Palaeolithic archaeological record in two main forms: either as groups of small retouched tools (SRT) or as groups encompassing all the types associated with the manufacture of lithic tools. Nodules and blanks are extremely rare whilst debris or unretouched flakes/blades are not especially common either (table 7.2).

In East Africa, all but the debris typological class is present during the Earlier Stone Age; however, there is a clear preference over small retouched tools or assemblages with the complete set of tool types. In the Middle Stone Age the number of obsidian tool classes decreases slightly; the «débitage» and «nodule» categories are totally absent at this period although representative examples were present during the Earlier Stone Age. This decrease in typological variability is followed by an increase in the number of cases for each of the represented categories. This is particularly true for the small retouched tools class which is also the most popular group throughout the Middle Stone Age. The same picture characterises the Later Stone Age use of obsidian in East Africa. The typological classes that were present in the previous period are also present in the Later Stone Age but with a substantial decrease in the numbers of cases representing each one of them.

In Central & South-eastern Europe the Middle Palaeolithic exploitation of obsidian has only generated instances of complete tool sequences and small retouched tools («SRT»). Tool kits that exhibit the whole typological range of specimens are most commonly encountered on the archaeological record of this period. During the Upper Palaeolithic the same two classes retain their popularity with even more examples representing each one of them. Furthermore, an additional class («debris») makes its appearance at this stage. However, as with the previous phase, the «all» category is the most frequently encountered typological class in the Upper Palaeolithic as well.

In the Near East the Lower Palaeolithic use of obsidian is represented by assemblages that comprise either of solely small retouched tools or complete typological sequences. The second class is the most common but only slightly so. During the Middle Palaeolithic an additional tool type class appears on the record. Specifically, the «débitage» group which was previously absent is now for the first time represented in the Near Eastern region. The «small retouched tools» class becomes at this stage the most numerous typological category. The same classes are associated with the Upper Palaeolithic record although in percentages that differ from those of the previous period. Now «débitage» is the most popular class and both small retouched tools and all products groups are represented by fewer examples than before.

	East Africa			Central & South-eastern Europe		Near East		
	ESA/ LP	MSA/ MP	LSA/ UP	MSA/MP	LSA/UP	ESA/LP	MSA/MP	LSA/UP
debitage (flakes, blades)	1						2	4
SRT/LCT	4	9	1	2	6	3	6	2
nodule/ blank	1							
debris/ waste		1	1		2			
all products	2	8	6	8	14	4	4	1
not specified	2	9	7	1	17		4	3

Table 7.2. General typological classes identified in each of the regions under investigation and separated according to Palaeolithic sub-phase.

In an attempt to develop a more comprehensive perception of the information provided by the typological data, the relevant information was classified using the chaîne opératoire concept. This method was employed in accordance to Davidson & Noble's (1993) «fallacy of the finished object», which posits that archaeologists cannot assume that the final shape of a stone tool was its intended shape, and the recognition of the diminishing value of tool typologies in elucidating cognitive/behavioural issues of the people of the past other than the possible functions of those tools. The tool types were transformed into tool production stages and they were taken to represent certain phases within an operational sequence of tool manufacture rather than just tool classes (Sellet 1993). Such an approach was chosen as it allows a more behaviourally-oriented interpretation of the patterns underlying obsidian use and it is considered as a more likely candidate in revealing the degree of connection between raw material use and spatial coverage (distance of movement).

Translated into stages in a tool production chaîne opératoire, the data indicate that obsidian enters the Palaeolithic sites of Africa, Europe and the Near East mainly as either completely modified specimens (retouched tools) to be used/discarded or in a very rough form in order to undergo the full range of modification on site. Overall, the most frequently encountered phase in obsidian tool manufacture is the final one, when a tool has already acquired its intended (for the task it was originally created) form and fulfilled the reasons for its original conception (table 7.3).

In East Africa the Earlier Stone Age horizons are occasionally (1 example) associated with the early stage of raw material procurement (nodules) although the commonest identified stage is the final stage of the lithic manufacture, namely the use/discard of retouched tools. This stage remains the most popular during the Middle Palaeolithic too with even more examples falling in the certain group. At this time, obsidian assemblages representing complete operational sequences or the first phase of secondary reduction (flakes/blades, small retouched tools) make their initial appearance. In the Later Stone Age, the same stages are present although their ratios change. In this last phase of the African Palaeolithic complete operational sequences are the most frequently encountered groups.

In Middle Palaeolithic Central & South-eastern Europe apart from instances of complete sequences, only examples associated with secondary reduction and use of retouched tools (stage 4) have been recorded. The first category is the most numerous during this period and it remains so during the Upper Palaeolithic. Evidence for primary reduction also appears for the first time in the Upper Palaeolithic but secondary reduction stages and complete manufacture sequences continue to dominate the European dataset with increased numbers of cases compared to the previous period.

In the Near East, obsidian is found in Lower Palaeolithic cultural horizons in association either with assemblages including the complete set of manufacture stages or the final stage of tool use/discard. Complete sequences are the most frequent cases at this period. Nevertheless, examples of this category are totally lacking from the Middle Palaeolithic dataset. At this period only the two secondary reduction stages are represented with the majority of the recorded examples falling into the last stage (use/discard of retouched tools). In the Upper Palaeolithic, this category shows a substantial quantitative decrease. Flakes/blades and small retouched tools (stage 2) are the most numerous class now. Complete sequences reappear during this period but they are far less common than they were during the Middle Palaeolithic.

	East Africa				Central & South-eastern Europe			Near East			
	ESA	MSA	LSA	**Total**	MP	UP	**Total**	LP	MP	UP	**Total**
stage 1/raw material procurement	1			**1**							
stage 3/secondary reduction	2	1	2	**5**		2	**2**		1	4	**5**
stage 4/secondary reduction 2 & use-discard of tools	4	9		**13**	2	5	**7**	3	7	2	**12**
all stages/ complete sequence	2	8	6	**16**	7	16	**23**	4	4	1	**9**
not specified	1	9	7	**17**	1	17	**18**		4	3	**7**
Total	**10**	**27**	**15**	**52**	**10**	**40**	**50**	**7**	**16**	**10**	**33**

Table 7.3. Operational sequence stages of obsidian assemblages divided among regions and Palaeolithic sub-phases.

3. ANALYSIS OF THE EFFECT OF DISTANCE ON THE DISTRIBUTION AND FORMATION OF OBSIDIAN ASSEMBLAGES

During the case studies analysis distance was identified as the leading cause for the patterns of the examined obsidian assemblages. Distance will now be analysed on a world-wide scale and encompassing all the recorded obsidian-bearing Palaeolithic sites in order to investigate its manifestation and control from a global perspective.

In East Africa, obsidian covers substantial circulation areas from very early in the Palaeolithic; however, the recorded distances do not seem to follow a patterned manner with regards to their upper limit (tables 7.4 and 7.5). Specifically, the lower-upper spatial limits (1 and >200 km respectively) remain the same throughout the Palaeolithic and it is only within this range that changes occur with regards to time. In the Earlier Stone Age obsidian is mainly confined to territories near the utilised obsidian sources. Distances <40 km have been recorded although the majority of cases is associated with figures much smaller than this, i.e. 1-10 km. The upper circulation limits for the Earlier Stone Age exceed 100 km but this result should be dealt with caution given the early dates of the respective sites (~1.5 Myr for Gadeb, ~1.6 Myr for Olduvai Gorge: HWK-East). Olduvai Gorge must be dealt with particular care as the obsidian specimens identified on site are manuports (Leakey 1971) whose transportation by natural means cannot be ruled out. In the Middle Stone Age, the lower and upper obsidian circulation boundaries remain the same but there is a greater variability within those limits. Obsidian is found in areas spanning the whole 1 - <200 km spectrum although two peak points can be identified. 1-10 km and 70-80 km are the two most abundant classes during the Middle Stone Age with the first class being the most numerous one. In the Later Stone Age lower and upper circulation distances do not change but the within variability range is reduced resulting in a picture similar to that of the Earlier Stone Age. The 1-10 km class remains the most abundant one during the Later Stone Age resembling the picture generated from the two previous periods (figures 7.1 and 7.2).

In Central and South-eastern Europe obsidian circulation exhibits a wide spatial coverage that is similar both in the Middle and Upper Palaeolithic (tables 7.4 and 7.5). In the Middle Palaeolithic obsidian covers distances ranging from 10 to >200 km with examples in most of the set classes. Overall, a cluster at 50-100 km is observed for this period with 60-70 km being the most numerous class although it is very closely followed by examples in the >100 km and 40-50 km classes. In the Upper Palaeolithic the within range variability is even greater. However, the upper and lower limits of this range are similar to those of the Middle Palaeolithic (1 to >200 km). Very short distances, i.e. 1-10 km, are observed for the first time and medium distances become more frequent. The major change occurs in the upper boundary as a clear dominance of the >200 km class characterises this period. Moreover, distances >300 km and >400 km are recorded for the first time and represented by several examples for each case (figures 7.1 and 7.2).

The Near Eastern data generate a perception similar to that of Europe with distances that indicate a spatially broad circulation of obsidian during the Palaeolithic (tables 7.4 and 7.5). A gap between the 50 to 90 km ranges is observed throughout this period with no examples falling within those limits. The Lower Palaeolithic distances of obsidian movement follow a patchy norm that does not permit any clear patterns to emerge. During this period, obsidian seems restricted within an area of ≤60 km. The recorded cases fall within 1-30 km, 50-60 km and >100 km but none of these classes is substantially more abundant than the other represented categories. The 1-50 km class remains the most highly represented category in the Middle Palaeolithic but now more examples fall within its upper limits than before. Several instances of >100 km obsidian distances have also been recorded and cases reaching 250 km make their initial appearance. In the Upper Palaeolithic short distances are totally absent from the Near Eastern record. During this period only the >100 and >200 km classes seem to be associated with the obsidian circulation in the Near East. Furthermore, the longest distance class (>200 km) is the most abundant represented mainly by examples from the 350-400 km category (figures 7.1 and 7.2).

	East Africa				Central & South-eastern Europe			Near East			
	ESA	MSA	LSA	**Total**	MP	UP	**Total**	LP	MP	UP	**Total**
1-10 km	5	9	5	**19**		4	**4**	2	2		**4**
10-20 km		1	1	**2**	1	1	**2**	1	2		**3**
20-30 km	2	3	1	**6**		2	**2**	1	1		**2**
30-40 km	1	2	3	**6**		2	**2**		1		**1**
40-50 km		2	3	**5**	2	4	**6**		3		**3**
50-60 km		1		**1**		3	**3**	1	3		**4**
60-70 km					3		**3**				
70-80 km		6		**6**	1	1	**2**				
80-90 km		1		**1**		1	**1**				
>100 km	2	2	2	**6**	2	3	**5**	2	3	4	**9**
>200 km					1	19	**20**		1	6	**7**
Total	**10**	**27**	**15**	**52**	**10**	**40**	**50**	**7**	**16**	**10**	**33**

Table 7.4. Group distances classified according to their regional and temporal framework and presented in 10 km intervals.

	East Africa				Central & South-eastern Europe			Near East			
	ESA	MSA	LSA	**Total**	MP	UP	**Total**	LP	MP	UP	**Total**
1-50 km	8	17	13	**38**	3	13	**16**	4	9		**13**
50-100 km		8		**8**	4	5	**9**	1	3		**4**
100-150 km		1		**1**	1	2	**3**	2	1	4	**7**
150-200 km	2	1	2	**5**	1	1	**2**		2		**2**
200-250 km						6	**6**		1	2	**3**
250-300 km					1	1	**2**				
300-350 km						3	**3**				
350-400 km						3	**3**			4	**4**
>400 km						6	**6**				
Total	**10**	**27**	**15**	**52**	**10**	**40**	**50**	**7**	**16**	**10**	**33**

Table 7.5. Group distances classified according to their regional and temporal framework and presented in 50 km intervals.

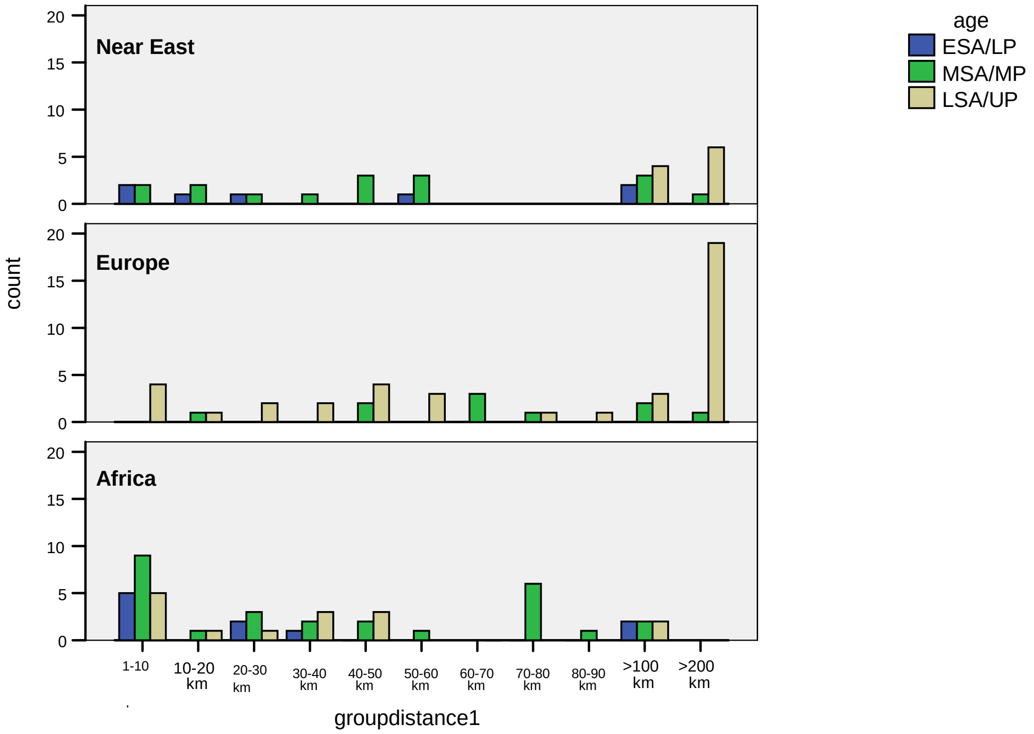


Figure 7.1. Graphic presentation of the recorded distance classes separated according to age and region in 10km intervals.

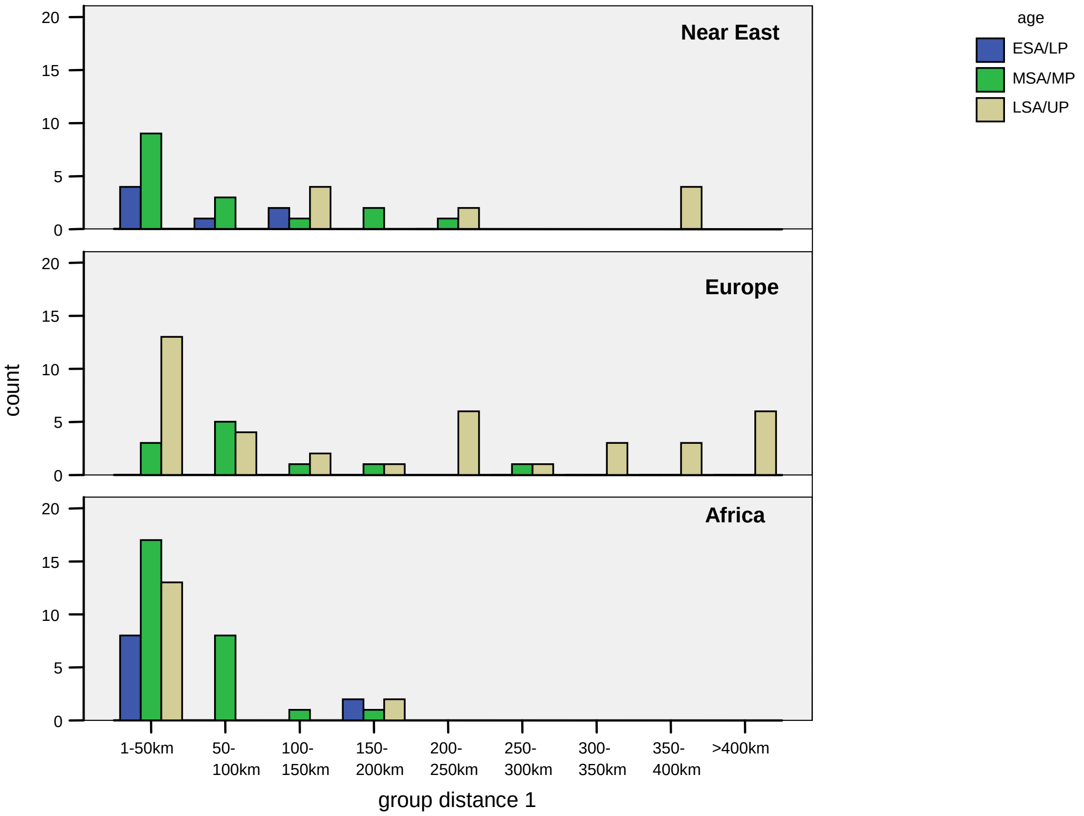


Figure 7.2. Graphic presentation of the recorded distance classes separated according to age and region in 50 km intervals

The above results were analysed in association to obsidian frequencies, typologies and technological issues of obsidian use in order to investigate the relationship between raw material form and distance of source-to-site movement.

The obsidian data with regards to its use during the Palaeolithic lend support to the notion that the longer the distance a raw material travels the smaller the quantity in which it is to be found (similar to Renfrew's down-the-line model). The investigation of the obsidian circulation shows that when in minor quantities obsidian exhibits a wider spatial coverage than when larger frequencies are involved (figure 7.3). This is an interregional characteristic in the exploitation of obsidian so the discussion that follows will concentrate on the temporal changes of the distance-frequencies relationship.

In the Earlier Stone Age of East Africa minor quantities cover an area substantially larger than any assemblage with >10% obsidian. Quantities grouped under «moderate» and «frequent» are always located within an <10 km radius. In the occasions where longer distances are involved they are always associated with obsidian quantities that do not exceed a maximum 10% of the total lithic assemblage. The same patterns characterise the obsidian presence in the Lower Palaeolithic of the Near East; minor quantities are always more widespread on the landscape compared to classes with higher frequencies. Furthermore, when the rates of obsidian frequencies are high (>10%) they are associated with the minimum kilometrical spatial units (1-10 km). However, the Near Eastern sub-set deviates from the African picture in two ways that need to be addressed. First of all, small percentages of obsidian are located further away from their sources than in East Africa; ranges up to 60 km have been recorded in the Near East opposite to a scale up to 40 km for the later region. Secondly, whilst in East Africa obsidian frequencies never exceed 50% of the total sum of a site's lithics, in the Near East evidence for obsidian totally dominating a site's lithic assemblage has been unearthed. One example of the «majority» (50-90%) and three of the «all» categories (90-100%) have been reported in association to areas of up to 30 km and 20 km distance from the source respectively.

In Middle Stone Age Africa minor obsidian quantities display a greater circulation range than previously but the upper limit of that range is not different to that of the Earlier Stone Age (>100 km). Moderate and frequent quantities move considerably longer distances than before covering an area up to 80 km opposite to an Earlier Stone Age radius of <10 km. In the Near East, the same pattern (greater variety in the movement of small obsidian quantities) is observed which is also true for the cases that fall within the «all» category. However, contrary to the African dataset, in this area a change in the scale of obsidian movement occurs in the transition from the Lower to the Middle Palaeolithic. Minor quantities of obsidian travel over distances of >200 km. However, a slight increase in the distances of the «majority» (MP: 40-50 km; LP: 20-30 km) and «all» (MP: 20-30 km; LP: 10-20 km) categories is also evident. European obsidian, despite the fact that it enters the Palaeolithic record late, exhibits a wide array of circulation distances; this is particularly clear when small quantities are involved. Usually these are located within a 60-70 km radius but examples connected to distances >100 km and >200 km have also been observed. >200 km is the furthest recorded movement of obsidian overall and in all regions under investigation. Worth noting is the fact that a Middle Palaeolithic obsidian assemblage representing a complete chaîne opératoire (Ballavölgyi) is associated with the >100 km class.

Finally, the Upper Palaeolithic/Later Stone Age obsidian assemblages do not deviate from the norm. In East Africa, quantities ranging from «moderate» to «all» are located within a radius that does not exceed 40 km and minor quantities occasionally exceed the 100 km limit but in instances that do not alter the picture of the Lower and Middle Stone Age phases. Throughout Eurasia, however, the 100 km barrier is crossed on several occasions always with regards to obsidian quantities that are not greater than 1-10% of a site’s overall lithic assemblage. In particular, there are 18 cases in Central & South-eastern Europe and 6 in the Near East where obsidian had been transported for >200 km. Moreover, distances >200 km are most commonly associated with the Upper Palaeolithic circulation of obsidian both in the Near East and Europe.

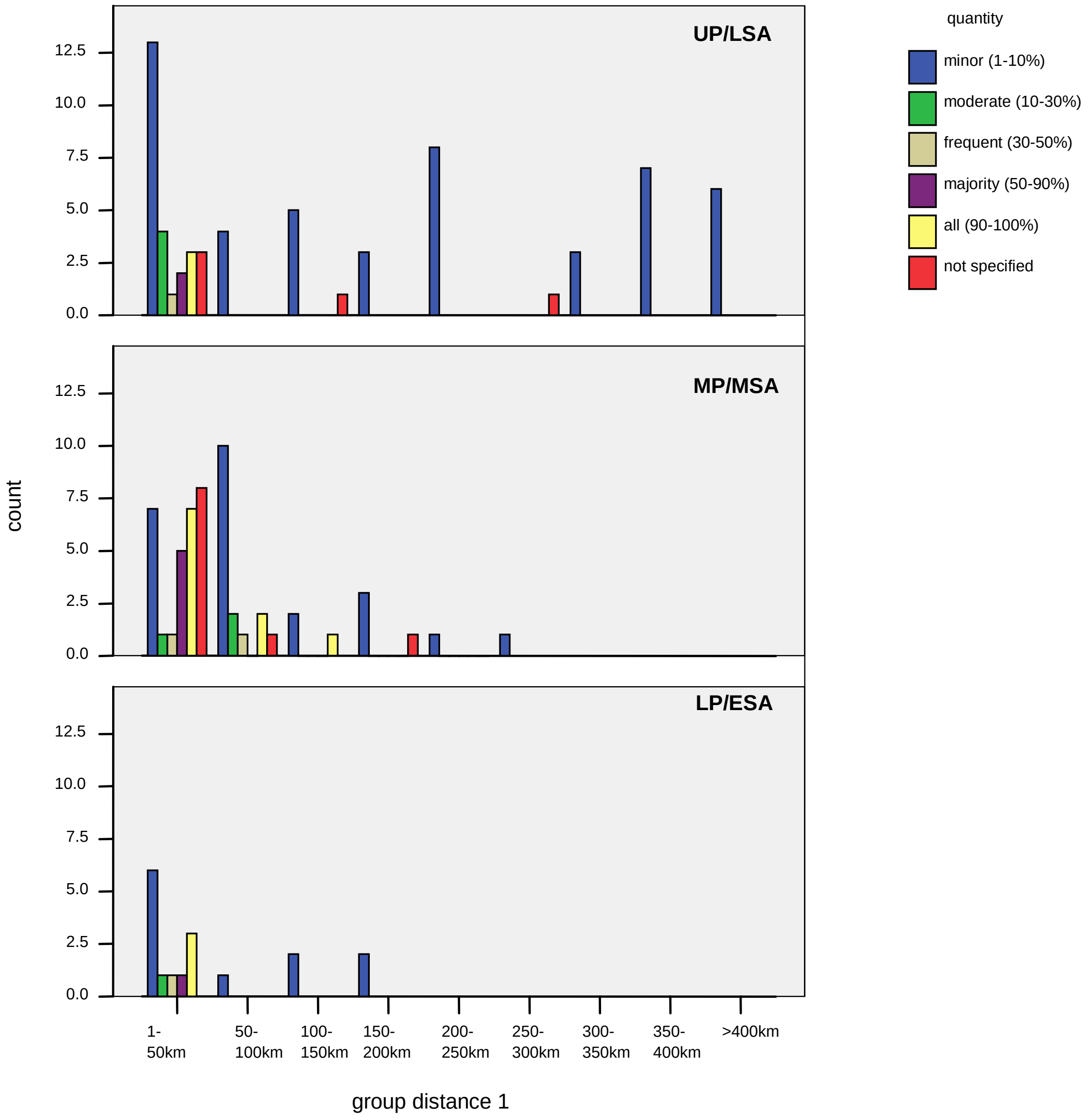


Figure 7.3. Obsidian frequencies and distances distributed in time and space.

A strong correlation underlies the relationship between distance and tool typologies as the analysis of the respective parameters has revealed (table 7.6 and figure 7.4). This observation characterises all regions under investigation and holds for each of the three Palaeolithic sub-phases.

Small retouched tools are the category travelling the furthest with examples occasionally exceeding even a 400 km radius. The obsidian quantities diminish with the increasing distance; nevertheless, small retouched tools are the only tool type that manages to move to such a large scale. Débitage, namely flakes and/or blades, is the second furthest moving typological class with occasional examples reaching up to 400 km. None of the remaining classes shows such a wide distribution range although long movement is not completely lacking as instances of the 200-250 km order indicate. This observation is particularly significant with respect to the «all» class as it implies the circulation of obsidian assemblages encompassing the complete typological range of tool production (cores-retouched tools). However, these instances are very rare and they do not alter the generated pattern of small retouched tools as the tool type generally associated with long distance movement.

Translated into stages of a tool production chaîne opératoire the above typological classes reveal the following patterns with regards to the relationship between tool production stages and distance.

Complete chaîne opératoires are commonly found in the vicinity of raw material sources whereas fragmented sequences or individual production stages are related to increasing source-to-site distances (table 7.7 and figure 7.5). Irrespectively of their regional background complete tool production sequences are associated with distances that do not exceed 250 km. This is the upper limit of the movement of this class and it only occurs in Europe; the respective limit is 150-200 km for Africa and 100-150 km for the Near East. However, these occasions are rare and in most instances sites with complete operational sequences are found in a very close proximity to their supplying source. Both the interregional and diachronic examination of the respective data shows that full chaîne opératoires are more closely connected to distances that fall within a 1-50 km radius. Any «all stages» occurrence outside this area is infrequent and dates from the Middle Palaeolithic/Middle Stone Age onwards.

Secondary reduction stages, namely core-to-débitage or débitage-to-small retouched tool, exhibit a wider spatial range than the «all products» class. Lithic evidence indicative of the artefacts' secondary modification is most abundant in short and medium distances, i.e. 1-50 and 50-100 km respectively. However, the instances when these distances are crossed are not infrequent and they occur throughout the Palaeolithic and in all examined regions. The longest distances associated with tools in their secondary reduction stage exceed 400 km.

This figure is observed only in Europe whilst in the remaining two areas, Africa and the Near East, 200 and 250 km respectively is the upper limit of the obsidian circulation in secondary form (figure 7.6). In terms of the temporal framework of these movements a linear increase in the transport scale characterises the dataset. The maximum Lower Palaeolithic/Earlier Stone Age «secondary reduction» distance is <200 km whereas the respective number for the Middle Palaeolithic/Middle Stone Age is 200-250 km and in the Upper Palaeolithic/Later Stone Age >400 km.

The obsidian evidence for the first two production stages is extremely scarce rendering any analytical or interpretative attempt unsound. One example from each category constitutes the sole representatives of these classes. The raw material procurement stage, namely unmodified blocks of obsidian, is associated with a distance 100-150 km. However, this result comes from the Olduvai Gorge HWK-East site where the problem of accepting a hominin-based transport over one that occurred by natural means is most prevalent. The single example of primary reduction, namely a core dominated assemblage, has been recovered from a source-to-site radius 50-100 km. Given that the «all products» class is frequently encountered >100 km, this boundary does not seem unjustified. Nevertheless, the lack of more data on this category does not allow any strong arguments to be made.

	1-50 km	50-100 km	100-150 km	150-200 km	200-250 km	250-300 km	300-350 km	350-400 km	>400 km	**Total**
débitage (flakes/blades)	2		1		2			2		**7**
SRT & LCT	10	10	3	3	2	1	1	1	1	**32**
nodule				1						**1**
debris/waste	3	1			1					**5**
all products	31	7	6	1	3					**48**
not specified	21	3	1	4	1	1	2	4	5	**42**
Total	**67**	**21**	**11**	**9**	**9**	**2**	**3**	**7**	**6**	**135**

Table 7.6. Typologies of Palaeolithic obsidian assemblages plotted with the nearest source distances from which the raw material could have derived. Distances are given in 50 km intervals.

	1-10km	10-20km	20-30km	30-40km	40-50km	50-60km	60-70km	70-80km	80-90km	>100 km	>200 km	**Total**
stage 1/ raw material procurement										1		**1**
stage 2/ primary reduction						1						**1**
stage 3/ secondary reduction 1				1					2		4	**7**
stage 4/ secondary reduction 2 & use-discard of tools	8	2	1	2	2	2	1	7		6	5	**36**
all stages/ complete sequence	12	3	2	1	2	1	2			4	2	**29**
Total	**20**	**5**	**3**	**4**	**4**	**4**	**3**	**7**	**2**	**11**	**11**	**74**

Table 7.7. Operational sequence stages of the identified Palaeolithic obsidian assemblages plotted with the nearest source distances. Distances are given in 10 km intervals.

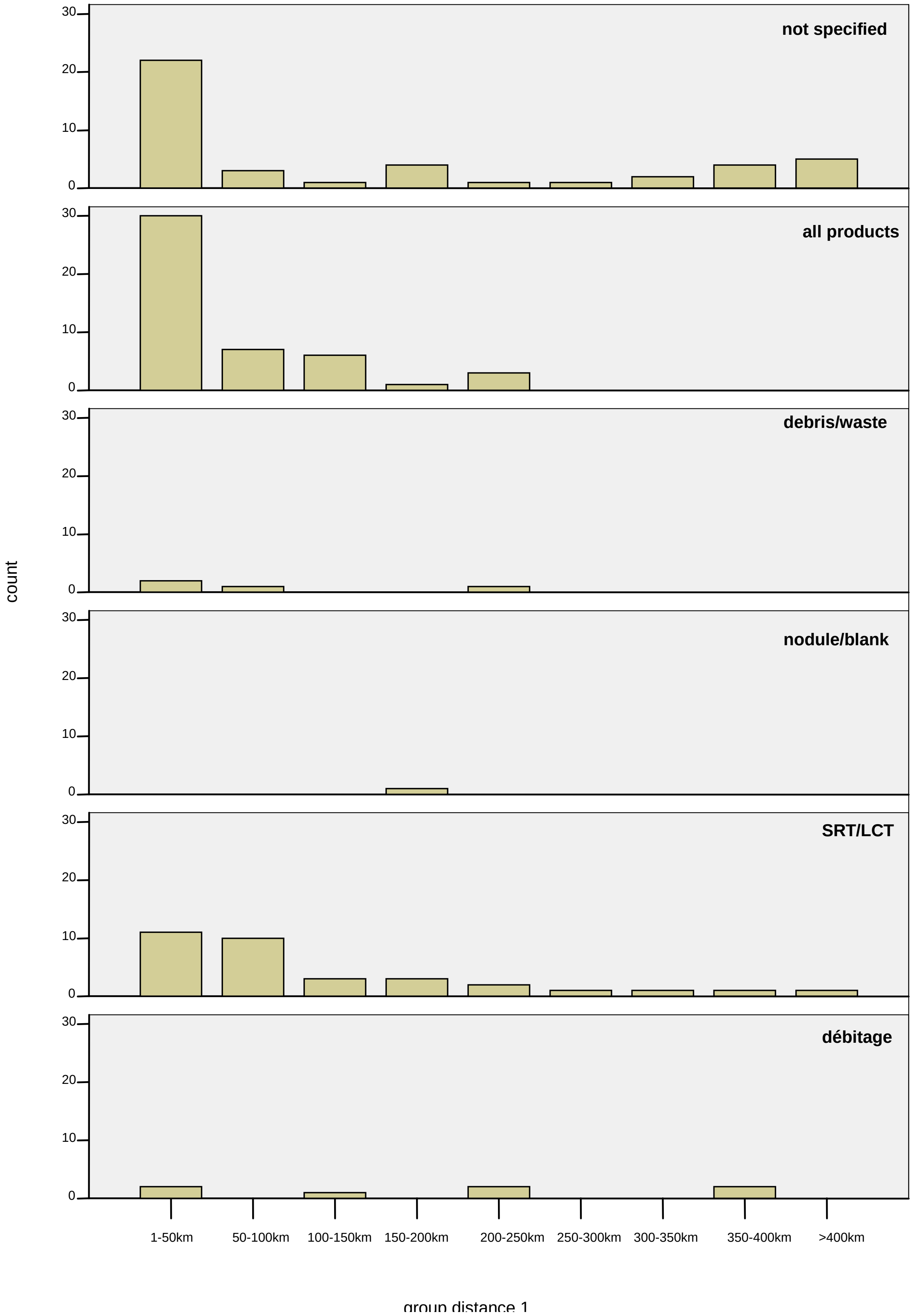


Figure 7.4. Distribution of typological classes based on their distance from source.

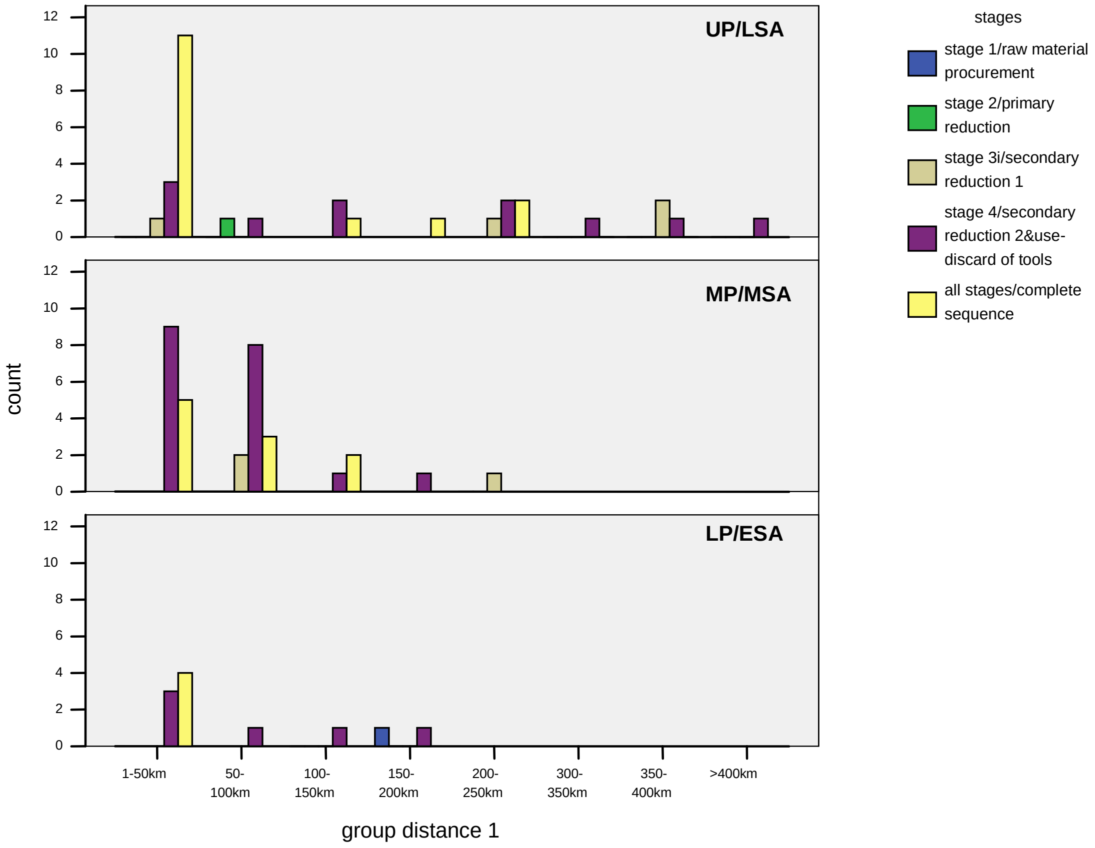


Figure 7.5. Distribution of chaîne opératoire stages in time based on source-to-site distances.

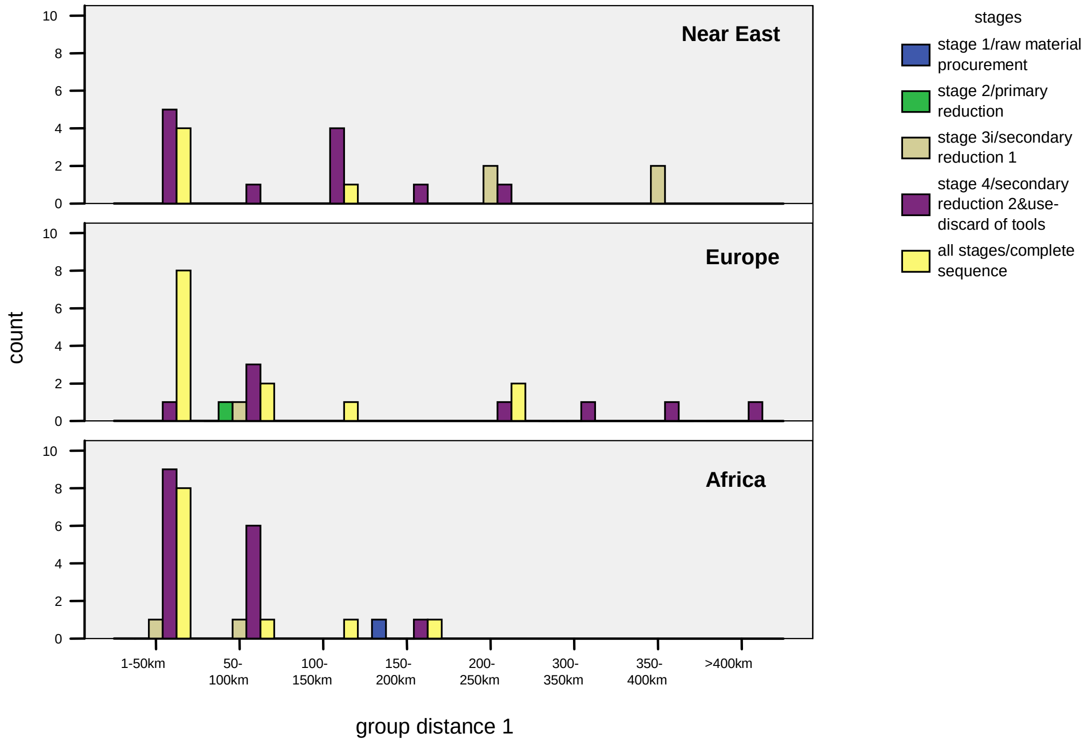


Figure 7.6. Distribution of chaîne opératoire stages according to region based on source-to-site distances.

3.1. Exploring the Scale of Palaeolithic Social Networking

The range of obsidian movement on the Palaeolithic landscape is a powerful tool for the exploration of the scale of social networking. Using the obsidian transport distances as a proxy a model emphasising the social aspect of raw material circulation was developed. Five social networks with distinctive spatial units and differing complexity levels of hominin interactions comprise the core of this model (chapter 3).

The analysis of the obsidian data in terms of social networks has generated a clear set of patterns with regards to the frequencies in which each of the identified networks appears on the record. When the dataset is taken as a whole the network with the greatest number of appearances throughout the Palaeolithic is the mesolocal (figure 7.7). Sites with distances up to 50 km from the nearest source constitute a 29.6% of the overall dataset making the mesolocal areas the ones most frequently visited by the hominins engaging to the circulation of obsidian. The local and exotic networks are also very highly represented contributing a 20% each to the total dataset (figure 7.7). Finally, the two remaining networks, namely the regional and extended, have an almost equal representation in the overall record with 15.6% and 14.8% respectively.

However, if the two networks associated with the furthest recorded obsidian movement ranges are combined into a single long-distance network (figure 7.8) then a different perception is generated. Previous studies (Hahn 2002, Fisher & Eriksen 2002, Floss 2002) on raw material movement having recognised the significance of transfers over a site's immediate vicinity identified transports over the 100 km border as exotic. Subsequently, the combination of the network associated with the >100 km range with the one described in my model as truly exotic, i.e. >200 km, is not unfounded. The conclusion to be drawn from the application of the combined networks on the obsidian data is a tendency of obsidian to move very far from its geological sources. Indeed, although mesolocal ranges remain the second most frequent class under the altered model, long-distance networks are the most popular in circulation of obsidian during the Palaeolithic.

On an intra-regional level the patterns that occur with regards to social networking are different to the perception generated by the data from all regions combined. When all the sub-stages of the Palaeolithic are grouped into a single cluster the pattern illustrated in figure 7.9 is generated. In Africa, local and mesolocal networks clearly dominate followed by the regional and extended networks in a descending order. Exotic webs of interactions are totally lacking in this area throughout the Palaeolithic as the distances of obsidian circulation never exceed 200 km. In Europe and the Near East a less concise but with greater variability, pattern emerges. In Central and Southern-eastern Europe the exotic network is the commonest when the Palaeolithic is taken as a single temporal unit. The second most frequent network is the mesolocal and then following in a downward order are the regional and extended networks. The network associated with the shortest source-to-site distances, i.e. the local, exhibits the lowest value in the respective section of the dataset. Finally, in the Near East, the mesolocal and extended networks are the most popular although they are closely followed by the exotic one. The local and regional networks are equally the least frequent webs of interactions occurring in the Near East.

When the distribution of social networks follows a chronological division with all the examined regions as a single spatial unit the following patterns emerge (figure 7.10). In the Earlier Stone Age/Lower Palaeolithic the local network exhibits the highest frequency value with the mesolocal, extended and regional networks following in a descending order. During the Middle Stone Age/Middle Palaeolithic the mesolocal network dominates closely followed by the regional one. Local and extended networks are also highly represented compared to the previous period. Furthermore, the initial appearance of obsidian transport distances connected to exotic webs of interactions coincides with this phase. Finally, in the Later Stone Age/Upper Palaeolithic a clear dominance of the exotic network is observed. All the remaining networks are represented during this period too but their values are now very reduced in comparison to the Middle Stone Age/Middle Palaeolithic. The mesolocal is the second commonest recorded network followed by an equal share between the local and extended and the least frequent regional networks.

If the above data are examined according to their regional and chronological distribution then the following perception is generated (figure 7.11). In Africa the distances of obsidian movement and the inferred scale of social interactions increase exponentially with time. Starting with the Earlier Stone Age when the majority of cases indicate strong local networking and minimum other contact, an increase in the number of non-local occurrences is observed in the Middle Stone Age. In the Later Stone Age the mesolocal and extended networks retain their popularity whereas the value for the local networks decreases indicating an inclination towards larger webs of social interaction.

In Europe the Middle Palaeolithic is characterised by networking on a regional scale according to the obsidian circulation distances data. Social interactions do occasionally cover extremely long areas creating extended and exotic networks but this is not a common feature of the period. On the other hand, extremely local networks are totally absent. In the Upper Palaeolithic social interactions range from very local to extremely distant and all the networks are represented with several examples. However, the exotic network clearly dominates the European dataset indicating that a robust web of hominin connections was already in place and very popular at that time. The mesolocal network remains frequent while local interactions appear in the record for the first time.

Finally, in the Near East the Lower Palaeolithic exhibits a lack of any patterning as kilometrical ranges indicative of local, mesolocal, regional and extended networks are equally represented on the dataset. A clearer perception is generated by the Middle Palaeolithic data according to which the mesolocal network dominates although the rest of the Lower Palaeolithic networks remain frequent. Exotic networks become an addition at this phase even though only a single occurrence has been recorded at this point. In the Upper Palaeolithic, nevertheless, these networks form the most popular category followed by the other long-distance web of interactions, i.e. the extended network. Social relations in the Upper Palaeolithic Near East appear to be solely based on a large-scale system as any inference about regional, mesolocal and even local networks is completely lacking from the dataset.

	East Africa				Central & South-eastern Europe			Near East			
	ESA	MSA	LSA	**Total**	MP	UP	**Total**	LP	MP	UP	**Total**
local (0-10 km)	5	9	5	**19**		4	**4**	2	2		**4**
mesolocal (10-50 km)	3	8	8	**19**	3	9	**12**	2	7		**9**
regional (50-100 km)		8		**8**	4	5	**9**	1	3		**4**
extended (>100 km)	2	2	2	**6**	2	3	**5**	2	3	4	**9**
exotic (>200 km)					1	19	**20**		1	6	**7**
Total	**10**	**27**	**15**	**52**	**10**	**40**	**50**	**7**	**16**	**10**	**33**

Table 7.8. Spatial networks as suggested by the obsidian movement in each of the three regions under investigation and the three Palaeolithic sub-phases.

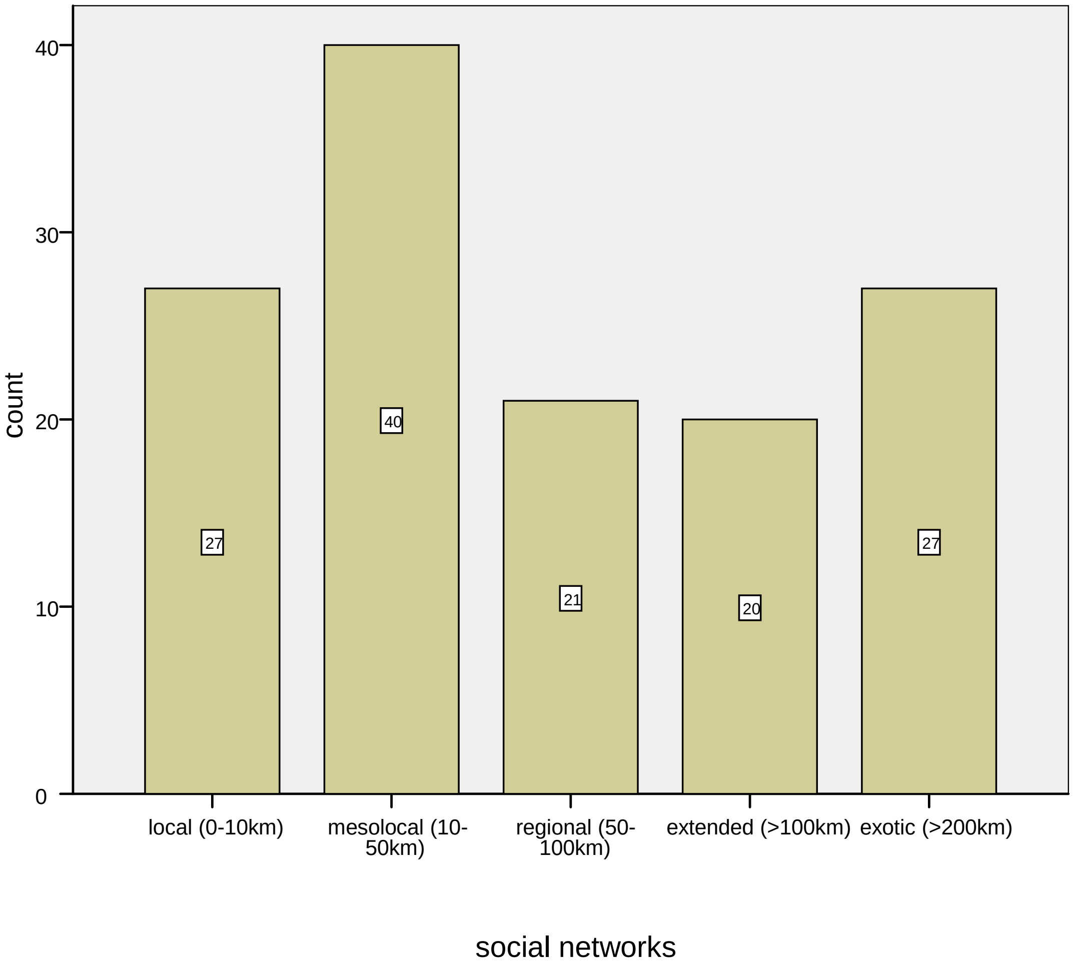


Figure 7.7. Frequencies of social network classes, i.e. obsidian circulation networks, when all phases and regions are taken as a whole.

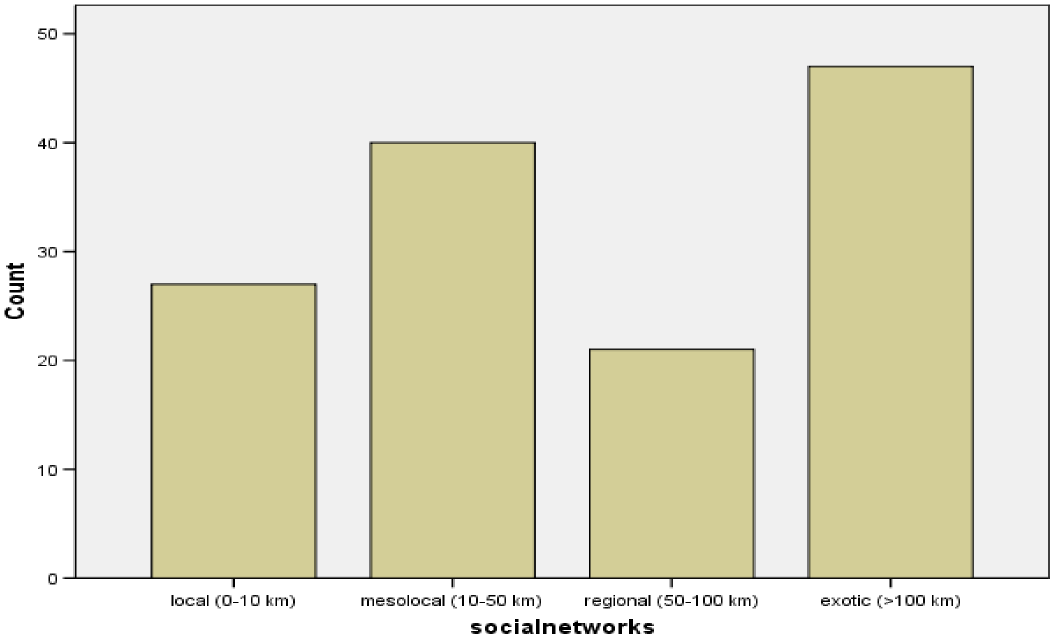


Figure 7.8. Social network classes as represented by the obsidian circulation data. When the two long-distance networks (extended and exotic) are taken as a whole it is clear that the movement of obsidian is most closely associated with very long source-to-site distances.

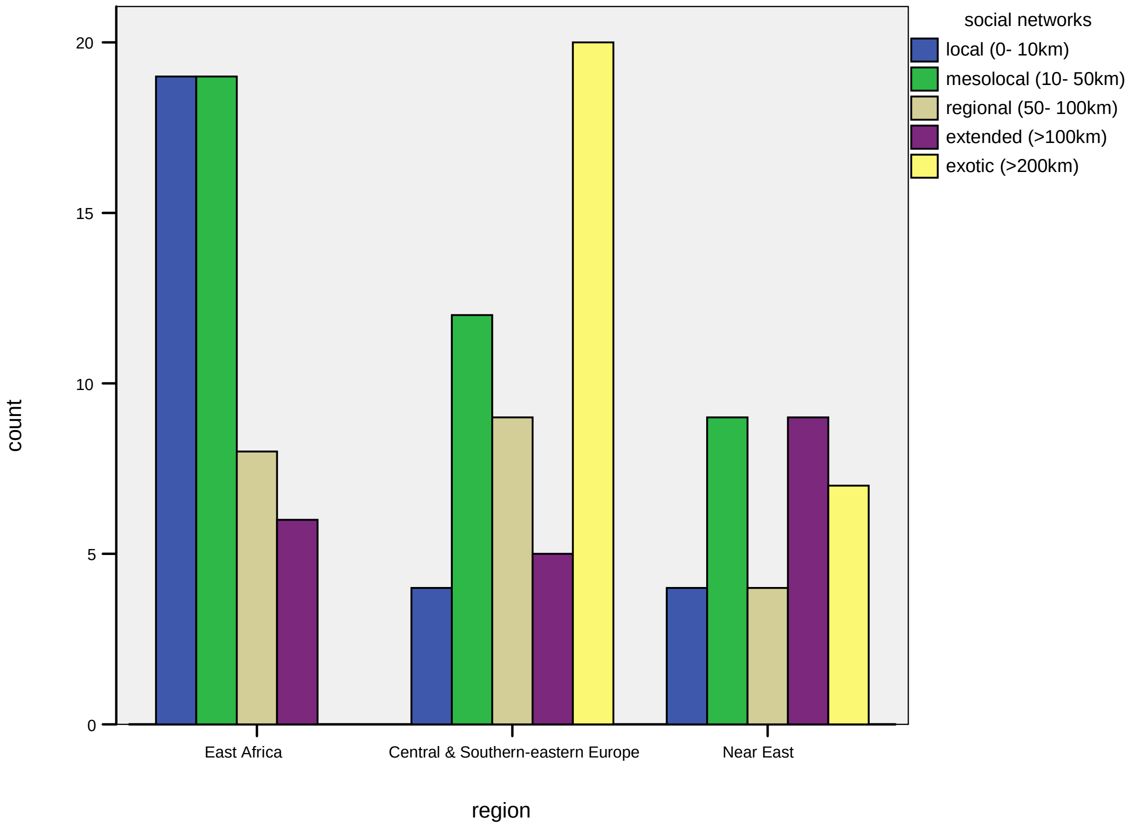


Figure 7.9. Distribution of spatial networks with respect to region as identified by the analysis of the relevant obsidian data.

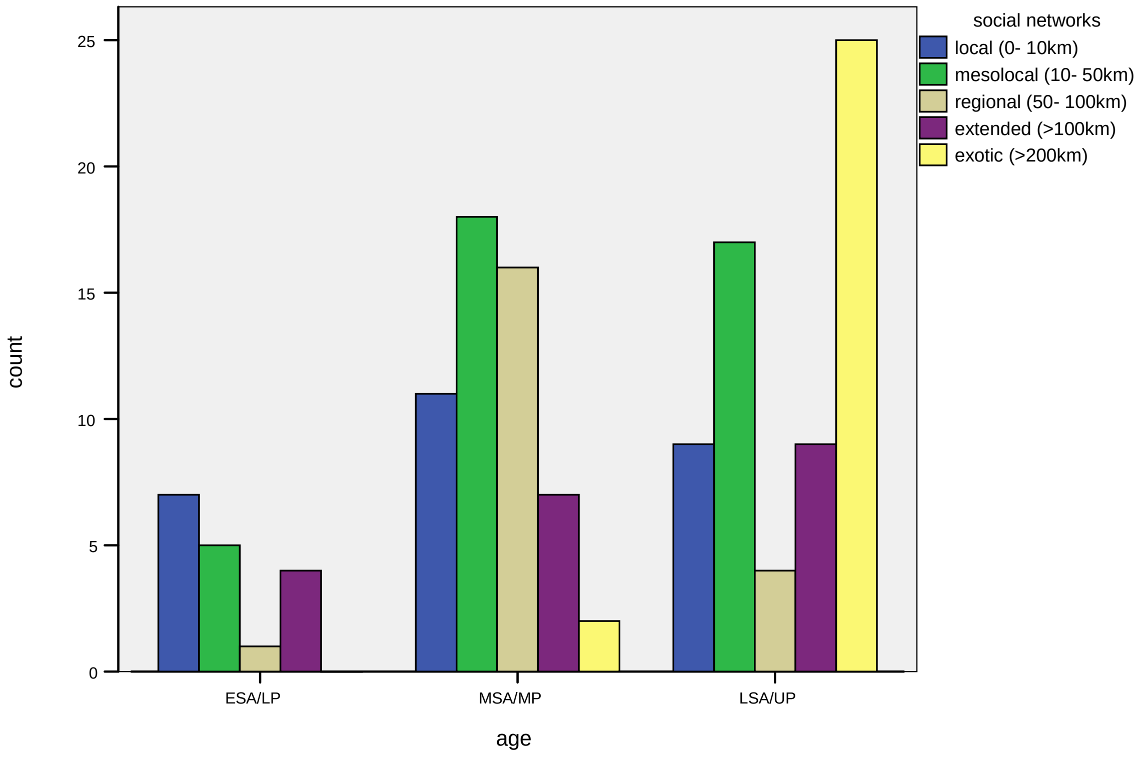


Figure 7.10. Distribution of social networks with respect to time as identified by the analysis of the relevant obsidian data.

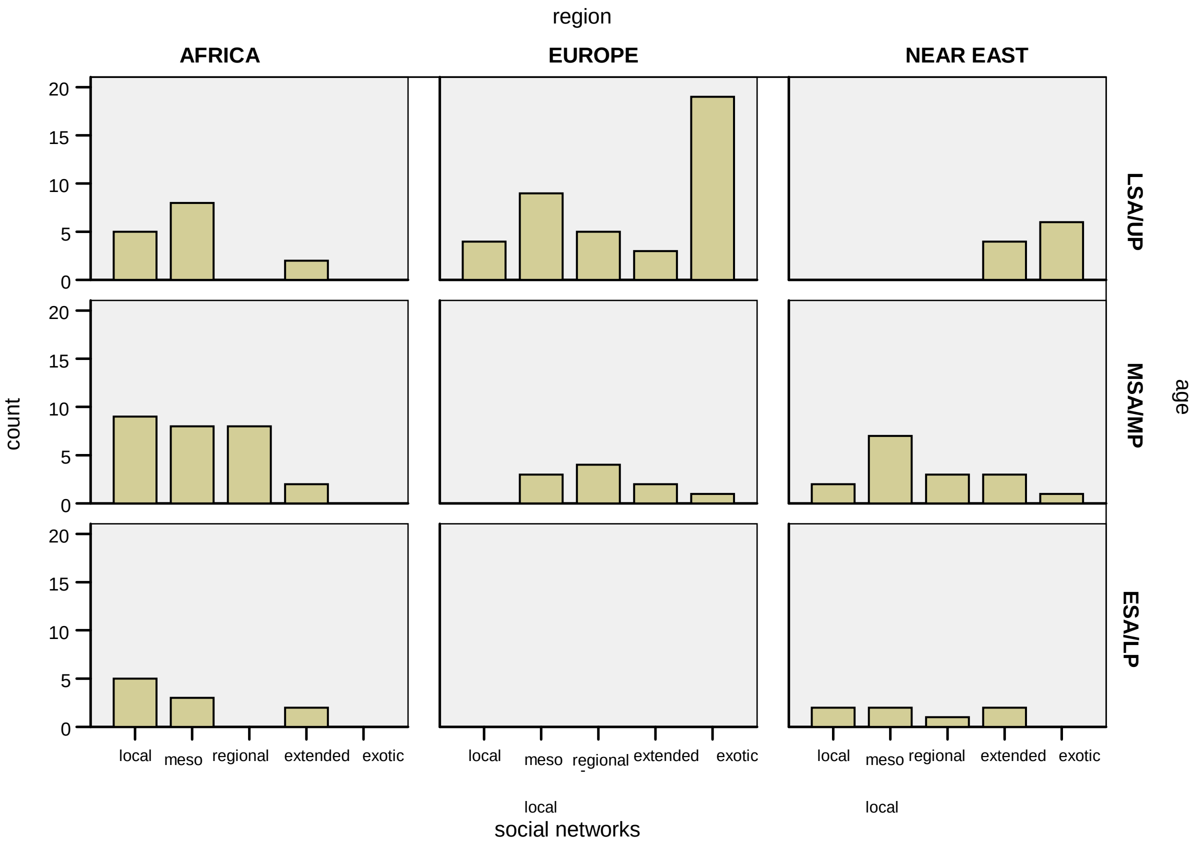


Figure 7.11. Graph illustrating the distribution of social networks combining time and region.

The investigation of the ways obsidian enters the Palaeolithic record has exposed a fact that no research has ever paid sufficient attention to: obsidian is a very «active» stone. Lithics made of the specific volcanic glass, in areas where sources producing its «knappable» varieties existed during the Palaeolithic, have been recovered from a wide geographical area exceeding distances at times when no material was supposed to or to an extent that no stone dating to the Palaeolithic should reach. Within the framework that sees life in the earliest phases of the Palaeolithic minimally complex and social networking almost inexistent or very restricted in space (Gamble 1982; 1993; 1999), obsidian provides the first evidence for long distance raw material movement prior to the Upper Palaeolithic. The occasions are rare but when they exist they are of a scale that is uncommon even in the later phases of the Palaeolithic. Not surprisingly, given its excellent knapping qualities, when obsidian sources are located in the vicinity of a group's camp obsidian is intensively exploited and constitutes the main material of the group's tool kits (e.g. GtJi15 and Bodrogkeresztúr). Its quantities only diminish after the 100 km threshold is crossed (e.g. Ballavölgyi and Pilismarót-Diós). Within this framework, obsidian changes from being a raw material (<100 km) to being a symbol (>100 km).

4. ANALYSIS OF VARIATION IN OBSIDIAN USE BY CLIMATE STAGE (WARM, COLD) AND LATITUDE

Palaeoecology is central in the discussion of hominin movement as understanding the conditions the Palaeolithic groups were faced with is vital in understanding the framework within which social life was experienced. Climate, in particular, has traditionally been perceived by archaeologists as the primary driving force controlling hominins' actions on the Palaeolithic environment. Climatic fluctuations undoubtedly had a strong impact on the landscape, primarily through the temperature/precipitation control on vegetation and geomorphic processes. This obviously affected a wide range of variables which would impact on human activity, for example the availability of food resources, water supply and the migration of game species. However, it would be misleading to base all our interpretations of past phenomena to a sole factor and the obsidian data provide strong support that climate cannot take full responsibility for the observed patterns. In the following sections the impact of Pleistocene climate and environment in the examined regions on the obsidian patterns will be addressed.

Providing a detailed record of the environmental/climatic changes of the Pleistocene world will not be attempted here. Nevertheless, the correlation of obsidian-bearing sites with their general climatic/environmental context is crucial in understanding and explaining the patterns underlying obsidian movement. The environmental background of this thesis' case studies (chapter 6) was used as a proxy for the reconstruction of the palaeoecology of the broader regions in which they belong. The exploitation of obsidian would have been subject to the respective climatic changes and the extent of its circulation affected by the scale of the available environmental niches.

The commonest perception of the Pleistocene is that of an inhospitable and harsh environment with severe climatic conditions where cold and ice prevailed throughout the 2.3 Myr of the era's duration. However, recent advances have proven that such a model is far from reflecting the actual phenomena. The new evidence supports a model of the Pleistocene environments as rich mosaics of seasonally important resources some of which constituted optimal foraging ecotones (Shennan & Horton 2002) for the Palaeolithic hunter-gatherers. The hominin populations under investigation were going by their daily lives adopting more specialised subsistence strategies for the exploitation of plant, animal and other resources during interglacial periods replaced by more experimentation in subsistence methods during deteriorating habitats and adverse climatic conditions. Within this framework of changing environments, changes in hominin and raw material movement have to be expected; greater movement and interaction between hominin groups during worsening weather conditions (Winterhalder & Smith 1981, Holt 2003), more relaxed bonds and less mobility in periods of warmth and very productive environments. However, the implications of this observation with regards to hominin capacities are not so straightforward. Human occupation of the Pleistocene world was always affected by full glacial/interglacial conditions. The proposed dates for the earliest appearance of hominins in the European continent are a good example of hominin abilities. The current evidence for the earliest appearance of humans north of the Alps dates to ca 680-780 kyr (Pakefield, Suffolk, UK and more recently Happisburgh, Norfok, UK; see Parfitt *et al.* 2005 and 2010). South of the Alps humans are present even earlier at approximately 800-1000 kyrs (at the Palaeolithic sites of Orce (Roe 1995 and more recently Scott *et al.* 2006) and Atapuerca (Arsuaga *et al.* 1997, Oms *et al.* 2000) in Spain.

The dates of those events indicate that the colonisation of Europe took place under glacial conditions and the human occupation of the continent was always affected by full glacial/interglacial conditions. This implies that climate alone cannot account for hominin moving capacities.

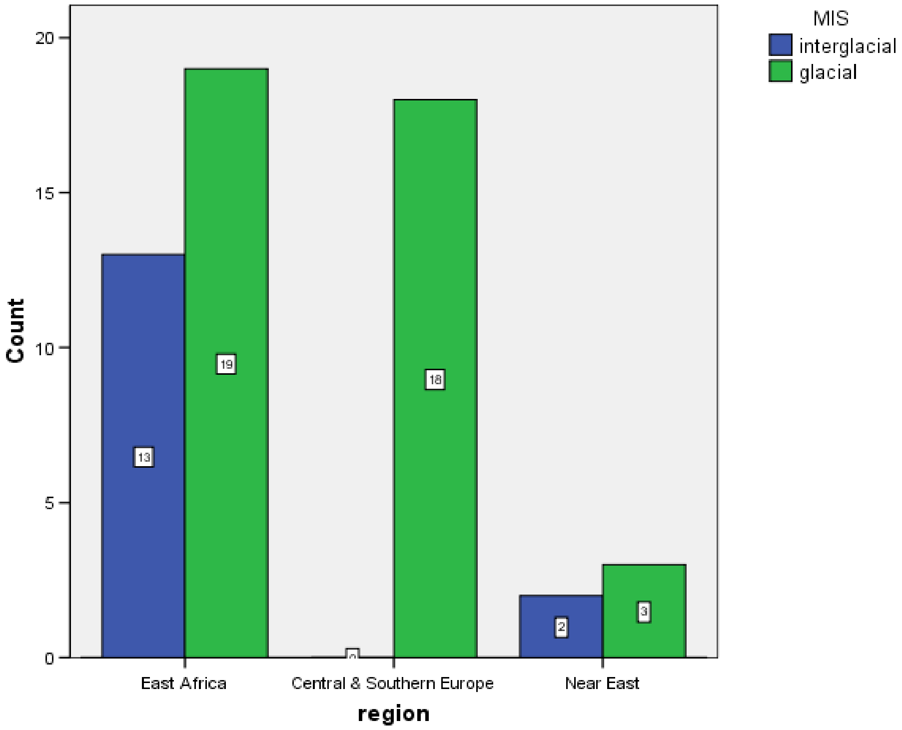


Figure 7.12. Frequencies of sites with interglacial/glacial conditions distributed according to region.

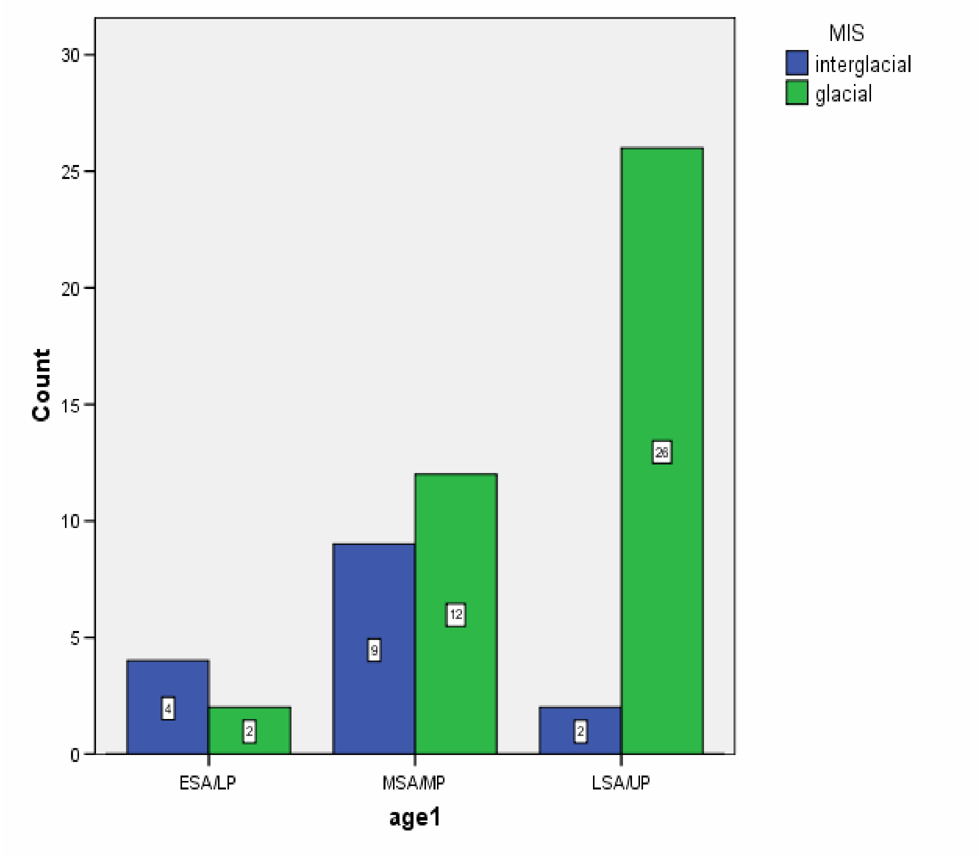


Figure 7.13. Frequencies of sites with interglacial/glacial conditions distributed according to time.

The lack of absolute dating for the largest proportion of the Palaeolithic obsidian-bearing sites makes their direct association to their environmental context sketchy. From the 136 sites recorded in this thesis, absolute dates exist only for 54 most of which come from the Upper Palaeolithic (figures 7.12 and 7.13). Indeed, the dating record for the last phase of the Pleistocene (130-10 kyr) is disproportionally larger, and of a better quality, compared to the earlier periods. This is due to the fact that the time frame of the Upper Palaeolithic falls within the applicability limits of a number of dating techniques that produce direct and highly precise results (e.g. TL, OSC, ^{14}C). An additional problem is that absolute dating information for the regions of concern is mainly confined to the Central/South-eastern European and African datasets. The fact that the majority of the Near Eastern data comes from surveys and not deep stratigraphic excavation units has not allowed for anything more than the assignment of the respective sites to a general time frame. The robust age estimates these techniques produce, allow a direct correlation to be made between the use of obsidian artefacts and climate history. Despite their small number, the available data allow a better understanding of the environmental controls on human migration and obsidian usage that would be otherwise lacking.

The combination of terrestrial and marine data portrays a palaeoenvironmental framework characterised by the succession of temperate and cold conditions for the complete duration of the Pleistocene. These climatic shifts were not identical throughout the Pleistocene but they experienced important changes on their cycle timescale (Adams *et al.* 1999). The Mid-Pleistocene Revolution (Maslin & Ridgwell 2005) shift (i.e. the transition between 41 and 100 kyr glacial/interglacial cycles ~1Myr ago) is the most well-known of those events. Understanding the functioning of glacial/interglacial cycles is important in this discussion as these cycles control the climatic conditions on a world-wide scale and they, thus, control the productivity of environments and hominins' lives.

Glacial climates would have imposed the greatest challenge to the Palaeolithic hominins. Regular extensive glaciations are something that Palaeolithic hominins would have had to cope with throughout their history, especially in Europe and the Near East but Africa was not left unaffected either. In the African continent, the uplift associated with the East African Rift Valley formation altered wind flow patterns (Maslin & Christensen 2007) resulting in a climatic shift towards increased aridity (Bobe & Eck 2001, deMenocal 2004). This shift was initiated in the Pliocene (2.8 Ma) but it produced a long-term drying trend - punctuated by episodes of short, alternating periods of extreme wetness and aridity – in the Pleistocene too. Faunal (bovids, Bobe & Eck 2001) and floral (Kerr 2001) data from several East African sites support a lasting drying pattern that dried the continent to grasslands. A gradual replacement of woodland by open savanna grasslands between 3 and 1 Ma is the picture generated for Africa with step-like increases in savanna vegetation at 1.8, 1.2 and 0.6 Ma (deMenocal 2004: 13).

The control of glacial conditions on the environment was more pronounced in Eurasia (Hoffecker 2003). The examined regions were affected by the Eurasian (expanding into the Netherlands, Germany, Poland and Russia) and the Alpine (expanding from the Alps) ice sheets, and any ice cap within the Caucasus. The proximity of these areas to glaciers or periglacial zones (Nilsson 1983) impacted on the environment, and hominins' activities, in three main ways:

- Lowering sea-level causing coastal plain extension. This would result in some of the islands getting connected to the mainland making them accessible. It depends on bathymetry as maximum reduction in the sea level is approximately 120 m (if an island is surrounded by marine floor greater than that then island conditions will still be maintained)
- Glaciations which bury certain regions, therefore, making them inaccessible to hominins
- Cold/dry climates forcing fauna out of regions and causing hominins to react accordingly (not to be further discussed here)

With regards to the obsidian landscapes examined in this thesis, the magnitude of the glacial climatic conditions on the visibility of the specific lithic resources has been most severe in the Mediterranean and the Caucasus regions. Central Europe was, of course, not left unaffected by the expansion/retreat of glaciers. However, several glacial refugia existed in the continent and the examined region (Carpathians) was part of them. Floral data indicate that during the ice ages, many temperate taxa survived in southern European refugia, from where they recolonised northern regions during the interglacials (Hewitt 1999, Petit *et al.* 2002). Moreover, alpine and high mountain taxa survived in non-glaciated areas in peripheral mountain refugia (Stehlik 2000). The Carpathians served as such a refugium as evidence suggests. Data from molecular and palaeofossil studies on temperate trees (Magri *et al.* 2006), butterflies, amphibians, snakes and mammals (Deffontaine *et al.* 2005) reveal that the Carpathians were an important glacial refugium during the Pleistocene. Local glaciers occurred only in the highest part of the Carpathians, usually above 2000 m but most of the mountain range remained ice-free even during the coldest periods. Analyses of the genetic structure of *Hypochaeris uniflora* species (Mráz *et al.* 2007) showed the existence of three well-separated groups of plants representing three geographical regions, the Alps and, specifically to this thesis, the western and south-eastern Carpathians, all functioning as refugia during cold stages. Additionally, pollen and charcoal data suggest the existence of glacial refugia for boreal forests in the eastern Carpathians and the Pannonian lowland (Willis & van Andel 2004). All this evidence advocate that the Carpathians formed a protective shield for the basin lying along their inner part allowing hominin groups to remain in the area even in periods of fully glacial conditions.

Other parts of the European continent were, however, more severely affected by the worsening climatic conditions of the Pleistocene glacial stages. Based on magnetostratigraphic data, a detailed chronostratigraphic curve was developed for Early and Middle Pleistocene eastern Mediterranean. The observed changes in marine faunal associations, sedimentary depositional environments and *Pinus* variations reflect changes in the climatic cycles and the environment of the region (Joannin 2007). However, lower sea levels and coastal plain expansion had been the primary result of the glacial advance in south-eastern Europe and the Mediterranean in particular. Bathymetric data and sea-level rise curves (van Andel & Shackleton 1982, Shackleton *et al.* 1984) provide a picture of the Late Quaternary geography of the Mediterranean formed of large coastal plains traversed by large lakes and rivers. The meltwater from the Alpine ice cap and the Apennine and Dinaric ranges that reached the central and western sectors of the Mediterranean are responsible for this event. For the part of the Mediterranean in which Pleistocene obsidian sources have been identified, namely Greece, extensive coastal lowlands (coastal plains) characterise its north-west and north-east sector. A large Cycladic semi-peninsula comprised of several islands joined together due to low sea-levels, a subsequent enlargement of the Greek mainland and a narrower Aegean Sea are the other main features of the Greek Pleistocene geography. With special reference to Melos, the main source of obsidian in the region, the lowered sea levels (of the order of ~115-130 m) suggest that access to this particular source would have been over land. The scarce available information concerning the use of Melian obsidian during the Upper Palaeolithic indicates that its exploitation would have required the crossing of a large coastal plain rather than a water barrier.

The inaccessibility of obsidian sources seems to have been the main impact of glacial activity in the Caucasus region. Both the Great and Minor Caucasus mountain ranges are characterised by a widespread glacial relief (e.g. moraines, troughs) indicating a pervasive glacial presence in the area especially during the Last Glacial Maximum (Gobejishvili 2004). Previous glacial advances, especially during the Middle Pleistocene (Don and Dnerp Glaciations), also affected the topography surrounding the Caucasian obsidian sources. The location of those sources in altitudes that were inundated by ice or water during major cold events suggests that accessibility to these areas was either restricted or completely prohibited at least during the cold phases of the Pleistocene. The fact that archaeological evidence of

Caucasian obsidian Palaeolithic exploitation comes from only one site (the cave site of Kudaro I in Georgia) supports this argument.

The chronological distribution of Palaeolithic obsidian-bearing sites suggests that climate cannot fully account for the observed patterns. For the earliest part of the Palaeolithic the correlation between archaeological sites and climatic conditions would be straightforward as at this time glacials/interglacials are barely indistinguishable. However, the lack of sufficient data allows only some inferences to be made. The oldest obsidian occurrences show a better correspondence with interglacial conditions but examples of sites associated with cold glacial stages are not missing either. Specifically, Gadeb dating to approximately 1.5 Myr and Garba (in Melka-Kunturé) dating to 1.6 Myr are clearly associated with interglacial conditions. On the other hand, evidence for obsidian exploitation during cold periods occurs in Africa at the site of Kariandusi (~800 kyr) and in northern latitudes at Kaletepe Deresi, the only Near Eastern site to which absolute dating has been successfully applied. Here obsidian artefacts have been recovered from the site's earliest horizons dating to at least 160 kyr (Slimak *et al.* 2004) and corresponding to the cold conditions of the Riss glacial.

Obsidian-bearing sites are abundant during the Middle Palaeolithic/Middle Stone Age but absolute dates are still lacking for the majority of them. According to the available information, the sites under examination fall within two broad groups: a) 250-120 kyr (African sites) and b) 70-30 kyr (Eurasian sites). The first group coincides with MIS 7-5e and the second with MIS 3 and 4. Marine isotope stage 7 corresponds to a period of interglacial climatic conditions whilst marine isotope stage 3 is an interstadial; both characterised by warmer temperatures and the retreat of ice sheets (Ehlers & Gibbard 2004). Nevertheless, Middle Palaeolithic obsidian exploitation is not confined to these temperate environments either in Africa or Eurasia. Based on the available dated sites obsidian assemblages are also found during the cold phases of MIS 6 and 4 and in numbers that do not differ from those of the warmer stages 7 and 3. Actually, the Middle Palaeolithic use of obsidian is more closely related to glacial conditions with 12 examples opposite to 9 associated with temperate interglacial environments. The fact that obsidian-bearing sites of a glacial character are recorded from all the regions under examination, contrary to interglacial sites restricted only in Africa, adds to the above observation.

In the last phase of the Palaeolithic well within isotope stage 3 (60-25 kyr) and up to the end of the Pleistocene (MIS 2: 25-10 kyr) the archaeological signatures of obsidian use for tool manufacture are even more abundant than before. Most of the Upper Palaeolithic sites studied for the purposes of this project fall within the boundaries of MIS 2, a period of deteriorating climatic conditions that reach a climax with the Last Glacial Maximum. Despite the fact that during this period large parts of northern Europe become devoid of any human occupation and deteriorating conditions prevail in East Africa the obsidian exploitation continues unabated. Although part of the Carpathians was partially glaciated (Nilsson 1983, Marks 2004, Matoshko 2004, Urdea 2004) the inner sector of the mountain range where the obsidian sources are located and the basin itself were well protected. The high mountains embracing this wide area prevented the ice cover of the Last Glacial Maximum from intruding enabling the inhabitants of the region to go by their daily lives. In Africa, the inferred climatic conditions from the available deep sea core records are characterised by cold and aridity which, however, did not prohibit the exploitation and circulation of obsidian among the Palaeolithic hominins.

The analysis of the available data identified the lack of connection between climate and the typological, technological and quantitative parameters of the obsidian use. However, a correlation between the alternating climatic conditions and the distances in the circulation of obsidian seems to be the case. A picture similar to that proposed by the habitat-specific hypothesis (i.e. effect of ecology on human evolution: Vrba *et al.* 1995, deMenocal 2004) seems to develop from the raw material circulation data as well. Mild and moist environments provide a better survival potential resulting in more confined movement for the acquisition and exploitation of raw materials. On the contrary, colder and drier landscapes force hominins to move further either purely due to their desire to acquire their preferred materials/objects or following the migrating game. In general, long distance movement of obsidian is associated with phases of deteriorating climatic conditions. Although distances >100 km are not uncommon during interglacial stages, it is usually shorter distances that are involved in obsidian exploitation during favourable conditions. The longest recorded distances in the circulation of obsidian come from sites associated with glacial phases.

4.1. Northern *versus* Equatorial Obsidian Movement

The comparative analysis of the obsidian data between Africa and Eurasia shows that the scale of the obsidian circulation system was responsive to the ecology of the two broad regions. In the previous section the glacial-interglacial cycling effect on obsidian transfers was discussed and variability in the movement of obsidian between Africa and Eurasia established. Although the alternating climatic conditions seem to have some contribution on the observed patterns, the identified ecological variability is the result of the effect latitude has on the formation of the examined regions' ecosystems. This ecological variation needs to be addressed, through the proxy of latitude, as it would have also affected the possible ways with which the construction of social networks was negotiated within so many different environments.

Ecological variation can be quantified making use of the effective temperature concept developed by Bailey in the 1960s. Essentially effective temperature (ET) estimates environmental variability by measuring the length of growing season and the intensity of solar energy available during the growing season (Bailey 1960, Kelly 1995). The ET concept was introduced in anthropological research in the 1980s by Binford (1980; 2001) in order to examine how and to what extent hunter-gatherers' mobility and diet is affected by environmental factors.

According to their effective temperature values environments are divided into humid, those with ET ranges from 8 to 12.5°C and 19.5 to 26°C, or arid, environments with ET values ranging from 12.5 to 19.5°C (Kelly 1995: 121). Effective temperatures by controlling the productivity of ecosystems affect and control mobility. Environments with high effective temperatures are food-rich characterised by higher food production rates. On the contrary, environments with low effective temperatures are food-poor ecosystems more consistently experiencing low food production rates (table 7.9). Overall, the pattern that emerges is that hunter-gatherers in tropical forests and extreme Arctic are usually very mobile, whilst in temperate forests and deserts mobility is seasonally constrained (Kelly 1995: 117, table 7.10). Using ethnographic parallels, Binford (1980: 14) established that in food-rich environments (high ET) hominin mobility is higher but it does not need to extend far whereas in food-poor environments mobility may be lower but it covers larger areas.

ecosystem	**primary productivity (kJ/m²/yr)**	**herbivore productivity (kJ/m²/yr)**	**carnivore productivity (kJ/m²/yr)**
forest/woodland	7200	3.6	0.03
savanna	4050	10.1	0.08

Table 7.9. Productivity of ecosystems; comparison between modern forests/woodlands and savannas. Data from Leonard *et al.*(2003).

		settlement patterns			
zone	**ET range**	**fully nomadic**	**semi-nomadic**	**semi-sedentary**	**sedentary**
tropical forests	26-21	9 (75)	2 (16.7)	1 (8.3)	0 (0)
tropical/subtropical deserts	20-16	9 (64.2)	4 (28.5)	1 (7.1)	0 (0)
temperate deserts	15-14	3 (9.3)	21 (65.6)	3 (9.3)	5 (15.6)
temperate forests	13-12	4 (7.5)	32 (60.3)	12 (22.6)	5 (9.4)
boreal forests	11-10	5 (11.1)	21 (46.4)	12 (26.6)	7 (15.4)
arctic	9-8	5 (41.6)	4 (33.3)	2 (16.6)	1 (8.3)

Table 7.10. Low effective temperatures indicate cold, seasonal environments with short growing seasons whilst high effective temperature values are related to tropical, non-seasonal environments with long growing seasons. Data from Kelly (1995).

A rapid increase in the land area (territory size) covered by a group is expected in environments where hominins have to depend on hunting for their survival. Ethnographic analyses actually record a strong relationship between the relative dependence on hunting and the total area exploited (Kelly 1995: 130). Additionally, hunting becomes increasingly important towards the poles where flora is far more restricted and patchy than in more temperate settings (Kelly 1995: 130). The size of the territory that fauna requires in order to support themselves depends on the production rate of a given environment. The lower the return rate of a given environment the larger the territory an animal species has to move in order to sustain itself in that particular setting. Since fauna need larger territories in cold latitudes, larger hominin territories are expected and observed in colder environments.

The fossil record also supports the link between environmental productivity and hominin movement (Behrensmeyer *et al.* 1997, Leonard 2002, Leonard *et al.* 2003). Whereas the primary productivity levels decrease in savanna environments, secondary productivity (herbivores) is about three times greater. This means that animal resources are much more abundant in the equatorial ecozone (i.e. Africa) offering the opportunity to Palaeolithic hominins to exploit them without having to embark on long-distance hunting trips. A recent study simulating potential palaeovegetation distribution in central Africa postulates lower leaf area indexes, especially during the Last Glacial Maximum (Cowling *et al.* 2008). This result supports the fossil evidence for the expansion of grasslands and their associated fauna). On the contrary, the European environmental conditions obliged hominins to travel further in order to collect enough resources to cover their subsistence requirements.

A similar conclusion was reached by primatologists researching chimpanzee communities; the range size of chimpanzee foraging area differs greatly with the environment; it is small in the forest, extensive in savannah woodlands and very high for especially arid regions (Tanner 1981: 85). For example, chimpanzees in the tropical forests of Uganda move around 7-20 km^2, a chimpanzee community located in a savanna woodland region of Tanzania covers an area approximately 190 km^2 whilst in an arid region of the same country chimpanzees were recorded covering an area up to 700-750 km^2.

Modern hunter-gatherer analogues can also be used to infer the degree of climatic variation among different parts of the Pleistocene world and their effect on Palaeolithic mobility and territory sizes. Effective temperatures (the mean temperatures of the warmest and coldest months) vary from 26 at the Equator to 8 at the poles (Kelly 1995, Binford 2001, table 9.3). In terms of area coverage this translates into smaller hominin territories in the Equator and larger territories in northern latitudes (table 7.11). Table 7.11 includes information only for groups located in ecozones representing the general environmental patterns of Pleistocene Africa and Europe and is, thus, incomplete. When all available data are taken into account (see Binford 2001) the differences between the different ecological zones is far clearer. In general, hominins cover increasingly wider areas as they move from warmer to colder landscapes and from southern to northern latitudes in their pursuit of food. This pattern is probably better illustrated in table 7.12 generated by the obsidian data and comparing Africa (southern, more temperate environment) and Europe (northern, colder, steppe-like environment).

Finally, the ecological control on hominin decision making is also reflected by hunter-gatherer technologies. The behavioural ecological theory (Henshilwood & Marean 2006) supports an overall decrease in technological complexity from arctic to tropical environments. Hominins occupying cold and temperate environments must invest more time and effort to store food relative to those living in equatorial/tropical areas. Societies that store more also need to invest in greater technological complexity, curation and tool maintenance. The implication is that the temporal appearance of technological complexity in Europe and Africa may be a response to processes unique to each region's environmental context.

ET (°C)	**Environment**		**Group**	**ET (°C)**	**Average distance (km)**	**Total area (km^2)**
25-21	fully equatorial	**temperate**				
20-16	semitropical		Makah	11.3	7.3	190
			Klamath	12.2	7	1058
10-16	temperate		Nootka	12.6	10	370.5
including			Crow	13	19.2	61880
10-11	boreal forests					
12-13	temperate forests					
14-15	temperate deserts	**equatorial/**				
		tropical	Hadza	17.7	8	2520
			Ju/'hoansi	18.8	23.6	260-2500
			G/wi	19.3	25	782
			Mbuti	23.7	5.2	150-780
9-8	arctic					

Table 7.11. The data used are from Kelly 1995 (table 4.1) on the average movement distance of hunter-gatherers in regions with ecosystems/ET values equivalent to those of the regions under investigation. The territory size was calculated using the average distance as the radius of a circle in order to enable comparisons with the obsidian dataset.

AFRICA		EUROPE			AFRICA		EUROPE	
R(km)	***Area (km²)***	***R(km)***	***Area (km²)***		***R(km)***	***Area (km²)***	***R(km)***	***Area (km²)***
198	123101	**489**	751356		*continued*			
168	88623	**474**	704959		**8**	201	**237**	176573
137	58935	**478**	718160		**161**	81392	**224**	156968
6	113	**391**	479595		**5**	79	**210**	138390
38	4534	**415**	541475		**40**	5024	**200**	125580
25	1963	**388**	473098		**33**	3419	**214**	144316
8	201	**388**	473176		**9**	254	**213**	142576
22	1520	**296**	275055		**77**	18617	**13**	517
21	1385	**331**	344304		**77**	18617	**23**	1658
12	452	**338**	357979		**4**	50	**6**	108
24	1809	**480**	722106		**11**	380	**53**	8839
8	201	**43**	5688		**191**	114550	**115**	41440
28	2462	**27**	2342		**8**	201	**73**	16598
37	4299	**10**	297		**43**	5806	**71**	15733
8	201	**81**	20459		**8**	201	**78**	19253
8	201	**50**	7745		**42**	5539	**39**	4684
36	4069	**61**	11712		**36**	4069	**144**	64938
87	23767	**61**	11498				**53**	8919
2	13	**224**	157103				**57**	10165
21	1385	**65**	13146				**87**	23920
46	6644	**85**	22845				**122**	46662
56	9847	**4**	61				**206**	133622
168	88623	**313**	308425					

Table 7.12. [Extract of table 3.13]. Minimum distances covered by Palaeolithic hominins during the exploitation of obsidian and the territory sizes estimated using those distances as the radius of a circular area. For Europe only the six definite sources have been used in the calculations. Note that overall the African ranges are smaller than in Europe. Highlighted cells are the ones representing the Kenyan and Hungarian sites.

EUROPE							
R (km)	*Area (km^2)*	*R (km)*	*Area (km^2)*	*R (km)*	*Area (km^2)*	*R (km)*	*Area (km^2)*
484	736391	**43**	5688	**305**	291165	**106**	35580
467	685668	**27**	2342	**228**	163482	**63**	12650
471	696841	**7**	166	**216**	146413	**61**	11822
385	465059	**72**	16430	**202**	128246	**68**	14691
410	527093	**42**	5455	**192**	115734	**39**	4684
382	458086	**52**	8392	**206**	132670	**136**	58173
386	467188	**53**	8669	**204**	130654	**45**	6461
293	269905	**215**	145784	**13**	517	**46**	6681
324	329560	**56**	9752	**23**	1658	**82**	21064
333	348208	**74**	17381	**2**	14	**12**	423
475	709155	**2**	9	**46**	6538	**198**	123658

Table 7.13. Taking into account all the possible central European obsidian sources.

Obsidian is distributed differently in Europe and Africa and this variation is best explained in ecological terms. Indeed, the organisational responses of the hominins involved in the circulation of obsidian seem to have been affected by the structure of their respective environments. The established ecological variation is most clearly reflected in the distances obsidian exploitation reaches in each of the two examined regions (tables 7.12-7.14). Prolonged warmer periods provided the opportunity to Pleistocene African groups to remain closer to their smaller exploitation territories while, on the other hand, the cold and arid conditions of central Europe drove hominins to extend their territories in order to successfully fulfil their subsistence requirements. The lithic resources available in these environments were utilised and the archaeological signature of this utilisation is expressed in short and long circulation ranges for Africa and Europe respectively. In Africa, obsidian is found in the vicinity of other useful resources a combination which turned those areas into favourable living spots and resulted in more concentrated, restricted spatial coverage in the circulation of obsidian. In Eurasia, however, greater movement ranges for the acquisition of obsidian are observed. This is a result of two factors; firstly, good quality obsidian sources are not located in areas favouring permanent settlement. Secondly, given the ecological circumstances, greater foraging/hunting areas had to be exploited for the fulfilment of food requirements.

obsidian territories		
	Africa	**Europe**
ET (°C)	**16-25**	**10-16**
Minimum	13 km²	50 km²
Maximum	123101 km²	750840 km²
	GtJi15	**Bodrogkeresztúr**
Minimum	201 km²	154 km²

Table 7.14. Minimum and maximum site-to-source distances and territory sizes according to obsidian. Note that Europe does not include the incomplete Mediterranean dataset.

Kenya	Hungary	Kenya	Hungary
distance (km)		**area (km^2)**	
2	**6**	13	108
6	**10**	113	297
8	**13**	201	517
8	**23**	201	1658
8	**39**	201	4684
8	**50**	201	7745
8	**53**	201	8919
8	**57**	201	10165
11	**61**	380	11712
12	**61**	452	11498
21	**65**	1385	13146
21	**71**	1385	15733
22	**73**	1520	16598
24	**78**	1809	19253
25	**81**	1963	20459
28	**85**	2462	22845
36	**87**	4069	23920
36	**115**	4069	41440
37	**122**	4299	46662
38	**200**	4534	125580
42	**210**	5539	138390
43	**213**	5806	142576
46	**214**	6644	144316
87	**224**	23767	157103
	224		156968
	237		176573
	313		308425

Table 7.15. Minimum site-to-source obsidian distances and coverage areas between Kenya and Hungary. Note that the Hungarian values include only the six definitely utilised obsidian sources.

				Bodrogkeresztúr											GtJi 15	
12	Erdobenye	42	Bysta	225	Nova Bana		40	Eburru	1078	K'one	34	ya Moto	100	Naivasha Scarp	524	Asille (ml)
14	Tolcsva	48	Kasov	205	Banska Stiavnica		16	Ololerai	1095	Fantale	132	Kisanana	42	Olagirasha	480	Shin
17	Csepego Forras	47	Cejkov	215	Hlinik nad Hronom		28	Akira	1145	Assabot	14	McCall's Siding	44	Suswa	256	Nasaken
33	Telkibanya	41	Mala Torona	209	Sklene Teplice		20	Opuru	1178	Afdem	22	Menengai (ml)	48	Kedong Escarpment	256	Emurua ngogolak
160	Khust	40	Szolloske	207	Kremnitz		112	Lukenya (ml)	1223	Dire Dawa	25	Longonot	56	Gicheru (2L)	145	Salawa Hill
10	Olaszliszka	40	Streda nad Bodrogom	18	Abaujszanto		110	Ol Donyo Nyegi (ml)	1232	Ayelu	18	Oserian	75	Githuya	139	Kampi ya Samaki
34	Palhaza	106	Beregovo	7	Mad		53	Kinangop	1073	Balchit	16	Kibikoni	54	Gacharage	140	Karau (ml)
39	Fuzerkomlos	116	Mukacevo	209	Kiralynegy				1034	Modjio	8	Sonanchi	66	Githumu	85	Mt Kenya
		116	Gertsovtse-F	5	Tokaj				268	Mt Kilim/ro (ml)	25	Masai Gorge	75	Mangu	80	Londiani

Table 7.16. GtJi15 and Bodrogkeresztúr distances from all the available obsidian sources in their regions. Coloured sources in Bodrogkeresztúr represent the six sources definitely in use (orange= Hungarian sources, light green= Slovakian sources). Coloured sources in GtJi15 (khaki) represent the Naivasha region sources, i.e. the most likely used sources in the broader GtJi15 area.

The obsidian data indicate greater material movement distances/foraging area sizes in Europe, even excluding the Mediterranean, than in Africa (tables 7.12 and 7.13). Based on their effective temperature values, the European ecosystem is colder and more arid than the African environment, a fact that conditions the scale of area coverage feasible in each of the two regions. Given the less productive environment, hominin populations in Europe as expected from table 7.10 are more mobile (50-750840 km²) than those in Africa (13-123101 km²). Using the minimum obsidian movement distances as a proxy of the radius of hominins' territories, it is estimated that Palaeolithic humans in Central Europe were covering an area of approximately 750000 km² whilst in Africa the same range is only from ~10 to 120000 km². Bodrogkeresztúr and GtJi15 (table 7.16) do not show a good correspondence with this observation but the explanation is simple and straightforward. Although both sites are located within 50 km from equal numbers of obsidian sources (16 and 15 respectively), GtJi15 is located further away from its nearest source (i.e. exhibits greater site-to-source distance) resulting in a home range size larger than that predicted for Bodrogkeresztúr. These two case studies are clearly a non-representative deviation from the general patterns; the relationship between territory size and ecological variation is supported not only on the regional (Europe-Africa, table 7.12) but also on the local (Hungary-Kenya, table 7.15) level.

The ecologically controlled variability in the ranges of obsidian and hominin movement shows a good correspondence with the changes the obsidian circulation scales undergo through time. More clearly reflected in the African record but also well illustrated in the European dataset (table 7.17) is the observation that although territory sizes expand with time, they remain diachronically more spatially restricted in Africa compared to Europe. Overall the European territories are larger than the African ones in each period of the Palaeolithic [even when all the Central European obsidian sources are taken into account (table 7.18)] although the picture is not so straightforward with regards to the earliest part of the Palaeolithic. The lack of Lower Palaeolithic obsidian transfers in Europe prohibits any direct associations with the African obsidian circulation of this early phase. However, the Near Eastern dataset can be used as a proxy in order to enable comparisons with the Earlier Stone Age African sites. The Near Eastern obsidian distances (table 9.19) should be regarded as only a generalised proxy for the estimation of the scale the obsidian transfers could have reached in Europe. Nevertheless, they do provide a framework for the generation of inferences otherwise unobtainable. The data from table 9.19 show a certain degree of similarity with the ESA section of table 7.17 with obsidian transfers covering a wide range of distances from very short to medium and even >100 km. Between the two regions, Africa is characterised by longer distances but only in a single case the difference is substantial (approximately 40 km: 161 to 124 km). From the Middle Palaeolithic onwards when direct comparisons between Africa and Europe are feasible it is evident that the circulation of obsidian covers a larger area in the later region than in Africa. Another point that derives from table 7.17 is the lack of 0-50 km obsidian transfers in Middle Palaeolithic Europe. Obsidian circulation is for the first time documented at this phase but it is already associated with medium to long distances, always over 50 km and in one occasion over 200 km. If Near East data are used as a proxy (table 7.20) it is apparent that this gap is only a feature of the European dataset since both Turkey and Caucasus have several examples within the 0-50 km range.

EUROPE							AFRICA					
MP		UP		UP			ESA		MSA		LSA	
R(km)	*Area (km²)*	*R(km)*	*Area (km²)*	*R(km)*	*Area (km²)*		*R(km)*	*Area (km²)*	*R(km)*	*Area (km²)*	*R(km)*	*Area (km²)*
53	8820	**4**	61	**224**	157103		**2**	13	**4**	50	**12**	452
57	10202	**6**	108	**237**	176573		**8**	201	**5**	79	**28**	2462
71	15829	**10**	297	**296**	275055		**8**	201	**6**	113	**33**	3419
73	16733	**13**	517	**313**	308425		**8**	201	**8**	201	**36**	4069
78	19104	**23**	1658	**331**	344304		**21**	1385	**8**	201	**40**	5024
115	41527	**27**	2342	**338**	357979		**25**	1963	**8**	201	**46**	6644
122	46736	**39**	4684	**388**	473098		**38**	4534	**8**	201	**56**	9847
206	133249	**43**	5688	**388**	473176		**136**	58077	**9**	254	**168**	88623
		50	7745	**391**	479595		**161**	81392	**11**	380	**168**	88623
		53	8919	**415**	541475				**21**	1385	**191**	114550
		61	11498	**474**	704959				**22**	1520		
		61	11712	**478**	718160				**24**	1809		
		65	13146	**480**	722106				**36**	4069		
		81	20459	**489**	751356				**37**	4299		
		87	23920						**42**	5539		
		144	64938						**43**	5806		
		200	125580						**77**	18617		
		210	138390						**77**	18617		
		213	142576						**87**	23767		
		214	144316						**137**	58935		
		224	156968						**198**	123101		

Table 7.17. Obsidian site-to-source distances and territory sizes divided according to Palaeolithic phase. European values including only the six definite obsidian sources.

	LP	
	R (km)	***Area (km^2)***
Turkey	5	79
	129	52253
Caucasus	2	13
	12	452
	29	2641
	57	10202
	124	48281

Table 7.18. Chronological distribution of obsidian site-to-source distances and territory sizes in central Europe including all the possible obsidian sources.

EUROPE										
MP		**UP**								
R (km)	*Area (km^2)*	*R (km)*	*Area (km^2)*	*R (km)*	*Area (km^2)*	*R (km)*	*Area (km^2)*	*R (km)*	*Area (km^2)*
46	6538	**2**	14	**45**	6461	**204**	130654	**333**	348208
46	6681	**7**	166	**52**	8392	**206**	132670	**382**	458086
61	11822	**13**	517	**53**	8669	**215**	145784	**385**	465059
63	12650	**23**	1658	**56**	9752	**216**	146413	**386**	467188
68	14691	**27**	2342	**72**	16430	**228**	163482	**410**	527093
74	17381	**39**	4684	**82**	21064	**293**	269905	**467**	685668
106	35580	**42**	5455	**136**	58173	**305**	291165	**471**	696841
198	123658	**43**	5688	**192**	115734	**324**	329560	**475**	709155
								484	736391

Table 7.19. Lower Palaeolithic obsidian transfers in Turkey and the Caucasus regions. Compare with the Earlier Stone Age (ESA) data from table 7.17.

MP		
	R (km)	*Area (km²)*
Turkey	3	28
	5	79
	16	804
	36	4069
	45	6359
	55	9499
	59	10930
	163	83427
	186	108631
	205	131959
Caucasus	12	452
	28	2462
	46	6644
	49	7539
	57	10202
	114	40807

Table 7.20. Turkish and Caucasian Middle Palaeolithic obsidian transfers and territory sizes. Note how the ranges missing from Europe appear in these regions and also the presence of greater values on the upper limit of the km range as opposed to central Europe.

The general trend for shorter African and longer European circulation ranges is supported by other raw material transfers too (table 7.21). Nonetheless, the perception generated by the obsidian movement in Europe is very different compared to the raw material transfers recorded for other lithic resources in the same region. The values presented in table 7.21 are far smaller than the respective obsidian data (table 7.17) in any of the Palaeolithic sub-phases for which direct comparisons can be made. Furthermore, regional, intra-European, differences have been demonstrated (figures 7.14 and 7.15) and they seem to correspond well with the obsidian patterns. In Europe when long distances of raw material circulation occur they are recorded in the central part of the continent only; the area where obsidian movements take place as well. Overall the values for long transfers that Féblot-Augustins

(1999) mentions for Europe only appear as an increase because of the inclusion of Central Europe in the dataset. The longest raw material transfers in Western Europe coincide with the Würm II when cold-stage and steppe fauna characterised the region and they thus suggest that the circulation followed a seasonal pattern of exploitation (Féblot-Augustins 1999). In Central Europe at the same time, raw material transfers reach 300 km (table 7.22) and an overall shift of frequencies towards greater distances takes place (53% as opposed to only 31% in Western Europe).

	EUROPE	**AFRICA**
LP	28.2 (n= 52)	14.6 (n= 52)
EMP	37.8 (n= 33)	
LMP	57.6 (n= 110)	
EUP	114.7 (n= 198)	
LUP	125.01 (n= 112)	

Table 7.21. Average maximum km ranges of other lithic materials in Palaeolithic Europe and Africa (Gamble & Steele 1999). The sample size for each period is given in the parentheses (n).

	WESTERN EUROPE	**CENTRAL EUROPE**
LMP km upper threshold	**100-120**	**300**

Table 7.22. Maximum raw material transfers in Western and Central Europe for the Late Middle Palaeolithic (Féblot-Augustins 1999).

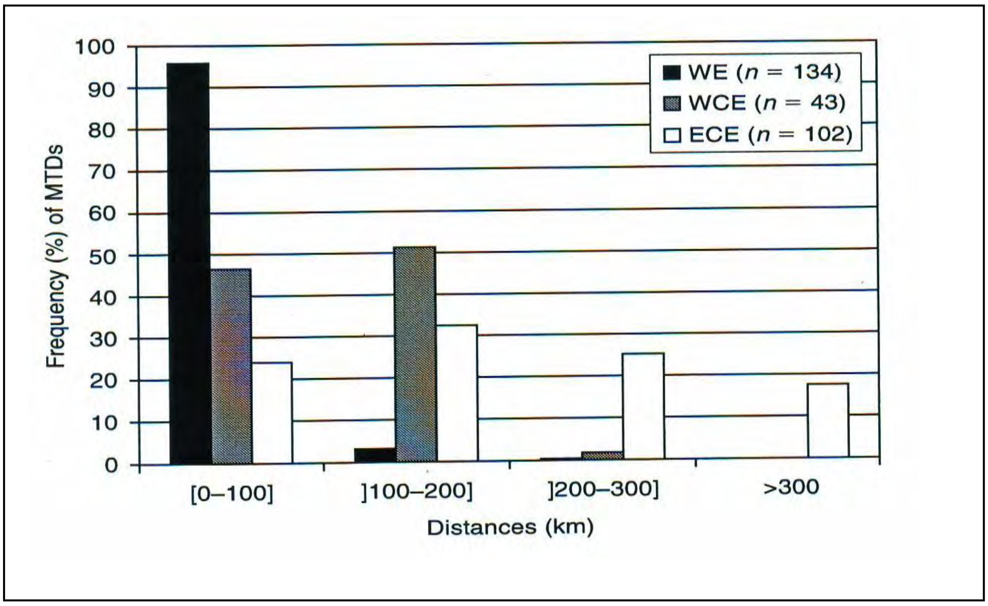


Figure 7.14. Distribution of maximum raw material transfers for Western Europe (WE), Western central Europe (WCE) and Eastern central Europe as established in Féblot-Augustins' 1999 study. From Féblot-Augustins 2009 (figure 3.3).

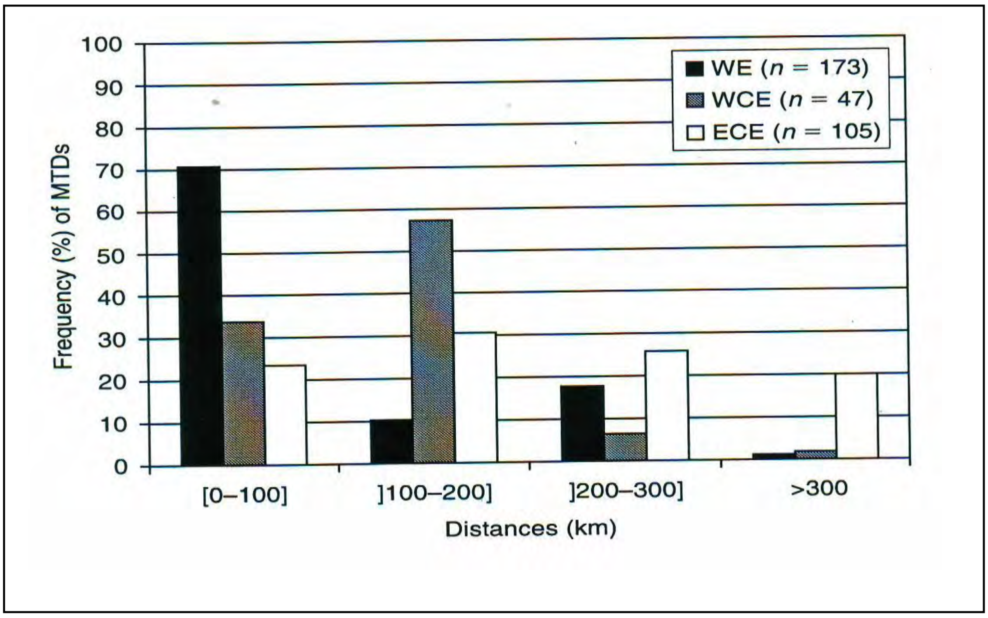


Figure 7.15. Updated frequency distribution of maximum raw material transfers for Western Europe (WE), Western central Europe (WCE) and Eastern central Europe. From Féblot-Augustins 2009 (figure 3.4).

The close link between great distances and central Europe is also validated in Fèblot-Augustins' updated version (2009) of her 1999 study. Great raw material movement distances are now documented from West Europe as well but they are extremely rare (table 7.23). Furthermore, maximum transport distances in central Europe exceed the initially recorded values, reaching over 300 km. More importantly, the 2009 study confirms that maximum transport distances are much more frequent in East central Europe than in any other part of Europe (figure 7.15).

	Western Europe	**Eastern central Europe**
Middle Palaeolithic		
Group mobility	100-120 km (300 km exceptional)	200-300 km
Interaction networks	?	200-300 km
Upper Palaeolithic		
Group mobility	130-270 km	200-250 km (common)
Interaction networks	Up to 380 km; <300 km (probable)	>300, 450, 700 km

Table 7.23. Féblot-Augustins' current propositions about the scale of group mobility and the extent of interaction networks in the European Middle and Upper Palaeolithic based on transfers of lithics alone. From Féblot-Augustins 2009 (figure 3.5).

Overall a 20-30 km round trip appears to be the maximum distance hunter-gatherers walk comfortably in a day in a variety of habitats (Kuhn 1992, Kelly 1995). Nevertheless, obsidian site-to-source distances very often exceed this range both diachronically and interregionally. Of course, the distance at which a resource can be gainfully procured is related to the source's return rate. High-return resources are procured at a longer distance from camp than low-return resources (Kelly 1995: 131). The scale obsidian covers during its movement suggests that obsidian was considered by the Palaeolithic hominins, diachronically and irrespective of region, a material with very high return rates in *social terms*. Its rarity and high visibility made the particular rock a very visible/recognisable symbol of relatedness especially effective at great distances.

5. HYPOTHESIS EVALUATION

Hypotheses 1-3 that obsidian was always treated as a special material, i.e. chosen for its aesthetic quality/ that because of its knapping qualities obsidian is always used when locally available in preference to other raw materials/ that obsidian, despite its aesthetic distinctiveness, complies with the general patterns of the raw material-distance relationship (expressed through quantity and retouch)

Predictions: obsidian is always found at a maximum distance greater than that of other raw materials found at the same locale/ obsidian is always the dominant raw material when a source is available less than 0-10 km away/ when the site-to-source distance is over 100 km, obsidian artefacts will be very scarce and fully retouched

The research has shown that the ranges of obsidian circulation are always variable encompassing both very short and very long distances. Figure 7.16 clearly shows that obsidian distribution is linked to either very short (1-10 km) or very long (>100 km) distances.

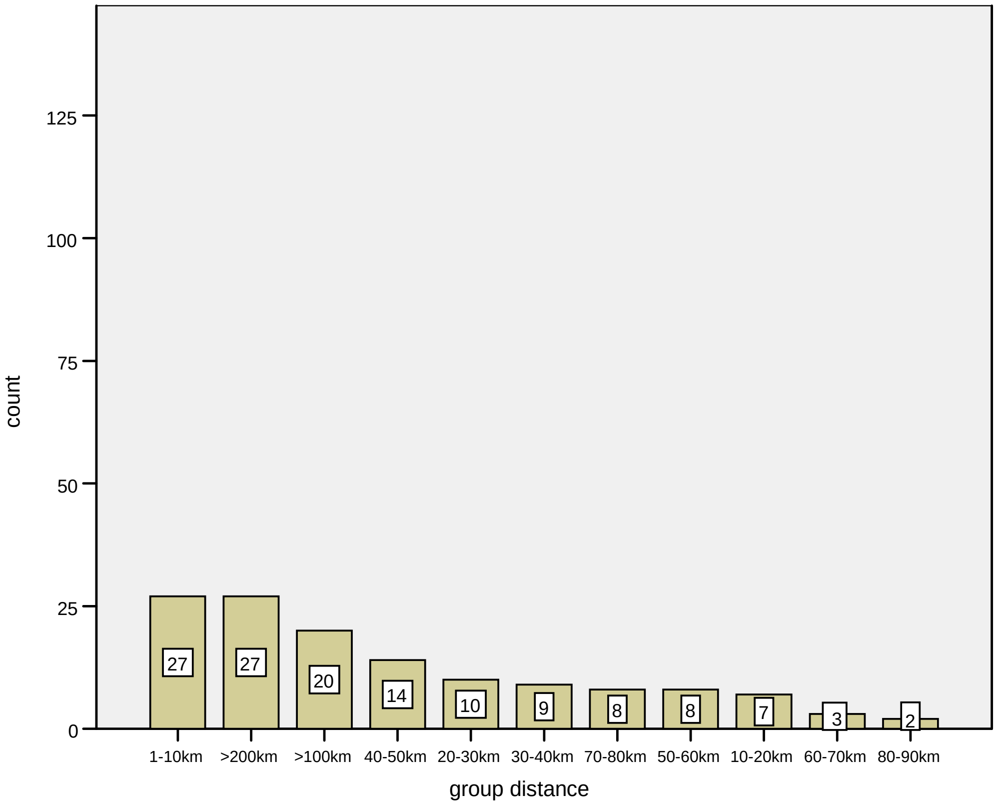


Figure 7.16. Distribution of obsidian distance classes when all regions and Palaeolithic sub-phases are grouped together.

Making the most out of one's local resources, as is the case for Bodrogkeresztúr and GtJi15, is not surprising when the local material is of a quality as good as that of obsidian. Given that short circulation distances are easily covered on a daily basis embedded or not in subsistence strategies greater care must be taken with regards to the long distances of obsidian movement. Previous research on raw material movement has established 100 km as a threshold for the characterisation of transfers as long/exotic although for other researchers (Geneste 1988) this limit is even shorter. Nevertheless, the obsidian data point towards a more complex model as it will be established in the discussion that follows.

The analysis has shown that obsidian circulation was a very vigorous activity during the Palaeolithic in all the research regions and Palaeolithic sub-phases. Distances ranging from a few kilometres up to hundreds of kilometres from the supplying source have been reported (tables 7.4 and 7.5 in section 3). Even if a degree of error is accounted for the generated calculations the result does not alter dramatically; obsidian moves throughout the Palaeolithic and it travels all over the landscape in smaller or larger quantities and in a range of typological forms. Figure 7.16 illustrates the frequencies with which each of the identified distance classes is represented on the dataset. The diagram clearly shows that two specific distance classes, 1-10 km and >100 km, appear on the archaeological record more often than the rest of the identified groups. However, during the same analysis it was also shown that the movement of obsidian corresponds better to very long distances when the two long distance movement classes, namely >100 km and >200 km, are combined.

Raw material circulation ranges that far exceed the radii of daily subsistence movements - as is the case with obsidian - suggest sophisticated behaviour as they involve the choice of materials whose cost of acquisition is far greater than what would normally be expected for covering someone's basic needs. The behavioural implications of this phenomenon are further supported by the Palaeolithic hominins' choice regarding the simultaneous presence of several obsidian sources; in these occasions they chose not to use their nearest sources and, instead, travel long distances for that specific stone, as a few characteristic examples in the previous sections indicated. Instead of using what is readily available, a group consciously decides to undertake a long trip in search of a particular material. In order to elucidate

Palaeolithic behaviour it is essential to understand the reasons that made such a choice necessary.

The notion of choice in the Palaeolithic has so far only been extended to the production and design of specific tool types in an assemblage serving as the medium in completing an immediate or long-term task (Binford 1983). The necessity to solve a particular problem leads to a number of possible solutions of which the most suitable one is chosen. This thesis puts forward the idea that the right of decision is exercised in every stage of the lithic production starting with the very first step of choosing the raw material with which the necessary tool-kits will be produced. More importantly, I argue that choice is a concept with direct links to hominin behaviour and that social behaviour can be fruitfully discussed in terms of choices in raw material use. Choice is already present in the intentions of the knapper prior to the lithic production process and is reflected on him/her actively deciding on the right material to serve the most suitable solution in aid of the goal he/she has set to achieve. As Torrence (1989b: 64) puts it: «…not feel that lithic technology is a direct reflection of the geological setting…but rather the result of careful choices made within the wider context of the tool-using behaviour».

Subsequently, decisions on issues of subsistence, technology or selection of raw materials are not choices of a strictly economic nature but involve social connotations as well. Indeed, webs of choices occurring at different levels and degrees seem to underlie the dynamic interplay between material culture and social life at all times.

Stout *et al.* (2005) and Gowlett (1984) provide clear evidence supporting the conscious exercise of choice by the Palaeolithic hominins. The Oldowan toolmakers at Gona, Afar, Ethiopia, seem able to locate, identify and preferentially select materials with particular attributes. A clear preference towards fine-grained, less porphyritic materials and vitreous volcanics, most likely related to the influence of these variables on fracture patterns and technological suitability, is observed. This high level of raw material selectivity exercised by the Pliocene hominins is a clear indication of deliberate and active choice. The available data demonstrate that in a situation where an assortment of raw materials was available, the Gona toolmakers were capable of exercising a high degree of raw material selectivity. Similarly, Gowlett (1984) has provided evidence supporting the argument that early hominins exhibited advanced mental abilities. The high degree of selectivity on raw materials for stone tools chosen for their particular properties is reflected upon regular and deliberate transports of specific materials.

The willingness to transport and trade materials and objects on a large scale can likewise be interpreted as a sign of deliberate choice on behalf of the people exercising it. With regards to obsidian the hominins' decision, both in Africa and Europe, of using the specific raw material when other useful resources were available supports the above argument. The fact that obsidian was preferred over other technologically competent rocks in a closer distance from the obsidian sources suggests choice on behalf of the Pleistocene knappers. Furthermore, a clear sign of active choice is observed when more than one obsidian sources are present in a lithic assemblage. In several instances, the most abundant obsidian type is not the one from the nearest source. For example, in the Kenyan site GvJm 16, Lukenya Hill, although good quality local obsidian ranges from 33 to 48%, the majority of the obsidian in the site's assemblage comes from a non-local source at least 65 to 135 km away (Merrick & Brown 1984). A similar situation has been observed in another Kenyan site, KFR-A5, dating to the Later Stone Age, from a total of six available obsidian sources in an area from 65 to 165 km, the Masai Gorge one at a 135 km distance was clearly preferred.

Clearly, when locally available, its excellent knapping qualities make obsidian the ideal raw material for the production of efficient stone tools. This reason is less convincing when obsidian is found in long distances. The idea put forward in this thesis is that obsidian was chosen for its aesthetic quality (see discussion in chapter 2), i.e. treated as special material. The comparison of the obsidian transport data with the results of other studies from the ethnographic and palaeoanthropological record showed that the obsidian distances exhibit a stronger correlation with movement for reasons other than subsistence. Specifically, the obsidian data indicate that the circulation of obsidian shows a much better correlation with the movement of a very special kind of «object», i.e. mating partners, rather than with materials of everyday use (see discussion 3.2 in chapter 3). The implication is that the circulation of obsidian during the Palaeolithic was controlled by factors unrelated to economic phenomena. It is reasonable then to argue that during the Palaeolithic obsidian was treated as a special material.

Its aesthetic quality (brilliance) made Palaeolithic hominins stick with it for longer, carry and transfer it long distances even where other raw material sources were present. More importantly, its visual distinctiveness made obsidian the preferred means for the creation of social networks, often much extended ones. Nevertheless, the results of the comparative examination of the selected obsidian samples indicate that despite its physical distinctiveness, obsidian complies with the general patterns of the raw material-distance relationship, particularly prevalent in quantities and retouch.

The site-to-source distances impose restrictions on the typologies of the transported artefacts. Specifically, full ranges of lithic tool production are commonly found in the vicinity of the raw material source with increasingly reduced tool forms correlated with the «stretching» of the source-to-site distance. This is the norm according to the obsidian data when obsidian is examined either in the form of tool types or stages of manufacture. Long distances are reflected typologically with increased numbers of small retouched tools, upon technology with the extensive presence of retouch and absence of cortex, smaller artefact sizes and an overall decrease in the abundance of obsidian specimens in an assemblage. Within a minimum 7 km radius all tool types are recovered with the tool forms becoming increasingly elaborate and reduced as the distances increase from 64 to 107 and 204 kilometres. In terms of operational sequence stages the increase in distance coincides with more advanced phases in tool manufacture. In its final level, this relationship is expressed by solely «finished» artefacts, i.e. small retouched tools, reaching distances over a 100 km.

Distance also exerts a strong effect on tool size; the relationship is expressed in an inverse manner with artefact dimensions decreasing as the distance from source increases. The further the artefacts move on the landscape the smaller their dimensions become. This is particularly apparent with regards to volume. The analysis has demonstrated that the dimension most directly affected by distance is weight. Specimens from sites exceeding the

200 km radius have been found to be the lightest compared to artefacts from archaeological occurrences from more restricted spatial units.

Apart from size, distance is responsible for the ways the basic technological features of the obsidian artefacts are expressed. With the increase in site-to-source distance the extent of cortex on the surface of the moving specimens gets reduced. The opposite relationship holds for the extent of retouch which increases similarly to distance. The technological characteristics of the Palaeolithic assemblages have been proven to be strongly connected to distance.

Distance from source similarly affects the quantities of the circulated material. The relationship established by the analysis of the obsidian assemblages sees that with increased kilometrical movement the raw material quantities transported substantially decrease. Although the extent of an obsidian source affects the initial numbers of tools produced the quantitative reduction these tool-kits experience as they move on the landscape is uniquely a result of the distance involved. The amount and size of «knappable» nodules is undoubtedly associated with their geological source but once the useful nodules have been chosen and the first set of artefacts created there is only a certain amount of tools that can be produced. Furthermore, this initial amount will always get shorter with distance being exclusively responsible for this phenomenon.

Hypothesis 4 that ecology, expressed through the proxy of latitude, will affect the distances over which obsidian is moved

Prediction when obsidian is found in low latitudes (South) it will travel short distances; when it is found in high latitudes (North), it will travel long distances

Earlier in this chapter I discussed the variation in obsidian use according to regional ecology; there I used latitude as my proxy of two ecologically different environments, high and low latitude niches. There it was shown that latitude by controlling the productivity of a region actually controls the ranges of movement, that being fauna, hominins and raw materials. The analysis showed that in general obsidian complies with the same patterns of Southern and Northern movement. This is clearly demonstrated when long-distance obsidian transfers (>100 km) between the two latitudinal niches are compared.

Keeping in mind the 100 km as a barrier in raw material transfers (Féblot-Augustins 1993), the obsidian data clearly demonstrate that even the Lower Palaeolithic/Earlier Stone Age hominins did have the capacities necessary for such a spatial coverage. Not only one but four cases of obsidian movement >100 km provide support to this statement; two in the Near East (Erikli, Kudaro) and two in East Africa (Gadeb, Olduvai Gorge: HWK-East). One of these cases is a unique example of the movement of manuports/nodules for over 100 km in order to be imported in a site (HWK-East) that dates to ~1.6Myr. Despite the problems that make this last case questionable (as it was mentioned earlier the transportation of the obsidian nodules by natural means cannot be ruled out) the remaining examples do provide evidence supporting the above argument.

This pattern is even clearer with regards to the Middle Palaeolithic/Middle Stone Age. Instances of long distance transport are very common in Europe and the Near East and they are not totally lacking from the African record either although they are limited and always of an equal or smaller scale than what is observed in Eurasia. For example, in the case of a stage 3 assemblage the African greatest distance is 80-90 km whereas in the Near East the same type of lithics have been recovered >200 km from their original source. In Eurasia obsidian exhibits a much greater variability range in the distances of circulation; the range is wider for stage 4 («finished tools») in the Near East and for complete reduction sequences in Europe. The furthest distance of Middle Palaeolithic/Middle Stone Age obsidian movement recorded irrespectively of region and form comes from the European continent; it is of the order of >200 km and, not surprisingly, it concerns a fully retouched specimen (Amaliada 13).

In the Upper Palaeolithic/Later Stone Age and beginning with Africa the following observation needs mentioning; the greatest obsidian transport distances do not alter the picture of the previous period. The furthest obsidian has been discovered >100 km from its nearest source; interestingly, but in correspondence to the Middle Stone Age, this distance comes from the «all stages» category. On the other hand, in the only other class present in Later Stone Age (stage 3) the distances appear more restricted than before; the Middle Stone Age 80-90 km radius does not move beyond 30-40 km during the Later Stone Age. In the Near East, no limitations seem to appear as far as the movement of obsidian is concerned; more than that, the specific raw material when present is always associated with the greatest distance classes irrespectively of tool type or operational sequence stage. Stages 3 and 4 (secondary reduction stages) break the 200 km barrier in several occasions whereas the single representative of the «all stages» category is also to be found in a great distance (>100 km). Finally, it is in Europe that obsidian is the most «active» covering a wide range of distances with several instances falling within the two furthest distance classes identified for the purposes of this research. Short distances are only detected in association to assemblages representing complete operational sequences; in the remaining cases obsidian is recovered from areas at least 40-50 km away from the supplying source. Most importantly, in all of the stages present in Europe, cases exceeding the 200 km barrier have been recorded on several occasions. Although this fact is not very surprising when the secondary reduction classes are involved, given that small amounts of retouched tools can travel such distances, it is worth noting that the «all stages» category has three examples of distances >200 km and also two of >100 km. Irrespective of period, these impressive distances are worth further examination in order to elucidate the reasons behind it.

Overall, the circulation of obsidian exhibits a more spatially restricted scale in Africa although instances of long movement are not totally lacking. In Europe, on the other hand, obsidian is always to be found in distances more extended than the African ones and they often reach truly exotic scales. The differing numbers of obsidian sources present in each of the examined regions are partly responsible for the variety observed in the spatial ranges of obsidian movement between Africa and Europe. In Africa the utilised obsidian sources are more densely concentrated on the landscape than what is the case for Central Europe. This means that the African hominins were more likely to encounter an obsidian source without being obliged to travel far making long trips for the acquisition of obsidian unnecessary. In Europe, on the other hand, the sources supplying obsidian suitable for knapping are more scarcely distributed in space resulting in longer trips for those hominins that did not have the satisfaction of occupying spots in the immediate vicinity of the sources of interest. Although the number of available obsidian sources and their distance from a site imposed restrictions on the site-to-source movement of obsidian, latitude undoubtedly was the controlling factor behind the ranges of obsidian transport when high versus low latitude sites are compared.

Hypothesis 5 that climate cycles will affect the distances over which obsidian is moved

Prediction when obsidian is found in cold stages, it will travel long distances; when it is found in warm stages, it will travel short distances

Climate, and its effect on the landscape and availability of resources, is traditionally regarded as the primary factor behind hominins' technological and subsistence decisions. The general environmental and climatic context of the obsidian-bearing sites provided evidence suggesting that, although differences between northern and southern territories do exist, climate alone cannot account for the observed patterns in obsidian exploitation.

The discussion about the Pleistocene environments with which obsidian exploitation is associated has provided strong evidence suggesting that climate cannot fully account for the observed patterns in the obsidian use. The analysis of the available data identified the lack of connection between climate and the typological, technological and quantitative parameters of the obsidian use. However, a correlation between the alternating climatic conditions and the distances in the circulation of obsidian is supported by the obsidian data. A picture similar to that proposed by the habitat-specific hypothesis (i.e. effect of ecology on human evolution: Vrba *et al.* 1995, deMenocal 2004) seems to develop from the raw material circulation data as well. Mild and moist environments provide a better survival potential resulting in more confined movement for the acquisition and exploitation of raw materials. On the contrary, colder and drier landscapes force hominins to move further either purely due to their desire to acquire their preferred materials/objects or following the migrating game. In general, long distance movement of obsidian is associated with phases of deteriorating climatic conditions. Although distances >100 km are not uncommon during interglacial stages, it is usually shorter distances that are involved in obsidian exploitation during favourable conditions. The longest recorded distances in the circulation of obsidian come from sites associated with glacial phases.

Based on the available data, obsidian use takes place both during temperate and cold conditions. Hominins move considerable distances on the landscape for its acquisition irrespectively of the climatic conditions prevailing at each period and their effect on ecology. Notwithstanding the general tendency to ascribe any patterns in hominin activity to climate, the fact that obsidian presence is increased during glacial phases provides further support to the above argument. The patterns characterising the use and movement of obsidian during the Palaeolithic indicate that this activity was not governed by purely utilitarian factors or connected to the survival activities of the Palaeolithic hominins. An alternative that now needs to be explained is the social framework that underpinned the distribution of obsidian. Especially, in the way they would have affected the formation of social relationships and the extent of the social networks present on the Palaeolithic landscape of Africa and Eurasia.

Hypothesis 6 that obsidian has the potential to be used as a marker of change for both the size and complexity of social networks

Prediction network changes will be detected by changes in the distances and frequency of obsidian use during the Palaeolithic

The distances involved in the circulation of raw materials and objects comprise the archaeological signature of the scale of human exploitation. More than that, however, what is observed in the archaeological record are the results of complex decisions made by hominins about the ways they interacted with their landscape, they organised their social environment and negotiated with the people they encountered. Based on the model proposed in chapter 3 and its application on the obsidian dataset a clear pattern has emerged; the gradual extension of the size of the Palaeolithic social networks (chapter 7, section 3.1).

The research has demonstrated that over time significant differences occurred in the scale of obsidian exploitation. *Change* is thus an important element in the movement of obsidian during the Palaeolithic. Time affects the frequency with which certain distance classes appear on the record and this is particularly so with regards to long-distance movement (see table 7.5). According to the available data the scale of obsidian transfers increases from the Lower to the Middle finally breaking all boundaries in the Upper Palaeolithic. Using the limited available information on absolute dates, figures 7.17 and 7.18 were created. Figure 7.17 illustrates the obsidian record of the last 600 kyrs whereas 7.18 shows the complete record of obsidian circulation for which precise dates exist. For the period prior to 600 kyr the number of well-dated sites is very small, all of them exhibiting obsidian movement ranges similar to those of the earliest part of the 600 kyr era.

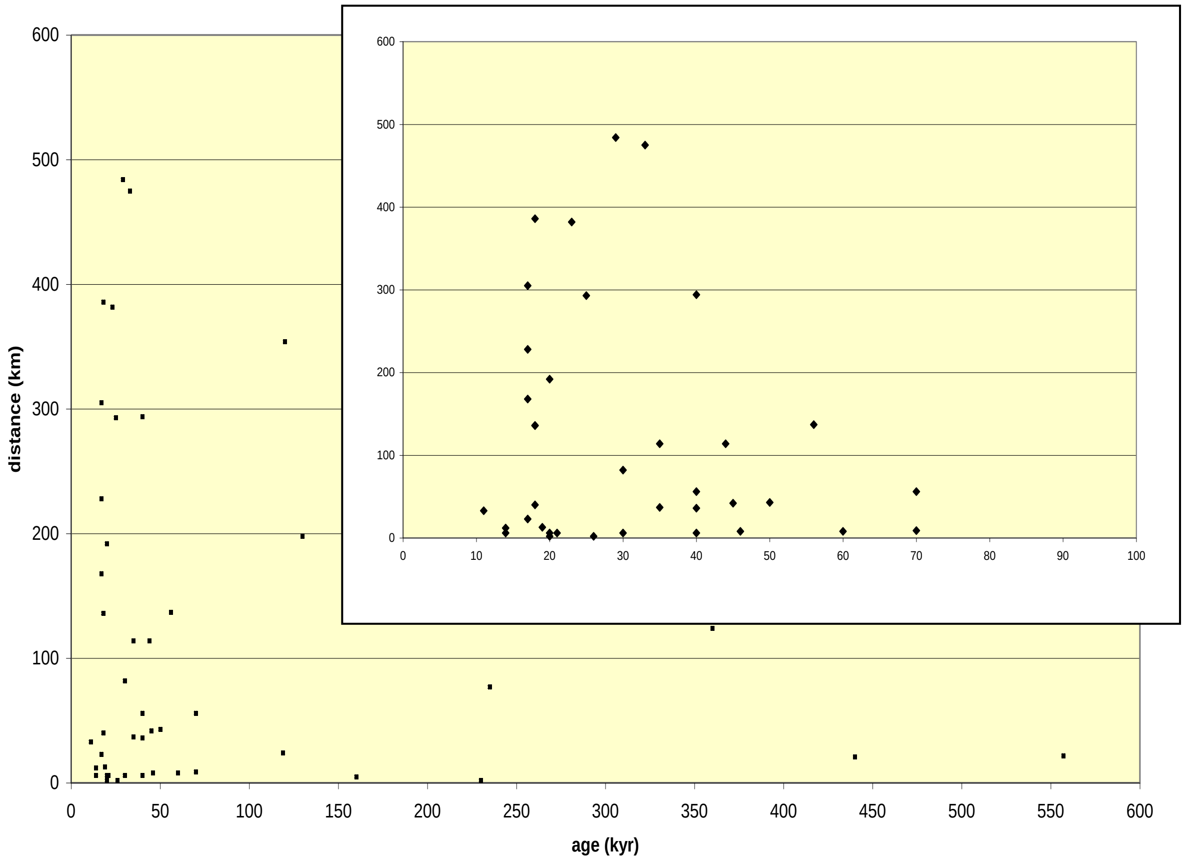


Figure 7.17. Changing scales of obsidian movement in the last 600 kyr. Only sites for which absolute dates are available are included in this graph. The inset shows a more detailed view of the last 100 kyr.

The key period in the changing scales of obsidian movement is the Upper Palaeolithic/Later Stone Age when distances over 100 km cease to be exceptions and become a common feature of obsidian circulation in both Europe and Africa. Or at least, this seems to be the case for central Europe where the lack of Lower Palaeolithic obsidian assemblages results in a limited perception of the region’s source-to-site movement ranges. Distances over 100 km – as well as >200 km - are initially observed in Europe during the Middle Palaeolithic. In the Upper

Palaeolithic a major increase in the number of distances over 200 km is observed. Subsequently, it is reasonable to suggest that the Upper Palaeolithic is the key period that brought significant changes in the scale of obsidian movement in Europe. This is further supported by the Near East dataset where a small diachronic raise in the number of cases exceeding 100 km is recorded. Again the increase from one to six >200 km examples from the Middle to the Upper Palaeolithic, makes the later the important period in increased raw material transfer ranges. However, Africa does not correspond well to this pattern. In East Africa obsidian movement over 100 km is recorded from the Lower Palaeolithic with the frequency of such examples remaining the same for the whole duration of the Stone Age/Palaeolithic. Similar to the rest of the examined regions, neither the scale nor the number of >100 km cases alter throughout that period. However, contrary to Eurasia, Africa never experiences obsidian movements >200 km. Even with the exclusion of the African dataset, the pattern that emerges is that during the Upper Palaeolithic there is a significant expansion in the ranges of obsidian movement as far as distances >200 km are concerned. Nevertheless, I argue that the transitional character of the Middle Palaeolithic must be acknowledged. It therefore appears that on an interregional scale the Middle Palaeolithic/Middle Stone Age is a crucial stepping stone in raw material and hominin movement that transformed long-distance transports from unique phenomena to regular tasks.

Undoubtedly, the occasions of distances exceeding 100 km prior to the Middle Palaeolithic/Middle Stone Age are critical in archaeologists' attempts to elucidate past hominin social behaviour and must also be acknowledged. Early examples of long-distance movement have been recorded and, despite their rarity they merit discussion. The limited absolute dating information for the earlier phases of the Palaeolithic make it hard to build a strong argument with regards to the social skills of the hominins involved in the circulation of obsidian. However, despite their scarcity examples of long-distance obsidian movement in the Lower and Middle Palaeolithic do exist (see outliers in figure 7.18). Their presence in the lithic record of the last 600 kyr suggests that the initial manifestation of skills that appear fully developed by ~50 kyr ago took place prior to the Upper Palaeolithic. Furthermore, the African record provides an example of obsidian movement >100 km in the Earlier Stone Age. In the open air site of Gadeb 8E in Ethiopia four pieces of obsidian are included in the site's lithic assemblage whose movement would have required at least 160 km. The suggested K-Ar and paelomagnetic reversal dates(Williams *et al.* 1979, Clark & Kurashina 1979, Clark 1980, Kurashina 1987, Haileab & Brown 1994) for the site's occupation at ~1.5 Myr (dates ranging from over 0.7 Myr, for the upper levels, to 1.5 Myr, for the older deposits) provide an estimate for very early long-distance obsidian transfers. By comparison, the first instance of obsidian movement over 100 km outside Africa for which secure absolute dates (the technique used is not provided) are available comes from Georgia and the cave site of Kudaro I (Baryshnikov 1999). An approximate date of 360 kyr BP is provided for the site located a minimum distance of 124 km from its nearest obsidian source. At a much later age and between 150-100 kyr BP distances even greater than 150 km are observed for the first time. Karain, a cave site located in southern Anatolia and dated by ESR and TL dates (Otte *et al.* 1998) at approximately between 120-60 kyr BP (two layers: 120-100 kyr and 70-60 kyr), provides the earliest dated instance of obsidian transport over 300 km (minimum recorded distance 354 km). In Africa, although such ranges are lacking, instances of obsidian movement for 200 km are present. An example comes from Tanzania and the rockshelter of Mumba Höhle (Mehlman 1979, Merrick & Brown 1984, Merrick *et al.* 1994, Ambrose 2002) where few obsidian specimens have been unearthed from the site's Middle Stone Age horizons (shell dates of at least 31,070±500 BP are provided for this horizon). The nearest obsidian sources that could have provided the site with the volcanic rock are to be found in Kenya at a minimum distance of 198 km.

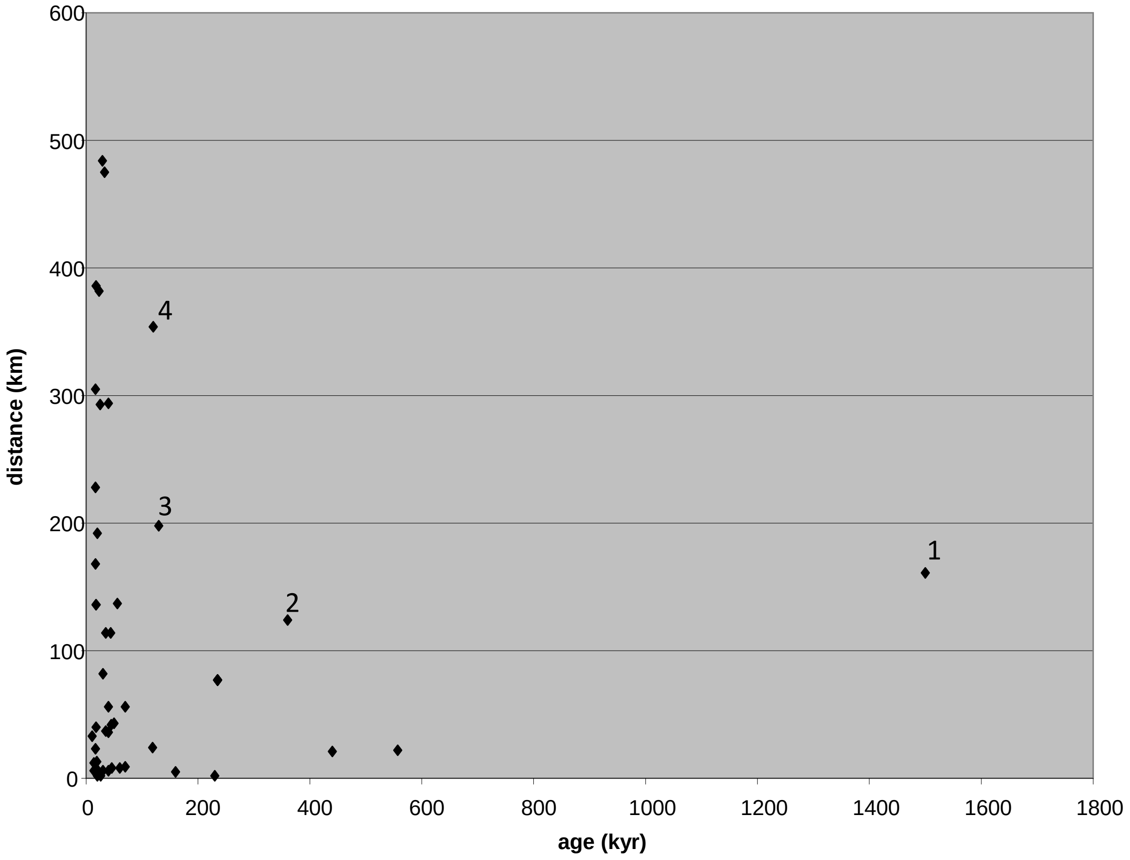


Figure 7.18. Absolute dates for the complete record of the Palaeolithic obsidian use. The numbered sites are the outliers discussed in the text: 1= Gadeb 8E, 2= Kudaro I, 3= Mumba Höhle and 4= Karain.

However, the crucial period in understanding the patterns of change characterising obsidian movement is the time when these exceptions become the general trend, in other words the period when obsidian habitually travels exotic distances. Clearly illustrated in figure 7.17 is the fact that obsidian circulation ranges undergo their most pronounced changes in the last 40 kyr of the Palaeolithic. During this period a substantial increase in the number of sites using obsidian from sources located over 100 km occurs. More than that, distances over 200 km become more common than before and, for the first time, occasions of movement of up to ~500 km are evident. The richer record of absolute dates regarding Upper Palaeolithic sites provides a degree of certainty to this observation lacking from the earlier periods. Furthermore, in the Upper Palaeolithic important changes occur with respect to the quantities of obsidian travelling long-distances. The lithic assemblage of Ballavölgyi in Hungary is dominated by obsidian deriving from Slovakia providing evidence for transports over 100 km - and over a water barrier (river). All this evidence make it reasonable to argue that a full expansion of obsidian circulation ranges characterises the lithic record of the Upper Palaeolithic (<50 kyrs).

Having discussed the changing scales of Palaeolithic obsidian movement and the reasons behind it, it is now time to examine the implications this movement had in the evolution of hominin social behaviour. Despite the different approaches over a suitable definition of modern hominin behaviour, all models recognise certain common features in which behavioural modernity is expressed in the archaeological record. Long-distance movement of raw materials, curation of exotic raw materials and long-distance exchange networks are regarded as a definite signature of hominins behaving in an essentially modern way (figure 7.19 and table 7.24). According to the definition of modern social behaviour I put forward - hominins' ability to intensively interact with each other and most importantly, their ability to create and maintain extended social networks where a feeling of relatedness is retained *in absentia* - these three parameters are particularly informative. I argue that it is indeed possible to infer modern social behaviour in the movement of raw materials as long as they are rare, distinctive and their origins can be securely identified. Obsidian is particularly useful in this respect as its distinctive physical properties (chapter 2) and rarity make it an excellent tool for the investigation of the changing scale of Palaeolithic social life (chapter 7).

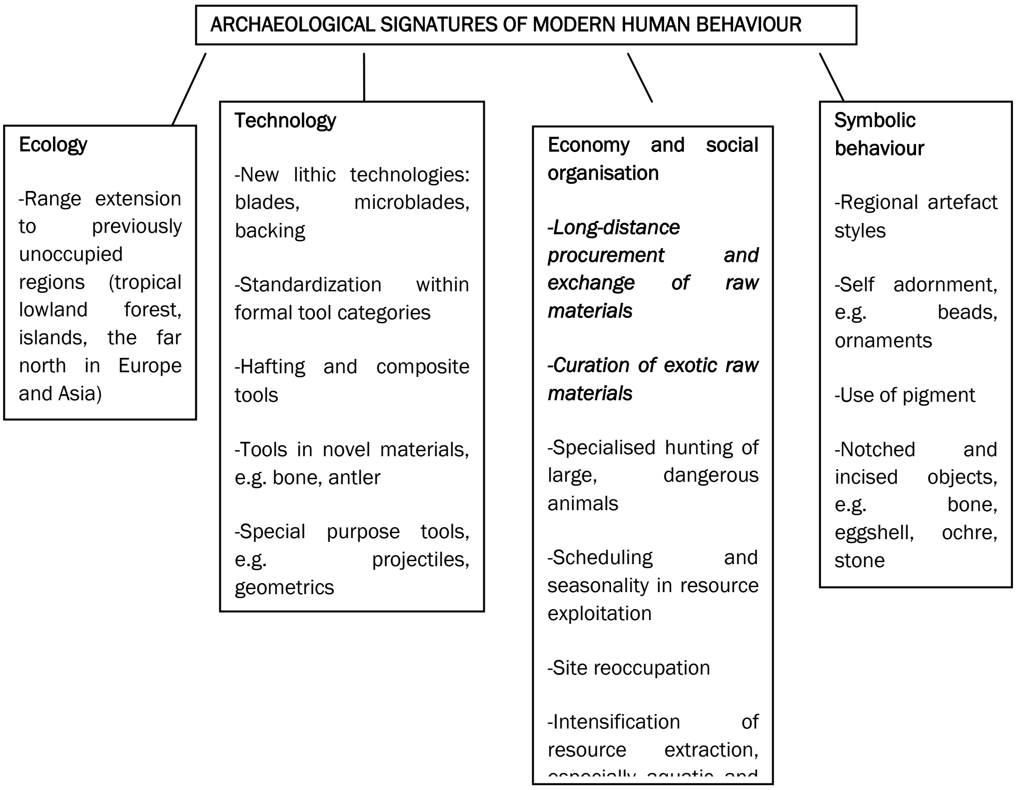


Figure 7.19. Archaeological signatures of modern human behaviour (redrawn from McBrearty & Brooks 2000).

The social expression of sophisticated behaviour, i.e. relatedness *in absentia*, necessitates hominins with the ability to intensively interact with each other and most importantly retain a feeling of relatedness even when face-to-face interactions are not involved in the process. The forming of social relations with people outside one's immediate environment (family) requires advanced behavioural capacities on behalf of the participating individuals. These capacities become increasingly sophisticated as the distance between the interacting individuals increases. When social relationships operate on a spatial scale that brings together complete strangers and allows them to communicate *in absentia* then a modern level of social behaviour has been achieved. The ability to build and maintain extended social networks where interaction/communication occurs on a large scale and is mediated through material culture is the main way modern behaviour is expressed in social terms.

List of traits currently used to identify modern human behaviour	
Trait	**References**
Burial of the dead as an indicator	Gargett 1999, 1999; Klein 1989, 1995; Mellars 1973; 1989;
of ritual	Chase & Dibble 1987
Art, ornamentation and decoration	Ambrose 1998; Chase & Dibble 1990; Deacon 2001; Klein
	1989a,b, 1995; Mellars 1973; 1989, 1991; Milo 1998; Renfrew
	1996, Thackeray 1992
Symbolic use of ochre	Clark, J. 1989; Deacon 2001; Klein 1995; Knight et al, 1995;
	Chase & Dibble 1987; Mellars 1989,
	Thackeray 1992
Worked bone, antler	Ambrose 1998; Clark, J. 1989; Deacon 1989, 2001; Gibson
	1996; Klein 1989, 1995, Knight et al 1995; Mellars & Stringer
	1989; Mellars 1973; 1989, 1991, 1996; Milo 1998; Thackeray
	1992; Vogelsang 1996
Blade technology	Ambrose & Lorenz 1990; Clark, J.1989, 1993; Deacon 2001;
	Deacon and Wurz 1996; Foley and Lahr 1997; Klein1989b;
	Mellars 1989;1996; Watts 1999; Thackeray 1992
Standardization of artifact types	Klein 1995; Mellars 1973; 1989, 1991, 1996
Artifact diversity	Ambrose 1998; Deacon 2001; Klein 1989, 1995; Knight et al,
	1995; Mellars 1973; 1989; 1991,1996, Milo 1998; Thackeray
	1992; Vogelsang 1996
Complexity of hearth construction	Ambrose 1998; Barham, 1996; Gamble 1993, Deacon 1989,
	1995, 2001; Deacon and Deacon 1999; Klein 1995; Mellars 1989
Organized use of domestic space	Deacon 2001; Ambrose 1998; Klein
	1973;1989
Expanded exchange networks	Ambrose 1998; Deacon 1989, 2001; Deacon & Wurz 1996;
	Ambrose and Lorenz 1990; Klein 1995
Effectiveness of large mammal	Avery et al 1997; Binford 1984, 1988, Klein 2001, Marean

exploitation	1998; Marean and Assefa 1999; Mellars 1989; Milo 1998;
	Thackeray 1992
Seasonally focused mobility	Avery et al 1997; Soffer 1989; Klein 1989; 1994, 1995, 1998;
Strategies	Milo 1998
Use of harsh environments	Deacon 1989; Foley 1989; Gamble 1994; Klein 1998, Mellars
	1989, 1993
Fishing and Fowling	Mellars 1973;Deacon 1989; Klein 1995; Milo 1998; Thackeray 1992

Table 7.24. Extended social networks are recognised as evidence of modern hominin behaviour even by the proponents of a late advent to modernity. From Henshilwood & Marean (2006).

Raw material procurement during the Palaeolithic should be considered as an integral part of a large set of strategies aimed at fulfilling not only economic but social requirements as well. In particular, the obsidian remains of the Pleistocene hominins' actions indicate that the specific groups were engaged in an active social life from very early on. The scale of obsidian circulation implies social interactions that suggest more elaborate forms of social structure than those required to ensure intra-group cohesion. The extent of the distribution mechanisms, especially in the case of obsidian, indicates a particular effort exerted for the creation and maintenance of extended social networks. A pattern similar to that observed in Mesolithic societies (Zvelebil 2006) seems plausible for the Pleistocene too. Movement on a regional scale could have relied on a direct system within which social life was intimate but spatially restricted. On the other hand, a specialised long-distance exchange is a more likely strategy for inter-regional movement. Within that system a socially contextualised exchange between distant groups was taking place and social life was increasingly expanding through gradually extending networks. Palaeolithic hominins were managing to retain a feeling of relatedness even from a distance (*in absentia*) stretching their social environment to an extent rarely recognised in the movement of other materials.

Exchange is a form of social communication (Wilmsen 1973) since the «connection between material flow and social relations is reciprocal» (Sahlins 1972: 186). Mauss (1990) has also recognised the importance of material exchange in making social ties tangible. An ethnographic account of the central role material culture has in human life is provided by the Australian Aborigines. Gould's study (1968) has shown that a group feels direct social, and ritual, ties to the stone materials originating from their totemic sites as they perceive them as part of their own being. Those stone materials are carried for use in other localities, within or outside their territorial area, even though material of workable quality is locally available as they help maintain their social connections. If modern humans are capable of placing such emphasis on material culture and use stones as a medium of social value then it is hardly arguable that the pioneers in the use of stone would have followed a similar approach.

The obsidian data support a social environment organised around networks of interaction gradually extending with time. The effort and the risks involved in the extension of social networking beyond one's local environment suggest that the size of their social environment was important to the Palaeolithic hominins. The establishment and maintenance of social networks in the Palaeolithic have always been an important part of hunter-gatherer adaptations to uncertain environments. The creation of social networks able to provide a flow of information among widely scattered hominin groups is traditionally regarded as a safety net in situations of local resource scarcity. Furthermore, information exchange via extended networks, a fundamental form of social behaviour, is regarded as a prerequisite for the colonisation of distant regions and the exploitation of widely dispersed food resources, especially in environments with low effective temperatures (Moore 1981). Although maximising the survival potential was undoubtedly one of the Pleistocene groups' priorities it is far too simplistic to believe that it would have been the only one. Looking for and procuring food and other essential materials from the environment could not have been the sole reasons behind hominins' movement, especially when this involved long-distance transport of materials in quantities too small to have been functional. The very few pieces of obsidian found for example 200 km away usually in an «exhausted» form could not have reached that far as a necessary part of someone's survival tool-kit. As Lovis *et al.* (2006) argue not all mobility and certainly not all exchange is conditioned by utilitarian factors; social needs, archaeologically intangible, may well have been a catalyst for group movement.

The hundreds of kilometres involved in the circulation of Palaeolithic obsidian support the concept of extensive networks built primarily to facilitate the transport of obsidian but also resulting in the extension of the scale of social life of those involved in those networks. The great distances often reached or exceeded by obsidian (chapter 7) support an extension of social life that is first observed in the Lower Palaeolithic, increases in frequency in the Middle Palaeolithic and becomes common in the Upper Palaeolithic when it reaches truly exotic scales. The desire for a specific product - obsidian – urged Palaeolithic hominins to devise strategies for the establishment of effective social relationships to which scale was not an issue. The obsidian material world enabled those hominins to successfully cover increasingly larger spatial scales and form an extended social landscape defined by longer and more varied social interactions than the ambulatory perception of any individual. According to the obsidian data, the Palaeolithic hominins had already mastered the ability for social manipulation in their dealings with the volcanic rock. Obsidian artefacts allowed Palaeolithic hominins to form social interactions without the physical constraints on their ability to interfere with each other. This in turn freed them from the necessity of face-to-face interaction for the establishment and maintenance of extended networks of communication. Within this framework relatedness is achieved through the exchange of materials. Throughout the Palaeolithic, artefacts enabled hominins to retain a feeling of relatedness during face-to-face interactions but, most importantly, from a distance (*in absentia*). In long distances, materials and objects are transformed into symbols «representing» a certain group/network and enabling the people who share in the material culture to attain a feeling of «belonging». Every network/micro-society attaches a portion of its «self» in the product exchanged and this self is transferred from group to group bringing all the micro-societies (networks) together into an extended macro-society (social landscape). The value of the artefact would have imposed restrictions on the scale hominins were willing to move for its acquisition. Obsidian, through its rarity and attractiveness, became a material with such a social value that creating and maintaining extended social networks for its distribution was a worthwhile effort.

The fact that the 100 km threshold (Féblot-Augustins 1993) is commonly crossed by obsidian, occasionally even in the Earlier Stone Age, requires an investigation of how distances of such a magnitude were achieved by the Palaeolithic hominins. If raw material movement is given a purely economic character, a problem arises for archaeologists; to ascertain whether they are dealing with a direct procurement system or with an indirect exchange system. Following research in the Neolithic period, these are the two strategies that could have been in operation: a) direct procurement or, b) indirect procurement/exchange. In the first case, the hominins themselves move directly to the obsidian source to acquire the desired material whereas in an indirect procurement strategy, the material reaches the hominins who desire it via exchange networks. I argue that the best way to tackle this problem is by replacing the purely economic aspect of networking by a more social understanding. Emphasising the social character of raw material movement leads our attention to the behaviour of the hominins with whom the artefacts travel. If approached as a behavioural phenomenon the direct procurement *versus* exchange model debate is not that central in understanding the formation of networks. Although it would be informative to securely claim whether long-distance raw material movement is a result of individuals or groups acquiring the material directly from its source or the end product of a long chain of smaller exchange events it is not vital in the study of modern behaviour. Indeed, the interpretative value of the direct/indirect procurement concept is limited when applied to the Palaeolithic record. The deficiencies of this dichotomy in explaining Palaeolithic phenomena becomes clear when it is realised that the direct/indirect procurement distinction was specifically built with the Neolithic record in mind aiming at explaining economic events of that particular period and the origins of centralisation. Both concepts (direct, indirect procurement) make implicit use of the notion of lithic quarries (for example Torrence 1982). In chapter 4, section 2 it was discussed that the Palaeolithic record in general lacks this type of information. Subsequently, Palaeolithic research cannot truly benefit by getting involved in the direct/indirect procurement debate. I argue that in the discussion of behavioural modernity the dichotomy of direct *versus* indirect procurement of raw materials is not essential. It is rather the scale of the transfers that are a more useful analytical unit than the mode they were fulfilled by.

The scale involved in long-distance movement of raw materials and other items strongly suggests that the acquisition and circulation of these materials have little or nothing to do with routine subsistence or other «utilitarian» activities (Whallon 2006). The obsidian data point towards an indirect procurement strategy in terms of behaviour. The fact that the scale of obsidian movement was repeatedly exceeding areas recognised as a daily subsistence radius points towards a special system for the successful accomplishment of the undertaken task. The results of the obsidian data analysis, especially the distance-typologies and distance-quantities relationships, support an indirect procurement strategy in the circulation of obsidian and advanced behavioural capacities on behalf of the participating hominins.

While local group mobility patterns can be predicted in terms of resource concentration and predictability, longer-distance networks seem most readily related to inter-group correlation of resource availability and predictability (Whallon 2006). Of course, the functions of one kind of movement are very likely to have been embedded in other kinds of movement. However, with regards to exotic items an indirect procurement strategy specifically dedicated to that purpose seems far more plausible. Especially when exotic items are the circulated objects, procurement by some process not related to regular subsistence moves is far more likely. In most cases, long-distance circulation of raw materials or items is interpreted as indications of contact among separate social groups, which are otherwise economically independent.

Irrespective of the exact patterns of their movement, raw materials and objects cover various distances on the landscape; distances whose coverage relies on the hominins' desire to acquire them. Materials move and with them people move as well; not randomly, not without reason, but as a result of forward planning. Irrespective of whether a single group covers the total recorded distance of raw material movement or a down-the-line system in the acquisition of the moving objects is employed, groups have to interact in order to communicate their «requests». The further the source of the desired material the longer the interacting network; even if it is not the same individuals covering the full length of that network. Part of their selves moves along the network through the demand and desire for the particular material. This allows for an extended social landscape which opens up innumerable possibilities for hominins to interact and communicate directly or indirectly.

Keeping in mind that the size of the procurement networks is regarded as a reliable measure of the size of the action radii of Palaeolithic hunter-gatherer communities (Roebroeks *et al.* 1988), social behaviour seems to account for the observed changes in obsidian circulation distances during that period. The identified patterns in the exploitation of the particular raw material seem primarily to be a function of fundamental changes in the behavioural abilities of the Palaeolithic hominins. Irrespectively of the means by which obsidian was circulated on the Pleistocene environment the scales involved and the effort exerted in the creation and maintenance of extended social networks.

6. CONCLUSION

In a social explanation of raw material movement, as it is sought in this thesis, *change* and *variation* are two crucial parameters. In section 3 change was established as a feature of the diachronic patterns in obsidian circulation whereas section 4 established variation as an element in the interregional patterns of the same phenomenon. Bringing those two parameters together in an attempt to build a social framework of the obsidian Palaeolithic exploitation will be the aim of chapter 8. The effect of ecology on the obsidian distances and the time it stops being restrictive, i.e. the time when humans overcame environmental limitations to their movements is socially critical. This is the time humans conquered their local environments and managed successfully a global landscape by organising/developing efficient social networks.

Indeed, there is a strong feedback element in the links between ecological and social factors in hominin evolution. As Foley and Gamble (2009) show, most of the major changes of human behavioural evolution coincide with climatic and environmental changes. However, not all hominin evolutionary trends respond to phases of climatic change. The evolution of 'human society' is underpinned by ecological factors, but these are influenced as much by technological and behavioural innovations as external environmental change (Foley & Gamble 2009: 3267). Some of the changes that occurred also involved the consequences of more endogenous elements of the hominins themselves (Foley & Gamble 2009: 3277). The development of a cultural mechanism that enabled humans to maintain extended social networks is an evolutionary trend for which ecology/climate alone cannot take credit.

The hominin ability to maintain a feeling of relatedness even in the absence of face-to-face interaction and to prescribe a part of one's self on an inanimate object, i.e. stone, which is then used to bring distant individuals into an emotional proximity, is such a behavioural innovation. Obsidian, in particular, with its distinctive physical and visual properties, attracted the hominins' aesthetic sense and acquired a central role in the expansion of social life both in Africa and Europe. Handled and exchanged among Palaeolithic hominins the obsidian «*...artifacts liberated individuals from physical constaints on their ability to* *interfere with each other and exposed them to material interference from others. This enabled human exploitation at scales otherwise inconceivable…*» (Wobst 2000: 48).

Chapter 8

Conclusions

1. PALAEOLITHIC SOCIAL NETWORKS; LITHIC, ORGANIC AND OBSIDIAN EVIDENCE

«...material objects are essential, active agents in the maintenance of complex social relations. They not only stand as tangible abbreviations for the quantity and quality of resources that an individual has access to, but also the production and acquisition of new classes of objects places groups of producers and consumers in new relations to one another...» (Gero 1989: 103).

This thesis set out to examine the archaeological evidence for the distribution of a very distinct raw material, namely obsidian, and then used these data to develop a network model of social interaction on a Palaeolithic timescale. Current models in the study of hominin evolution have failed to satisfactorily explain a crucial aspect of hominin life: society. The aim of this thesis was to establish the theoretical framework with which a more fruitful approach to the subject of social evolution could take place and test it with raw material (obsidian) data. Material culture, expressed through obsidian, served as the means through which the mental and social patterns in the behaviour of past human groups were investigated.

Obsidian, a natural volcanic glass, was chosen as it is one of the very few raw materials that its special physical and chemical properties enable archaeologists to track pathways of trading networks and, most importantly, hominin interactions. Keeping in mind that obsidian outcrops occur in distinct areas, that these volcanic fields are a rare occurrence on the landscape, and furthermore, that obsidian flows are usually uniform in chemical composition, this raw material is ideal for the characterisation of geological sources and the secure correlation of artefacts with them.

The research demonstrated the chronological and regional framework of the obsidian use and the changes occurring in association with the time/space parameters. It has been shown that obsidian was not only present in the everyday life of Palaeolithic populations but its exploitation was probably strongly connected to behavioural rather than purely utilitarian or environmental factors. Through the distribution of the specific raw material social encounters were taking place and social relationships were created among individuals and groups. This was achieved either through direct (face-to-face) communication among the sharing individuals or indirectly by using obsidian as a symbol of relatedness. The distances obsidian covered on the Pleistocene landscape helped in the understanding of the scale of hominin interactions and led to inferences concerning the changing scale of social life in the Palaeolithic. The emphasis was not on the establishment of the type of procurement strategies involved in the movement of obsidian but on the cognitive and behavioural implications the transport of artefacts, especially valuable ones (like obsidian), has in the social life of the interacting participants.

The results of the obsidian data analysis brought to light a number of observations that appear to be in marked contrast with traditionally established models regarding Palaeolithic social life. According to the generated patterns the movement of obsidian was most closely linked to long-distance transports. This observation suggests extended social networks which, according to the social brain hypothesis, necessitate minds that function in a modern way. The social brain hypothesis claims that a modern mind is characterised by its «carrying» capacity, however in this thesis what distinguishes a modern mind is its ability to retain a feeling of relatedness *in absentia*, enabling human relationships to stretch over a face-to-face scale. The distances involved in the obsidian movement, the planning depth required for the successful coverage of those distances, the degree of choice and the aesthetic criteria implied by the selection of the specific material all argue for hominins who think and behave in a modern way.

Two key questions have been answered in this thesis: a) when the shift to modern patterns in social behaviour occurred and, b) where this shift first took place. As such it contributes to the discussion of one of the most exciting but complicated issues in human evolutionary studies, namely the social structure and social relationships of our ancestors. Various approaches have been employed with the aim to provide a satisfactory model describing the process of socialisation, i.e. modern social behaviour, and determining the basic features of hominin behaviour and how they evolved. Modern hunter-gatherer societies/ethnography (e.g. Lee & DeVore 1968, Schweizer *et al.* 1997, Stark 1999) had traditionally been examined as the best analogue of Palaeolithic societies. More recently, primatology and primate socioecology (e.g. Rodseth *et al.* 1991, Butovskaya 1995, Silk 2007, Barrett *et al.* 2007) have been very widely used in scientists' attempts to understand the evolution of hominin society and hominin social behaviour. However, it becomes increasingly clear that none of these analogies constitute the best way of approaching this issue. Their explanations are based on existing systems of social organisation which cannot be directly applied to the past (Wobst 1978). For example, see Wobst (1978) arguing against the «tyranny» of the ethnographic record in archaeology. Moreover, researchers have failed in detaching themselves from contemporary ideas as to what constitutes modern behaviour and how it should be expressed, resulting in a much skewed perception of the past.

From the above it is clear that the archaeological literature has dealt with the concept of modernity using proxies that fail to bring behaviour to the front. However, with my thesis I argued for modernity as a behavioural phenomenon. In doing so, I am not the first researcher to take behaviour into account in the context of archaeology. Starting from different viewpoints and using a variety of means a number of theories have been developed providing their own output in the identification of the earliest modern humans. Although the concept of modern behaviour has received a lot of attention in recent archaeological research, the problem of developing a precise definition remains unsolved. Scholars interested on the subject have proposed a number of definitions emphasising a number of different parameters according to the period and region they investigate.

From a Palaeolithic perspective the investigation of modern behaviour has mainly been discussed in association to anatomical modernity. The various ideas that have been proposed can be summarised in two main theories: a) the Replacement/Out of Africa model (Stringer & Andrews 1988, Klein 1999) according to which the first fully modern humans evolved in Africa, at some point moving towards Eurasia where they absorbed or replaced the archaic humans present in the area and, b) the Multiregional Hypothesis which claims that modern humans independently evolved everywhere at more or less the same time and then genetic intermingling allowed African, European and Asian humans to assume a common genetic makeup (Wolpoff *et al.* 1994). Genetic and palaeontological data support an African origin of modern humanity but irrespectively of which scenario someone chooses to accept, both these models fail to provide convincing data on the timing of modern social behaviour.

The first model sees behavioural modernity as a co-product of anatomical modernity. This biological definition emphasises characteristics of modernity and is based on a prior definition of biological modernity in terms of morphology and speciation (Henshilwood & Marean 2003). Within this context behaviour is expressed in a number of neurological changes that are implicitly associated with Anatomically Modern Humans (Klein 1973; 1995; 1999; 2000; 2001; 2006). This theory regards the appearance of modern hominin behaviour as a sudden revolutionary event that occurred at some point during the last 50 kyr and it usually referred to as the Upper Palaeolithic Revolution.

The second set of theories sees behavioural modernity as independent of anatomical/biological changes and rather as a gradual evolutionary process that was initiated at some point during the Middle Stone Age and is archaeologically observable. The proponents of this model claim that it is possible to infer modern behaviour in the archaeological record and they have developed lists of such archaeological traits of modern behaviour. Traditionally, Europe has served as the place for the identification of those behavioural traits that separate modern from pre-modern populations (Mellars 1989a; b; 1991; 1996). Cave art, body adornments and figurines are considered the *par excellance* traits of a behaviourally modern species. More recently, however, Africa has received its own «trait list» (McBrearty & Brooks 2000) of behavioural modernity emphasising parameters other than the ones solely linked to symbolism or style. Technological complexity and extended networking become now the crucial aspects of modern behaviour according to the Gradual Evolution Model as they require social learning.

Establishing the temporal framework of modernity has proven a much more demanding research topic. This is partly due to the means with which modernity has been described and scholars' controversial ideas on how modernity is expressed. In Palaeolithic research especially the problem of recognising the archaeological signatures of modernity has been a very difficult one to tackle. Again, two models prevail: a) the Revolution Hypothesis and, b) the Gradual Cultural Evolution Hypothesis. The Revolution Hypothesis predominantly based on European data but arguing for Africa as the place of origin, claims that fully modern human beings evolved, biologically and culturally, in a sudden event that took place very recently (Mellars & Stringer 1989). The «quantum leap» that this hypothesis recognises in human evolutionary history is associated with a fortuitous change that enabled the human brain to represent the world in a symbolic manner. The proponents of the Revolution Hypothesis suggest that the «revolution» occurred at the period around 50 kyr, a phase that in Europe is marked by the appearance of the cultural signatures associated with the Upper Palaeolithic (e.g. Klein 1989; 1994; 1998; 1999; 2000, Stringer & Andrews 1988). Secondly, there is what could be termed the Gradual Cultural Evolution Hypothesis. The advocates of this hypothesis (e.g. McBrearty & Brooks 2000, Barham 2001, Henshilwood & Marean 2003) also place the origin of modernity in Africa but they see it mainly as a gradual cultural process rather than an abrupt change event. According to this model the characteristic signals of the technological and social modern human repertoire were accumulated gradually and at the same time with the appearance of the first anatomically modern forms of *Homo sapiens*. This transition is expressed intermittently from the Middle Stone Age onwards with its initial stages dating as far back in time as 350 kyr ago. The advocates of the Gradual Cultural Evolution Hypothesis claim that the material expression of behaviours associated with modern thinking, such as symbolism and innovation, can be found in Middle Stone Age African assemblages and are not an exclusive property of the European Upper Palaeolithic.

For the proponents of the first model, the Revolution Hypothesis, modernity is a biological phenomenon and as such it is equated with the appearance of the Anatomically Modern Humans or *Homo sapiens* (Mellars 1973; Mellars & Stringer 1989, Klein 1998; 1999; 2000, Stringer & Andrews 1988). Within this framework, emphasis is placed on the anatomical features of the species; *Homo sapiens* were also behaviourally modern but the stimulus for this modern behaviour was a neurological advance, most likely a random, selectively advantageous mutation. Furthermore, *Homo sapiens'* behavioural modernity was assumed after the species had acquired its full set of anatomical/biological modern characteristics. The most likely date for this development is the period between 50 and 40 kyr. On the contrary, the proponents of the second model, Gradual Cultural Evolution Hypothesis, claim that modernity should be understood as a process implicitly associated with hominins' behaviour and its material expression (McBrearty & Brooks 2000, Barham 2001; 2002, Henshilwood & Marean 2003). As such, it is not necessarily related to the emergence of modern forms of *Homo* but it should be understood as a behavioural phenomenon that, depending on the material evidence could have taken place prior the occurrence of the biological changes that resulted in the appearance of Anatomically Modern Humans. The advocates of the Gradual Cultural Evolution Hypothesis state that several of the signatures of modern human behaviour are clearly present in the archaeological record (at least the African one) of the period between 350 and 200 kyr.

Despite archaeologists' recent interest in hominin modern behaviour, this thesis is the first attempt to discuss behaviour in archaeological terms, i.e. stone tools. I argued that modern behaviour is expressed in social complexity and I showed that its temporal framework can be successfully established through social networks and obsidian movement. In order to deal with this research gap most effectively a completely different approach is required; a method that emphasises the surviving residues of those past social encounters that took place in the Pleistocene world. In other words, what is needed is a discussion of social evolution in archaeological terms. Palaeolithic discoveries are often regarded as insufficient to undertake this task and too fragmentary. However, it must not be forgotten that it is these objects that constitute our only direct link to the past phenomena archaeologists try to explain. I argue that in order to fully understand hominin behaviour and social evolution researchers have to concentrate on archaeological artefacts. In the context of my thesis I will aim to provide sufficient evidence that a social understanding of the past is feasible through material culture.

According to the features claimed as archaeological proxies of modern behaviour (see figure 7.20 and table 7.24 in chapter 7) long-distance procurement and exchange of raw materials and long-distance exchange networks are clear indicators of a behaviour associated with a behaviourally modern hardware. In essence, the ability to travel long distances and create long networks, is a basic characteristic of modern behaviour and, subsequently, the study of these networks provides an unparalleled assistance in understanding and explaining modernisation. I am particularly interested in modern social behaviour which I define as the hominins' ability to intensively interact with each other and most importantly, their ability to create and maintain extended social networks where a feeling of relatedness is retained even when face-to-face interactions have ceased. I argue that it is indeed possible to infer modern social behaviour archaeologically and specifically in the movement of raw materials as long as they are rare, distinctive and their origins can be securely identified. The movement of raw materials and finished objects constitutes the most archaeologically visible evidence for Palaeolithic networking. Obsidian is particularly useful in this respect as it is a rock that forms only under very special tectonic conditions which denote it with distinctive physical and chemical properties and make its geological sources a very rare occurrence on the worldwide landscape. Its rarity makes it an excellent tool for the investigation of the changing scale of Palaeolithic life. By examining the use of obsidian and the spatial dimensions of its movement on the Palaeolithic landscape I showed that modernity is not a biological phenomenon but rather a cultural (behavioural and social) one.

1.1. Three «Revolutions» and the Time-Frame of Modern Social Behaviour

«…representational art, in a painting on a cave wall, or in a finely shaped bone object, requires essentially a development of the mental abilities shown in stone working, in the proportions of the Kilombe bifaces and in the technology of Kapthurin…» (Gowlett 1984: 188).

«...if we are right to assume that **Upper Palaeolithic** *hunters...were capable of making occasional movements…there may also have been some small-scale exchange between groups and individuals...this would not have been remarkable in itself...»* (Renfrew 1966: 50, my emphasis)

The Palaeolithic obsidian record discussed in this thesis has provided an important input in the investigation of the evolution of modern hominin social behaviour. The data I have presented have established extended social networking as an implicit characteristic of modern social behaviour. The obsidian data allowed an investigation of Palaeolithic society and the changing scales of hominin social behaviour diachronically in order to put modern social behaviour in its appropriate temporal context. This section deals with the time-frame of this phenomenon making use of a concept traditionally employed in discussions of change: revolutions.

Revolutions have been a key theoretical tool in archaeological research in explaining human's interference with the physical world and the changes in the material signatures the various hominin species left behind (Bar-Yosef 1998). The best known use of the concept is by Childe (1958) who proposed the Neolithic Revolution as an explanation to the changes that appeared on the archaeological record with the adoption of agriculture (Cole 1959). Childe claimed that the effect the sedentary way of life had on humanity was so significant that a revolutionary character was to be granted to the Neolithic period. Within this framework, the evolution of human behaviour was not left unaffected; the Neolithic Revolution became for years the boundary between pre- and modern behaving human species, them *versus* us.

In his sapient paradox (1996) Renfrew preserved the distinction between pre- and modern humans, by claiming that humans had indeed acquired modern mental/behavioural capacities by approximately 30 kyr, especially the use of symbols, but for some reason did not use them until «a sedentary, farming life allowed them to realise their full potential and assume a modern identity» (Gamble 2007: 160). Even the most recent developments of Palaeolithic archaeology have not managed to alter this perception significantly. The advocates of a recent advent to modernity (e.g. Klein 1998, Mellars & Stringer 1989) retained this separation between non-modern and modern behaving hominins only moving the timing of this phenomenon back to the Upper Palaeolithic (~50 kyr).

Within the time-frame of the Palaeolithic obsidian exploitation three revolutions can be recognised. The first one, which could be defined as a Pre-Human Revolution, broadly coincides with the Earlier Stone Age/Lower Palaeolithic. In archaeological terms it is associated with the shift from the trees to the ground, the acquisition of upright posture (bipedalism) and the first appearance of stone tools. The second one is the Human Revolution as promoted by the advocates of an early timing for the appearance of complex lithic technologies and advanced *Homo* species dating to the Middle Stone Age/Middle Palaeolithic. This «revolution» is closely linked to the development of the brain (encephalisation), intelligence and, possibly, language. Finally, the third, and most popular, revolutionary event is the Upper Palaeolithic Revolution chronologically coinciding with that period, directly (and exclusively) linked to Anatomically Modern Humans and reflected in representational art and symbolism. It is with the changes this «revolution» brought that hominins entered civilisation as society, morals and advanced technology first appear as a result of this event.

These three revolutions have been central in the investigation of modern hominin behaviour. Indeed, the origins of modern human behaviour research has caused one of the most severe debates in archaeological thought summarised in the two statements opening this section. Palaeolithic archaeology in particular, investigating the where and when evidence of this phenomenon first appear, has played a central role in the above dispute. Although various definitions have been offered, as modern is usually described a behaviour that is mediated by socially constructed patterns of symbolic thinking, actions and communication that allow for material and information exchange between and across generations and contemporaneous communities (Henshilwood & Marean 2003) even when face-to-face interactions are not involved.

Even though the importance of symbolism is not disputed, the previous sections concentrated on features that are recognised as connected to modern behavioural hominin abilities with regards to their social environment. There it was shown that extended social networks, planning depth, choice, and a sense of aesthetics are attributes that characterise human life from very early on. The ability to form intense social attachments has a biological architecture with definable molecular and neural mechanisms (Young & Wang 2004) that evolved sometime within the Pleistocene. Individual intelligence is strongly correlated to social complexity; as Humphrey (1976; 2007) states «the higher intellectual faculties of primates and hominins have evolved as an adaptation to the complexities of social living. Styles of thinking which are primarily suited to social problem-solving colour the behaviour of man and other primates even towards the inanimate world» (Humphrey 1976: 316). So, it is possible to infer the level of social behavioural complexity in the archaeological record and *vice versa*.

Many of the behavioural skills that were traditionally assumed to have developed very recently and in association to anatomically modern humans appear to have already been in place much earlier than expected (D'Errico 1998; 2007, Kozlowski & Sacchi 2007). A high level of cognitive, behavioural and social complexity characterised the armature of Pleistocene hominins. Archaeologically demonstrated in raw material selectivity and raw material circulation ranges modern behaviour seems to have been a very early development in human history. In terms of selectivity, the great age of the Gona sites (discussed in section 5, chapter 7) indicates that such an ability did not develop over time but rather was a feature of the Oldowan technological variation from its very inception (Stout *et al.* 2005). A similar situation has been described by Schick and Toth (1994) and Hay (1967) for raw material preferences in Olduvai Gorge. In addition, the established movement of artefacts over distances well in excess of 10-15 km observed even with respect to *Homo habilis* (Toth 1985, Potts 1988) demonstrates that anatomical modernity should not be regarded as a prerequisite to behavioural modernity. The investigation of the Palaeolithic obsidian use indicates that abilities seen as an expression of modern behaviour are already evident in early hominins. Although the extent to which these skills are manifested change with time, pre-anatomically modern humans regularly anticipated needs from one day to the next, they exercised their right to choice and selectivity, they had a sense of aesthetics and were able to form and maintain extended social networks *in absentia*.

Establishing the temporal framework of modern behaviour and the changes it underwent with time is central in our understanding of the formation and organisation of Palaeolithic societies. According to Wynn (1985; 1990) modern intelligence evolved sometime between 1.5 million and 300 thousand years ago. An examination of the chronological framework of the Palaeolithic obsidian use indicates that the period associated with the period around 300 kyr has indeed been crucial for the behaviour of Pleistocene hominins. In chapter 7 it was discussed that non-local materials, high-quality raw materials and curation are some of the signs of modern behaviour. The obsidian data, as analysed in chapters 6 and 7 show that indeed all these features of lithic technology were in operation before the Upper Palaeolithic.

More importantly, long distance movement of obsidian, although most popular in the Upper Palaeolithic, was not uncommon from the Middle Stone Age/Middle Palaeolithic (300 kyr) onwards suggesting hominins that functioned in an essentially modern way from at least that period.

Further support to the above argument is provided by the comparative analysis of two early hominin groups and their technological achievements. Wynn (1985) applied Piagetian theory (psychological method) on the Olduvai Gorge Bed I and Isimila and attempted to assess their intelligence. The conclusion that was reached indicated that the Levallois is not a conceptually demanding technique and it does not represent a greater intellectual level than that of Acheulean handaxes. Levallois and blade technologies are usually regarded as representing different degrees of intelligence have been found not to be that dissimilar to other technologies after all. In fact, the geometry of Acheulean bifaces (Wynn 1990, Gowlett & Crompton 1994) requires a stage of intelligence typical of fully modern humans indicating that the Levallois and blade technologies, although important, do not mark a leap in the hominin cognitive and behavioural abilities. The cognitive and behavioural similarity between anatomically modern humans and their predecessors is even more pronounced in the Neanderthal record. The two groups do not appear to have been radically different especially in their technical cognition; the Neanderthal skills in tool manufacture have been identified to be as effective as those documented for modern humans (Wynn & Coolidge 2004).

The temporal framework of the obsidian use supports the Middle Palaeolithic/Middle Stone Age as the period when these essentially modern abilities were more or less fully developed. The social brain hypothesis (Dunbar *et al.* 1998; 2003) points towards the same conclusion too. Brain size is important in the discussion of social evolution as it controls the size of social networking (expressed in group size) by constraining the hominin memory for relationships and the social skills to manage those relationships. Applied to primatological and hominin data, a significant increase in brain/neocortex size was observed with connection to the Middle Stone Age. This finding shows a good correspondence with the obsidian data and the early development of the advanced social skills its long-distance circulation requires.

However, this result is in disagreement with traditional theories on social evolution, articulately summarised in Renfrew's statement above. According to these models, long distance movement, the most archaeologically visible modern ability, was definitely not a characteristic of the earlier phases of the Palaeolithic. Even if occasional movements were to be accepted for the Upper Palaeolithic they again would not have been remarkable. Nevertheless, the perception generated by the obsidian data points towards the opposite direction. Even with conservative estimates, occasional long-distance movement (exceeding 100 km) has been recorded from the Earlier Stone Age/Lower Palaeolithic. With the advent of Middle Stone Age a more pronounced change occurs both in the number of sites exploiting obsidian and the scale of its circulation. Combined with the appearance of archaeological evidence for the exploitation of obsidian in Europe in the Middle Palaeolithic, this period must be regarded as a crucial stage in the evolution of modern human behaviour with significant implications for the organisation of social life. The discussion with regards to the changing, increasingly expanding, scale of hominin networking (section 3.1 in chapter 7) supports an early timing for the acquisition of the advanced behavioural skills they required.

Where previous theories regard the Pleistocene as a time when small hominin groups were scattered on the landscape only able for minimum interactions restricted to their immediate surroundings, the obsidian data support a perception of the Palaeolithic as a period when people were engaged in a very active social life. Alliance networks and the essential social structures making interaction possible are supposed to have only started developing in the Upper Palaeolithic (Gamble 1986) and they were loose and restricted to occasional intergroup relationships (Féblot-Augustins 1993). The patterns in the use and circulation of obsidian provide evidence arguing for cognitive and behavioural capacities that would have enabled the pre-Upper Palaeolithic hominins to achieve something more than «simpler, less complex forms of interaction» (Féblot-Augustins 1993: 251). Obsidian served as the link between local and distant individuals/groups; but whereas in short distances it was just a pretty and practical raw material, far from its source it was transformed into a symbol. The hominin ability to do so demonstrates their modern behavioural hardware. Based on the obsidian information these signs of modern behaviour must not be associated with an Upper Palaeolithic revolution event but must rather be seen as a gradual evolutionary process that was initiated at least 200 kyr ago.

1.2. Africa versus Europe: the Place of the Transition

Identifying the place were the first archaeologically visible signs of modern hominin behaviour had been expressed has not been one of this thesis' aims. However, the two theories discussed in the previous section do have strong implications with regards to the specific parameter inviting a short remark here. For the proponents of an Upper Palaeolithic revolution the patterns of modern cognition and behaviour emerged by a «purely internal process of behavioural and cognitive evolution among the local European populations, extending directly through the European Neanderthal line» (Mellars 2005: 12). On the contrary, the advocates of modern behaviour as a Gradual Evolution Process support that «at least the majority of the new behavioural patterns, as well as the cognitive hardware necessary to support these innovations, was due to a major influx of new populations into Europe deriving ultimately from either an African or Asian source» (Mellars 2005: 12).

Based on the obsidian data, long-distance distribution of objects and exploitation of high quality, non-local raw materials is observed in the East African archaeological record at a time prior to that of Europe. At this early stage the signs of a modern mind are mainly restricted to the conscious selection of particular materials and less in their long-distance circulation, although instances of this event are not missing completely. The East African material signs of modern social behaviour predate those of Europe for thousands of years making Africa the most likely candidate as the place where modern behaviour originated. However, the data in table 7.17 imply that the answer to the timing and placing of modern social behaviour is not so straightforward. In Central Europe the movement of obsidian starts late but in the Upper Palaeolithic it reaches a scale and intensity that far exceeds that of Africa. On the other hand, obsidian is present in Earlier Stone Age assemblages dating from approximately 1.5 Myr but its circulation ranges (especially the long-distance ones) remain constant throughout the Palaeolithic. These results synthesise a complex picture that sees material evidence for modern social behaviour initially appearing in Africa but being most pronouncedly expressed in the archaeological record of Europe. The obsidian data support an independent development for the social behaviour of the Palaeolithic hominins occupying two very different ecological niches of the Pleistocene world. An early manifestation of modern social behaviour occurred in East Africa as the result of the better environmental/climatic conditions and the plethora of «knappable» obsidian sources which allowed the inhabitants of the region to thrive in a more «restricted» spatial scale. On the other hand, the harsh conditions that prevailed in Europe for the greatest part of the Upper Pleistocene combined with the few obsidian sources of workable quality pushed hominins to expand their territories to very large scales. These patterns argue for a twofold route in the manifestation of modern social behaviour; a southern one that lends support to the Gradual Evolution Hypothesis and the African origins of modernity and a northern, Euro-centric, one arguing for modernity as a late and very pronounced Upper Palaeolithic phenomenon. Finally, the diachronic and interregional investigation of obsidian movement that was followed in this thesis avoids the regionalist despotism that has been prevailing in Palaeolithic research for years. Obsidian argues for independent social evolutionary paths between Africa and Europe and leaves it on the individual researcher to decide whether time or space/scale should take precedence in identifying the «birthplace» of modern hominin behaviour. However, it should be kept in mind that the stability in the African circulation ranges is a result of ecology and completely independent from social factors. The appearance of clear signs of modern social behaviour several hundred thousands of years earlier than Europe supports Africa as the place where social modernity emerged.

1.3. Revolution or Gradual Evolution Process? the Nature of the Transition

«A separate argument is related to the nature of the transition; whether it was rapid and deserves the status of 'revolution' or a long and gradual process…» (Bar-Yosef 2000: 107).

The proponents of a recent advent to modernity see the events associated with this phenomenon taking place in an abrupt and rapid fashion sometime in the end of the Pleistocene era (Klein 2000, Mellars 1989; 2005). The Upper Palaeolithic revolution resulted in the accumulation on behalf of anatomically modern humans of those behavioural traits that are linked to a modern functioning mind. A fundamental point in this argument is that the acquisition of the capacities for modern behaviour happened suddenly after a long period of stability and inactivity. Archaeologically, modern behaviour is observed in a number of characteristics absent from the material record of the previous phases of the Palaeolithic. Art, personal ornaments, bone objects, large variation in lithic technology, expanded exchange networks, use of non-local raw materials are considered as the empirical evidence of a *par* *excellance* modern behaving hominin. All these «modern» traits are regarded as a package whose presence marks the advent to behavioural modernity (Henshilwood & Marean 2006). Their more or less simultaneous appearance on the archaeological record of the Upper Palaeolithic resulted in them used as evidence of a sudden behavioural «metamorphosis» (Klein 2000).

However, the analysis of the available information with regards to the use of obsidian during the Palaeolithic supports an alternative model that sees modern behaviour evolving gradually in a longer time span than that of the Upper Palaeolithic. As such it is in accordance with the Gradual Evolution Process model that argues for the development of modern human behaviour sometime during the Middle Stone Age (Knight *et al*. 1995, McBrearty & Brooks 2000, Barham 2001). The behavioural metamorphosis scenario is disputed on the basis that anatomical evidence for a highly advantageous neurological change after 50 kyr is lacking and that the allegedly material signs of Upper Palaeolithic human behaviour are not anymore restricted to the particular chronological stage. The obsidian data are particularly informative in this respect. The fact that even the earliest hominin species recognised the exceptional functional quality of the volcanic rock and repeatedly used it in their tool-kits but especially the distances it covered on the Pleistocene landscape justify the above argument. Since extended exchange networks and the use of non-local, high quality raw materials constitute part of the «modern behaviour package» the temporal framework of obsidian use and its changes with time can be used to establish the timing and pace of modern hominin social behaviour. The scale of obsidian movement and the observed differences in each of the three Palaeolithic sub-stages indicates a gradual expansion in the ranges of raw material procurement and, subsequently, the scale of social interactions, both direct signs of modern behaviour. The gradual extension of the distances obsidian circulated on the Pleistocene landscape argue for a continuous development that reached its peak in the Upper Palaeolithic but only as part of a longer gradual process void of sudden revolutionary changes.

Despite the popularity they still retain in archaeological thought, revolutions comprise an inadequate concept for the investigation of the past and hominin behaviour in particular. As Gamble puts it «revolutions are…the right tools only if we continue to believe that change is an essential ingredient of the past and we only have to scrape away at the record to reveal it»

(Gamble 2007: 81). Changes controlled by behaviour/cognition do not occur suddenly. They may appear as sudden events in the fragmented archaeological record but they in reality necessitate time to be conceived, organised and executed and as such they are best regarded as gradually evolving phenomena. Filing changes under revolutionary events – cognitive advances under Human Revolution, social advances under Upper Palaeolithic Revolution – will not help understand the processes through which hominin brains became human minds.

2. THE CONTRIBUTION OF THE PHD TO WIDER PALAEOLTIHIC RESEARCH

In the last thirty years Palaeolithic archaeological research has focused on a number of «big» issues and the evolution of modern behaviour is central among them. This thesis attempted to approach this phenomenon through material culture by putting forward the proposition that the elucidation of social behaviour in the past is feasible through the investigation of lithic remains. The social aspect of behavioural evolution comprised the focus of this project and it was dealt with by making use of the patterns in the use and circulation of obsidian. Raw material movement studies have been conducted with success for several years now but they rarely concentrated on a Palaeolithic time-frame or used as a means for investigating phenomena other than economic. This thesis provided evidence arguing for the credibility of raw material movement and lithic material culture in the elucidation of past behaviour.

This thesis has contributed to archaeological research in a number of ways:

- Substantive: new quantitative and qualitative data were collected and recorded and are now available for use in future research. Most importantly, this thesis constitutes the first intercontinental synthesis of archaeological information. In addition, a major advance of this project was the development of a database that for the first time brings together all the available information for the presence of obsidian in Palaeolithic stratigraphic units of Africa, Europe and the Near East. Site names, coordinates, dates as well as quantities and typologies of the identified obsidian assemblages have been recorded and a gazetteer was generated. This gazetteer fulfils a substantial shortcoming in the archaeological literature and aims at facilitating future research.
- Methodological: this thesis provided a sound alternative to lithic studies that are interested in explaining behaviour by establishing that even the use of only the basic elements of a lithic analysis - size, cortex, retouch – is sufficient to infer useful

information. The methodological framework that was adopted in this project runs a deep chronological sequence and a wide geographical area. This approach enabled the investigation of obsidian use and movement diachronically and interregionally. For the first time it became possible to examine the characteristics of social evolution on a large geographical and temporal scale. Furthermore, the comparative approach adopted, i.e. Africa *versus* Europe, facilitated the identification and explanation of the similarities and differences underlying the social processes in each region. The interpretative quality of the generated data suggests that such a comparative approach is more promising than site-specific studies in our understanding of the past. Furthermore, despite the «polemics» against them, raw material circulation ranges do provide an excellent criterion for the examination of hominin behaviour.

- Theoretical/conceptual: this thesis contributed to the Human Revolution debate by providing an alternative way of viewing the relevant archaeological record. Replacing the data commonly used to support one of the two main theories forming this ever-lasting debate, with the interregionally and diachronically used obsidian allows researchers to overcome the obstacles of choosing one or the other. Obsidian provided firm evidence for the inefficacy of «revolutions» as a conceptual tool in archaeology. Additionally, it showed that the distinctive features associated with the «revolution that wasn't» developed gradually over a long period of time and were expressed differently in Europe and Africa. Furthermore, the obsidian data illustrated rather clearly the effect of ecology on hominin decision-making and its material residues. The Palaeolithic hominins examined in this thesis were all very capable of forming extended social networks, retaining a feeling of relatedness *in absentia* and they did so from very early on (Middle Stone Age Africa) and the scale necessary given the environmental circumstances (Upper Palaeolithic Europe). Finally, a major contribution was made with regards to the social brain hypothesis. This thesis has provided strong support to the arguments of the above hypothesis by establishing «relatedness *in absentia*» as a key concept in investigating past behaviour and showing that it is indeed possible to approach hominin behaviour by using material culture (obsidian) as a proxy.

3. FUTURE RESEARCH

Based on the restrictions imposed by the available resources a number of assumptions had to be made on the outset of this project. The most important one regards the measurement of the site-to-source obsidian distances. The lack of data associating obsidian archaeological assemblages to specific geological sources made imperative to accept the shortest calculated distances as the ones representing the actual events, even though a different scenario is equally plausible.

Future research could satisfactorily deal with this shortcoming by establishing which obsidian sources were actually in use in each of the recorded Palaeolithic assemblages. Geochemical analysis of samples from geological sources and archaeological artefacts would be able to securely associate artefacts to specific obsidian sources and thus to provide the essential information for the generation of a detailed map of obsidian movement. Moreover, establishing the number of obsidian sources utilised in a single site would facilitate inferences with regards to selectivity criteria exercised by the Palaeolithic hominins as well as the organisation of their social lives. Although costly and time consuming, geochemical research on selected well-investigated Palaeolithic sites and the obsidian sources present in the investigated regions comprises the best means of turning the unavoidable assumptions into set certainties. It would then be possible to shake off any scepticism with regards to the exact level of the cognitive and behavioural abilities of Palaeolithic hominins. The conservative estimations of the obsidian movement during the Palaeolithic have established that our ancestors were not a-social beings leading a restricted social life to a small geographical area. Geochemical fingerprinting offers the possibility of pinpointing the actual scale of obsidian movement providing archaeological research with the unique potential of revealing the precise extent of the Palaeolithic hominins' social interactions.

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