Lithic raw material exploitation and circulation in Prehistory

A comparative perspective in diverse palaeoenvironments

Masayoshi Yamada & Akira Ono

Preface
Marcel Otte

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Italian obsidan fragments
Obsidian fragment picked on the Mount Etna volcano in Italy.
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Preface

Very honored by my esteemed colleagues, Drs. Yamada and Ono, I present here some remarks regarding the research presented in this volume and comments about these unusual materials.

Indeed, until now, these obsidian artifacts hold a sort of magic. Instantly recognizable during excavation, they are set apart by their beauty, colors, translucence and extraordinary brilliance! Of uniform and fragile texture, obsidian is highly suitable for knapping. Their edges are as sharp as glass and stronger than steel. All of these prestigious elements were felt at all times, as the contributions here amply show. Wherever this raw material is found, it was subject to elaborate and specific behaviors, both symbolic and technological. Its mineral composition allows its dispersal following different technical modalities: from core to sophisticated point. This work thus assembles both the infinite flexibility offered by the exploitation of obsidian and the fruitful attempts developed by archaeologists to decode the mysteries, in two key regions: Japan and Europe. These could also be applied as well in the Near East, Mexico, Polynesia and East Africa, for example in another volume. The prehistoric behaviors recorded in the state of these artifacts illustrate the existence of trade networks throughout prehistory, linked to distances to sources and stages of abandonment: raw blocks, blades, used tools, for example (Schäfer & Biró). Chronological development is one of the axes for these variations, which are combined with the values dictated by cultural traditions (Stepanchuk, Bertola). The result is the lack of a universal rule in favor of distributions each time structured around obsidian with complex links through time, across space and with trade networks (Shiba, Shimada). This particular relationship with obsidian can be seen with the earliest humans (Carter) and presents rich cultural overtures when it is put in relation with geography or artistic data, for example (Floss). Such significant potential has been recognized due to the establishment of a lithic reference collection, a lithic library, in Central Europe (Biró) and by the fundamental historiographic approach applied in Japan (Yamada, Ono).

In the hollow of my wet hand, I have often seen these obsidian fragments glimmer, when water sieving at excavations in Turkey,

Très honoré par nos estimés collègues, Messieurs Yamada et Ono, nous présentons ici quelques remarques issues de cette masse de travaux et de nos réflexions quant à ces étranges matièriaux.

En effet, jusqu'aujourd'hui, ces obsidiennes possèdent une sorte de magie. Directement reconnaissables, dès la fouille, elles se distinguent par leur beauté, leurs couleurs, leur transparence et leur éclat proprement extraordinaires ! De texture homogène et fragile, elles se prêtent à la taille avec docilité. Leur tranchant coupe comme du verre, plus durement que l'acier. Tous ces éléments prestigieux furent ressentis en tout temps, comme toutes ces contributions l'attestent amplement. Partout où ces roches volcaniques affleurent, elles firent le même objet de comportements élaborés et particuliers, autant à vocation symbolique que technique. Leur composition minéralogique autorise d'en tracer la dispersion selon les diverses modalités techniques : du nucléus à la pointe sophistiquée. Ainsi, cet ouvrage rassemble autant l'infinie flexibilité offerte par le traitement de ces roches que les fructueuses tentatives lancées par les archéologues pour en décoder les mystères, en deux régions essentielles : le Japon et l'Europe. Elles pourraient tout aussi bien s'étendre au Proche-Orient, au Mexique, à la Polynésie et à l'Afrique orientale, par exemple dans un autre volume. Les comportements fossilisés enregistrés par l'état de ces roches illustrent en tout temps des réseaux d'échanges, liés aux distances et aux états d'abandon : blocs, lames, outils utilisés, par exemple (Schäfer et Biró). L'évolution chronologique constitue un des axes à ces variations, mais elles se trouvent combinées aux valeurs dictées par les traditions (Stepanchuk, Bertola). Il en résulte l'effet d'une absence de règle universelle au profit de répartitions, à chaque fois structurées, autour de ces roches aux liaisons complexes à travers le temps, l'espace et les réseaux d'échanges (Shiba, Shimada). Cette relation particulière aux obsidiennes se manifeste dès les origines de l'humanité (Carter) et présente des ouvertures culturelles riches, lorsqu'elle est mise en relation avec la géographie ou les données artistiques par exemple (Floss). Cette importante potentialité a bien été comprise grâce à l'établissement d'une lithothèque au centre de l'Europe (Biró) et par l'approche historiographique fondamentale menée au Japon (Yamada, Ono).

Au creux de ma main humide, j'ai souvent vu briller ces fragments d'obsidienne, lors de tamisage à l'eau aux fouilles en Turquie, en Iran ou en Europe Centrale. Toute l'imagination s'enflamme alors : une matière lointaine et belle fit l'objet de cette sélection, de cette transformation et de ces déplacements. Tout à coup, il ne s'agit plus d'un déchet en pierre, mais du témoin d'une aventure, d'une sensibilité et d'une émotion, tout cela assemblé, combiné, dans le fond d'un tamis de fouille. Aussitôt, le choix de cette roche s'enrichit, car les vestiges en obsidienne lointaine n'obéissent plus aux coutumes techniques ordinaires, ils s'approchent du défi : le soin apporté à leur mise en forme, la sélection des éléments appropriés aux déplacements, les étapes suivies par leur parcours et la raison de leur abandon, tels des repères à cette aventure. Ces roches agissent comme un conservatoire de l'esprit, des étapes symboliques qu'il a suivies et des valeurs qu'il transportait, accompagnées par le raffinement évident qu'elles incarnaient spontanément. Ce miracle de la pensée et de la beauté réunies dépasse leurs seules considérations techniques, autant la lumière se reflète dans ces roches colorées, autant les idées en surgissent. Sans aucun doute, ces réflexions ont-elles traversé l'esprit des populations jadis responsables de ces enchaînements à travers l'espace et les valeurs emboîtées, un peu sur le modèle de nos monnaies actuelles qui gagnent par leur rareté et leur éloignement. Des fragments de ces roches, aussi rares et aussi belles, semblent prendre la fonction technique pour prétexte à leur valeur prestigieuse, un peu comme une hache polie en jadéite n'a jamais servi à couper, mais assemble le symbole d'une arme à celui d'une roche rare et belle. Sur ce modèle, les pointes solutréennes ne peuvent « servir » à rien, car beaucoup trop fragiles, bien que façonnées en abondance, rassemblées, dissimulées et protégées. Peut-être, lorsqu'il mérite vraiment son nom, l'homme authentique ne peut-il distinguer les différentes composantes du symbole : l'efficacité et son allusion plastique, le prestige et la solidarité. À la lumière de ce bel ouvrage, tout semble l'indiquer.

Marcel Otte

Iran and Europe. The imagination ignites then: a distant and beautiful raw material was selected, transformed and transported. All of a sudden, they are no longer stone waste, but evidence of an adventure, sensitivity and emotion, all brought together at the bottom of a sieve. The choice of this raw material is immediately enriched, because the remains of distant obsidian no longer obey ordinary technological practices, they resemble a challenge: the care used for their preparation, the selection of elements appropriate for transport, the stages followed along their path and the reason for their abandonment are all milestones in this adventure. These obsidian artifacts act as a conservatory of the mind, symbolic stages that they followed and the values they transported, accompanied by the evident refinement that they spontaneously embody. This miracle of united thought and beauty goes beyond simple technological considerations; the more the light reflects off these colored stones, the more ideas burst forth. Without a doubt such thoughts crossed the minds of the people originally responsible for these links across space and the nested values, a little like modern currency that increases in value with rarity and distance. Obsidian fragments, so rare and beautiful, seem to take on a technological function as a pretext for their prestige value, like a polished jadeite axe that was never used but combines the symbol of a weapon with that of a rare and beautiful raw material. In this model, Solutrean points may have been "used" for nothing because they were too fragile, although made in abundance, grouped, dissimulated and protected. Perhaps, when he truly merited his name, true humans could distinguish between the different components of a symbol: effectiveness and its plastic allusion, prestige and solidarity. In the light of this excellent volume, everything seems to indicate this.

Marcel Otte

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Forward

The Center for Obsidian and Lithic Studies (COLS), Meiji University, is unique because it is the only research center in Japan with facilitated various research aspects of obsidian studies, both of natural and the social sciences. Collected papers in this volume all form the International Symposium held in 2012, titled "Lithic Raw Material Exploitation and Circulation in Prehistory: a Comparative Perspective in Diverse Palaeoenvironment."

In general, archaeological studies are based on chronologies produced by two principal methods; one is absolute dating which enables us to make a chronological table, and the other is relative dating based on stratigraphy which can be clearly distinguished from accumulated distinct layers with interfaces.

The typological analyses of stone tool assemblages which play a central role in defining cultural layers are characterized by various complex elements, pertaining to morphological and technological observations, as well as chronological and ethnographical considerations.

While such synchronic studies are extremely valuable, diachronic studies help us to understand the space where human relations and interactions were played out.

Obsidian analysis makes it possible to precisely identify their sources and their circulation areas thanks to methods coming from the natural sciences. Moreover, it is possible to classify several types of lithic material from different stages of the chaîne opératoire: 1) Phase of acquisition and exploitation of raw material, a. Consumption, b. Circulation, 2) Phase of production and débitage of blank, a. Consumption, b. Circulation, and 3) Phase of transformation into a retouched piece, a. Consumption, b. Circulation.

The results of the structured circulation of obsidian enable us to do comparative studies among areas, which did not have any direct communication.

We are now able to propose a series of research perspectives for further lithic raw material use and circulation, i.e. 1) having

Le Centre pour les Obsidiennes et les recherches lithiques (COLS) de l'Université de Meiji est unique car c'est le seul centre de recherches au Japon où les divers aspects de la recherche sur les obsidiennes sont facilités tant du point de vue des sciences naturelles que sociales. Les articles rassemblés dans ce volume correspondent à l'ensemble du Colloque international qui s'est tenu en 2012 et intitulé : « Lithic Raw Material Exploitation and Circulation in Prehistory : a Comparative Perspective in Diverse Palaeoenvironment. »

En général les études archéologiques sont basées sur des chronologies établies grâce à deux méthodes principales : la datation absolue, d'une part, qui nous permet de réaliser un tableau chronologique et d'autre part la datation relative basée sur la stratigraphie qui peut être clairement distinguée des couches accumulées avec des interfaces.

Les analyses typologiques des assemblages d'outils en pierre qui jouent un rôle central en définissant les couches culturelles sont caractérisées par divers éléments complexes concernant aussi bien des observations morphologiques que des considérations chronologiques et ethnographiques.

Tandis que de telles études synchroniques sont extrêmement précieuses, les études diachroniques nous aident à comprendre l'espace où les relations humaines et leurs interactions se sont déroulées.

L'analyse des obsidiennes permet d'identifier avec précision leurs sources et leurs aires de circulation grâce aux méthodes venant des sciences naturelles. De plus il est possible de classifier plusieurs types de matériel lithique à différents stades de la chaîne opératoire : 1) phase d'acquisition et d'exploitation de la matière première, a. Consommation, b. Circulation, 2) phase de production et de débitage du support, a. Consommation, b. Circulation, et 3) phase de transformation en objet retouché, a. Consommation, b. Circulation

Les résultats de la circulation structurée de l'obsidienne nous permettent de faire des études comparatives parmi des régions qui n'ont eu aucune communication directe.

Nous pouvons maintenant proposer une série de perspectives de recherches concernant davantage l'utilisation et la circulation de la matière première c'est-à-dire : 1) établir des échantillons standardisés d'obsidienne correspondants à une échelle transrégionale en Eurasie, 2) faire des études comparatives en utilisant des échantillons standardisés, 3) construire un modèle d'acquisition et de circulation de l'obsidienne, pouvant s'élargir à d'autres sortes de matières premières.

Ce livre est soutenu par le « Program for the Strategic Research Foundation at Private Universities, 2011-2015 », par le « Ministry of Education, Culture, Sports, Sciences and Technology of Japan ».

Cette conférence et cette publication n'auraient pas eu lieu sans les encouragements, aides et soutiens de nombreux individuels et institutions. Parmi ceux-ci nous remercions en premier et particulièrement le Professeur de l'Université de Liège, Marcel Otte qui a gentiment évalué notre processus comme une contribution majeure à l'exploitation et à la circulation des matières premières tant pour l'obsidienne que pour d'autres matières premières et le publiera dans un volume spécial d'ERAUL. La publication d'un processus est parfois un grand résultat pour les organisateurs d'un symposium.

Nous sommes très reconnaissants à l'aide apportée par Mr. Jean-François Bussière, Musée d'Anthropologie préhistorique de Monaco et par Ms. Lillian Dogiama, Department of Anthropology, McMaster University, Canada.

Masayoshi Yamada.

Photo 1 – Center for Obsidian and Lithic Studies (COLS), Meiji University, Nagano Prefecture.

Photo 2 – Symposium invitees at the presidential section of Meiji University, Tokyo.

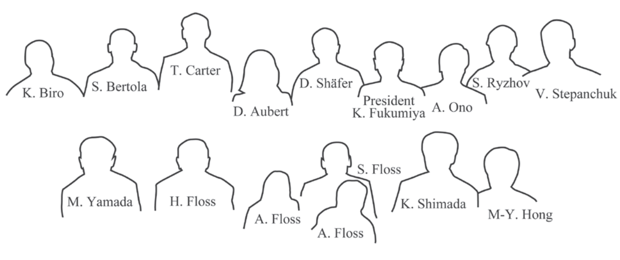
standardized common analytical samples in trans-regional scale for obsidian among Eurasia, 2) comparative studies using standardized obsidian samples, and 3) constructing an obsidian procurement and circulation model, extending on other kind of raw material. It is possible to set out our goals of obsidian studies, but we would like to stand on sound empirical outcome data just including in this volume, and our long-term studies have just begun.

This conference and the publication of the proceeding is supported by "Program for the Strategic Research Foundation at Private University, 2011-2015", Minister of Education, Cultures, Sports, Sciences and Technology of Japan.

This conference and the publication of the proceeding would not have taken place without the encouragements, assistances and supports of numerous individuals and institutions. We thank amongst these, first and foremost is Professor of University of Liege, Marcel Otte who kindly evaluated our proceedings as a crucial contribution to lithic raw material exploitation and circulation issue both on obsidian and other raw materials, and to be appeared one of a special volume of the ERAUL. Publication of the Proceedings is sometimes big issue for the organizers of the symposium.

We gratefully acknowledge the invaluable help provided by Mr.Jean-François Bussière, Musée d'Anthropologie préhistorique de Monaco, and Ms.Lillian Dogiama, Department of Anthropology, McMaster University, Canada.

Masayoshi Yamada



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Introduction

As one of the programs at Meiji University's Center for Obsidian and Lithic Studies in 2012, we organized an International Symposium entitled "Lithic raw material exploitation and circulation in prehistory: a comparative perspective in diverse palaeoenvironments", which was held October 27 - 28 of that year at Meiji University in Tokyo. This symposium was also supported by the International Union for Quaternary Research (INQUA) (project no.: 1207; title: "Palaeoenvironment and lithic raw material exploitation in North and East Asia during MIS3 and MIS2"; project leader: A. Ono). All articles in this volume have originated from contributions to this symposium.

Lithic raw material provenance studies have a long tradition in both Europe and East Asia. Specifically, the scope of obsidian provenance studies has greatly expanded in the past two decades in Japan and neighboring regions, such as the Russian Far East and the Korean Peninsula. Archaeological interpretations of lithic raw material procurement systems and distribution patterns or transportation systems have also developed in various areas, and there have been many case studies on different lithic raw materials. The symposium aimed to discuss these topics with particular reference to the comparative perspective between Europe and East Asia. Through the symposium, we shared various geochemical analyses and archaeological studies on lithic raw materials other than obsidian in Europe, but the differences in the development of palaeoenvironmental research backgrounds was also made clear. We clarified further necessary points for future collaboration in lithic raw material research irrespective of geology or the archaeology.

Papers cited in this volume focus on various aspects of lithic raw material procurement and circulation from Europe to the Far East, mostly in the Upper Palaeolithic. H. Floss emphasizes rivers as one of the powerful means of human migration and cultural transmission in the Upper Palaeolithic in Central Europe, with a lot of evidence of lithic artifacts, personal ornaments, and mobile and parietal arts. D. Schäfer and S. Bertola discuss various local and non-local lithic raw materials, centering on their excavations at Ullafelsen, an early Mesolithic site in the Stubai Alps, Tyrol. They elucidate that the high mountainous area did not serve as a barrier to human exchange networks, but rather served as a positive contact zone for material transportation. V. Stepanchuk introduces lithic raw material exploitation in Ukraine, and discusses the significance of the Mira site case on remote raw material exploitation in the Dnieper River.

T. Carter, K. T. Biro, S. Ryzhov, V. Stepanchuk, H. Sato, Y. Yakushige, K. Shimada and K. Shiba focus on obsidian. T. Carter discusses the interpretative potential of obsidian characterization studies in relation to a more holistic behavioral concept of an "operational chain." K. T. Biro gives a synthetic summarization of Carpathian obsidian studies, both of archaeological and physicochemical non-destructive analyses. S. Ryzhov describes his own excavated key site, Malyj Rakovets, which has seven well-stratified cultural horizons including Lower, Middle and Upper Palaeolithic industries bearing obsidian. V. Stepanchuk discusses a unique case of the Mira site, located a valley of the river Dnieper, concerning the characteristic features of the EUP layer I, and the authentic UP features Layer IIa. The Layer I indicates repetitive dense occupation with almost 60,000 lithic artifacts compare to the Layer IIa with only about 200 knapped flints. Issues of coexistence of Middle and various kinds of Upper Palaeolithic cultures in Eastern Europe were also discussed. H. Sato and M. Yakushige introduce the results of archaeological analyses of the Upper Palaeolithic in the northernmost of the

Japanese Islands, Hokkaido. Their extensive analysis reveals that eight obsidian sources were used in the Upper Palaeolithic, and these results shed new light on obsidian utilization throughout the Upper Palaeolithic in Hokkaido. K. Shimada tries to elucidate the beginning of obsidian exploitation in the early Upper Palaeolithic in central Japan. The significant roles of the Central Highlands concerning obsidian procurement and distribution patterns are also discussed. K. Shiba tackles obsidian exploitation patterns from the beginning of the Upper Palaeolithic through to the Incipient Jomon period with 10 distinctive cultural phases in Kyushu, the south-westernmost of the Japanese Islands.

This volume does not aim to set out a testable referential model for interaction between humans and their natural environment through various methods of lithic raw material exploitation in palaeoenvironmental contexts. However, causal relationships between humans and their natural environment are easy to speculate about, though difficult to elucidate. There are three different research levels: the first is the macro-environmental level that is totally independent of human activity or accessibility; the second is the so-called "effective environment" level; the third and final level is the purely archaeological level that is exclusively led by human-made artifact phenomena. The "effective environment" level should be the central target for an explicit discussion of human-environmental interactions.

Finally, I would like to touch briefly upon the background of the international symposium held October 27 - 28, 2012. Meiji University founded the Center for Obsidian and Lithic Studies in April, 2001, but was newly re-organized in April, 2010 for the further enhancement of obsidian studies and international research collaboration networks. The Center's research proceeds with the following four focuses: 1) Advancement of archeological research enhancing obsidian exploitation in a geological source area, lithic tool production studies, and the reconstruction of circulation systems; 2) Reconstruction of obsidian formation mechanisms, eruption dates, and standardization of obsidian samples, through various physicochemical analyses; 3) Paleoenvironmental reconstruction during MIS3 and MIS2, with particular reference to Palaeolithic and Jomon subsistence; 4) Establishment and development of international obsidian research networks. Obsidian studies focusing both on fundamental analysis and application research for source identification, as well as on archaeology, are part of the core axis of research at this Center. However, we have also set forth the idea that "human-natural resource environment" studies, concerning the elucidation of human-environment interaction together with archaeological, geological, and palaeoenvironmental studies, should be another part of our core axis. How have humans used their natural resources since the prehistoric times? Because the methods for the exploitation of resources are reflected sharply throughout the different ages of human history, we could link together and evaluate the specific methods and resources from modern perspectives.

Our ongoing project, "Historical variation in interactions between humans and natural resources: towards the construction of a prehistoric anthropography" (Abbreviation: Natural Resource Environment and Humans) is supported by the MEXT (Ministry of Education, Culture, Sports, Science and Technology) program for the Strategic Research Foundation at Private Universities, 2011-2015. This project aims to integrate humans and their natural resource environments as a system, and to construct an anthropography of historical variations. The range of issues with regard to humans and their resource environments covers all of human history. We intend to reconstruct the interactions between humans and their natural environments as a prehistoric anthropography when they live symbiotically with their surrounding resource environment, and to provide a unique viewpoint with which to examine contemporary resource-environmental issues. This project will be the major research body of the Center for Obsidian and Lithic Studies until the end of the fiscal year 2015.

The international symposium held in 2012 was one of our programs to be realized following this guideline. I would like to express my sincere gratitude to all contributors in this volume who have provided us with new research results and perspectives on our own study areas and beyond.

PART I:
GENERAL PERSPECTIVES

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1.1. Rivers as orientation axes for migrations, exchange networks and transmission of cultural traditions in the Upper Palaeolithic of Central Europe

Résumé
Les grands réseaux fluviaux ont joué un rôle important comme axe d'orientation pour les chasseurs-cueilleurs du Paléolithique supérieur en Europe. Nous illustrons cette hypothèse par des observations sur la dispersion de la matière première lithique le long des systèmes de rivières importants, c'est-à-dire le Danube, le Rhin et le Rhône. La mobilité humaine et la présence des systèmes d'échanges régionaux permettent le mouvement d'artefacts lithiques, de matières premières et d'éléments de décoration personnelle. Ces résultats sont examinés par l'étude et la comparaison des éléments de l'art mobilier et pariétal à la période glacière.

Abstract
Major river systems played an important role as orientation axes for European Upper Palaeolithic hunter-gatherers. We illustrate this hypothesis by observations on lithic raw material dispersal along major rivers systems, i.e. The Danube, the Rhine and the Rhône. Human mobility and the presence of supra-regional exchange systems led to the move of lithic artefacts, raw material contingents and elements of personal decoration. These results are tested by the study and the comparison of elements of Ice Age mobile and parietal art.

Keywords: Europe, Upper Palaeolithic, lithic raw material, embedded procurement, migrations, exchange systems, Danube, Rhine, Rhône

1 – Introduction

This paper discusses the hypothesis if major river systems could have played a decisive role as orientation axes for mobility and exchange for the first anatomically modern humans dispersing into Europe. We are completely aware that this hypothesis can only be one aspect in a complex system of factors influencing human behaviour, but we do think that this aspect had measurable influences on the human activities. As we discuss in other papers (Floss 2000b; Hussain & Floss 2012, Hussain & Floss, in preparation), these observations are not the same all over the European Upper Palaeolithic, because we see important chronological differences. The Early Upper Palaeolithic, particularly the Aurignacian, is marked by the dispersal of anatomically modern humans into Europe and therefore rivers, for instance the Danube, nearly automatically play this role as a focal system. Contrary to that, the Middle Upper Palaeolithic procures the impression that different cultural entities now had been formed and that rivers could play a certain role as boundary between these entities. The eastern limits of the Solutrean along the river Rhône in France can be seen as a striking example for this kind of observation. After the late glacial maximum, in terms of the Late Upper Palaeolithic, particularly in the evolved Magdalenian, migrations in formerly uninhabited areas took place and exchange systems over long distances attained their maximum. Given this background, rivers regained an important role as orientation axes, as it shows for instance the presence of Mediterranean mollusc beads in Central European Magdalenian sites (Floss 2000b).

2 – Humans and the use of rivers

Generally spoken, the major European river systems of today existed already in the course of the last glacial period, apart from the fact, that the European land mass was widely extended due to the lower sea-level. The major rivers flowing into the Atlantic Ocean or the Mediterranean Sea, consequently were a little longer than today. Another aspect concerns the continued Holocene sedimentation of river valleys which made late Pleistocene river valleys, at least in mountainous areas, much deeper than they are today. Drillings at the valley bottom of tributaries of the river Danube in the Swabian Jura showed for instance post-Pleistocene sedimentation rates achieving 10

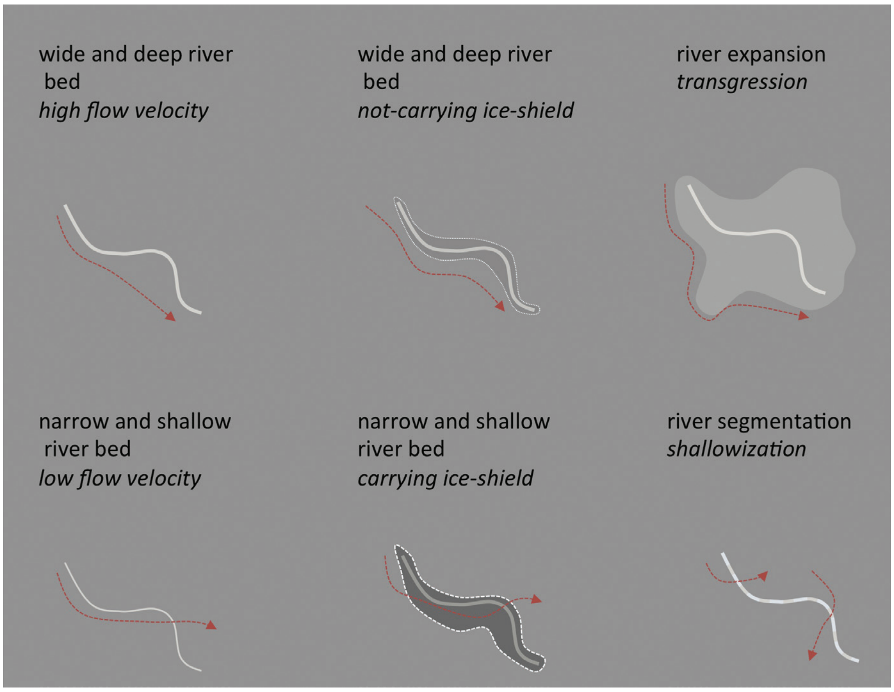


Figure 1
Pleistocene river types in Central Europe (Hussain & Floss 2012)

to 15 meters. Rivers were very important for Palaeolithic people not only in terms of communication but as well in terms of basic needs of subsistence. Rivers and their banks yielded water, fish, waterfowls, molluscs, edible plants, big game using rivers as drinking place or crossing the rivers at fords. Rivers yielded as well diverse raw materials, for instance pebbles for the lithic production, hammer stones, other tools and housing construction or many vegetable raw materials, so as reed or cattail. On the whole, it is not at all astonishing that the majority of the Upper Palaeolithic sites in Central Europe is situated in the direct vicinity of big rivers (Floss 2003a). To which degree, rivers could then have been used as orientation axes, ford passage or even means of fluvial transport, depends on many factors, which are for instance the regional geological and geographical setting, stream velocity, but as well general climatic conditions and seasonal oscillations. Generally, different scenarios are possible (Fig. 1). Rivers could be crossed when they were slow, with shallow water, carrying an ice sheet or were segmented. They could not be crossed if the river was wide and/or deep, had high flow velocity, was not carrying an ice sheet or was expanded due to floodwaters. In terms of residential mobility, the elevated plains flanking the river valleys were much more convenient to move than the valley bottom barely penetrable due to the thicket, morass and the presence of insects and snails, particularly in the summer.

3 – Hunter-gatherers, mobility and exchange

One of the major possibilities to reconstruct Palaeolithic hunter-gatherer territories and migrations, consists in detecting the origins of lithic raw materials. In the uniform and open European ice age landscape, residential mobility rates were high and lithic materials were mainly embedded (according to L. Binford) within these residential moves. In some exceptional cases, we cannot exclude a direct procurement in order to obtain materials of a particularly high quality. An important problem is to distinguish embedded procurement and exchange. If we plot, in a broader European scale the distances between the Palaeolithic sites and the raw material outcrops (Floss 1994, 326), the graph clearly declines at about 100 to 150 km. Beyond this range, only very few single objects, mostly tools, blades or bladelets occur. In contrast, if we plot the distances of objects of personal decoration, as mollusc shells or fossils (Floss 1994, 337), we observe partly very high distances exceeding several hundreds of kilometres. In this case, in our point of view only complex exchange systems can be responsible for these high distances. According to stone artefacts and their raw materials we conclude, that materials of an origin inside 150 km were probably transported in the context of residential moves. Nevertheless, in this scale we cannot exclude exchange. In contrast, if distances go beyond this range of 150 km, we consider that these distances cannot anymore be explained by simple migrations inside the own group territory but by exchange of single objects or, in rare cases, of raw material contingents.

4 – Raw material identification methods

Concerning raw material identification, we use mainly a system of macroscopic characteristics which has been developed over the last 25 years (Floss 2012). Colour, colour distribution, grain size, gloss, inclusions, cortex, nodule size and shape, all these criteria allow in many cases an accurate identification. If these methods come to their limits, microscopic observations or trace element analysis can be applied. A very important archaeological method to identify at least approximately the distance to the raw material origins, is the chaîne opératoire – method. Since their exploitation at the outcrop, lithic materials are continuously transformed and reduced within the human migrations and settlement cycles. In other words, the more the material is distant from the outcrop, the more these materials get scarce and are only represented by single pieces, mostly blades, bladelets or tools. Many studies could clearly establish this relation, c.f. in the Rhineland (Floss 1994) or in southwest Germany (Burkert & Floss 2006).

5 – Nature, culture and rivers

For prehistoric hunter-gatherers, landscape is an important factor conditioning their activities. As a part of the surrounding environment, the landscape as perceived by Palaeolithic hunter-gatherers is always both a natural as well as a cultural phenomenon (Descola 2011). In other words, space is not only something naturally given, but also something culturally inherited. As soon humans are involved, the ideal natural space vanishes, giving rise to the cultural space of landscape. These landscapes were always structured with tracks, pathways and semantic places embedded in the natural environment. The main river courses of the Upper Pleistocene were important focal points of these landscapes and mirror the interconnection of nature and culture. Palaeolithic hunter-gatherers therefore might have conceptualized their entire land use practices in relation to them. Beyond that, assuming an animism-like system of belief, we can expect rivers to become important semantic places which structure the landscape and help mapping it. As illustrated by many ethnographic, but as well prehistoric examples, rivers and particularly big streams can take the role of axes for migrations, but as well as boundaries of different territories. In view of these observations, I would like to explore the role of focal rivers as axes of orientation, taking the examples of three major river systems of central Europe, those of the Danube, the Rhine and the Rhône.

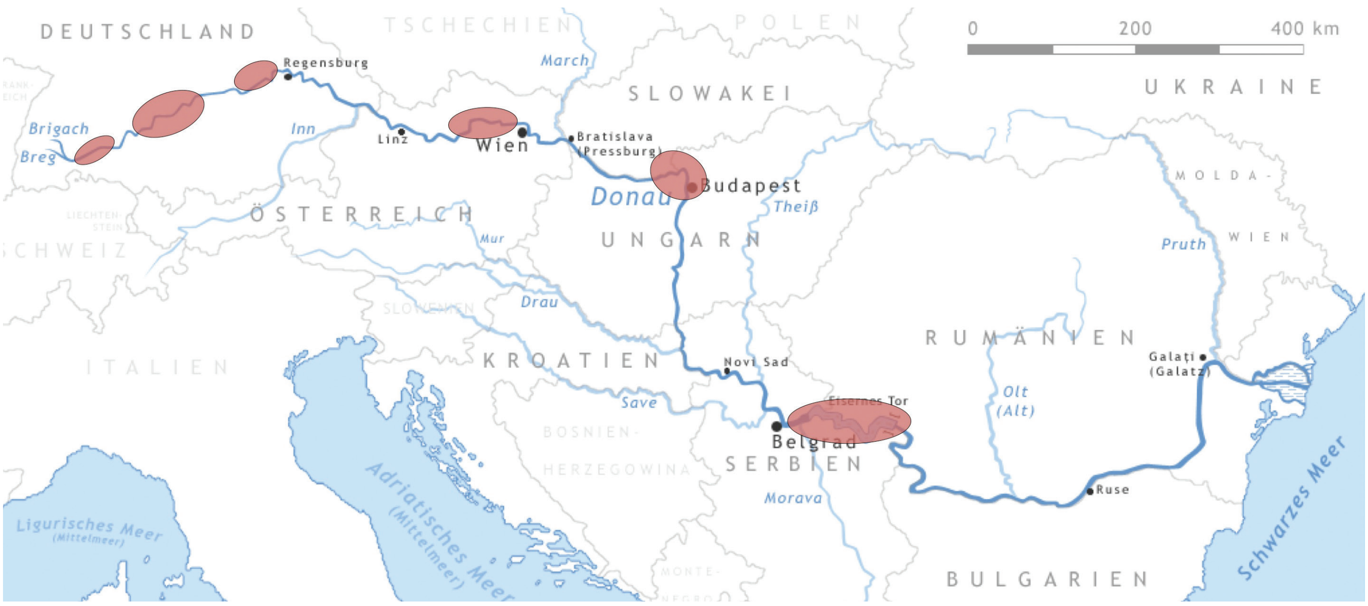


Figure 2 – Important Palaeolithic and Mesolithic settlement centers along the Danube (from west to east Upper Danube, Swabian Jura, Bavaria, Lower Austria, Danube knee, Iron Gate)

Figure 3 – Set of spectacular examples of Aurignacian mobile art and musical instruments from the Swabian Jura. Left: flute made of a vulture bone, Hohle Fels; top; three animal figurines made of mammouth ivory, Vogelherd; Bottom: female figurine made of ivory, Hohle Fels. Photos: J. Liptàk & H. Jensen, assemblage Ch. Hoyer

6 – The Danube

With a length of about 2.850 km, the Danube is the second longest river in Europe. The Danube has its source in the German Black forest and leads to the Black Sea in Rumania. This river obviously attracted Palaeolithic and Mesolithic hunter-gatherers. Important occupation areas, so as the Upper Danube, the Swabian Jura, the Altmühl valley, The Wachau in lower Austria, the Danube knee and the region around the Iron Gate, are situated in the immediate vicinity of this river (Fig. 2).

One of the most famous regions of the European Palaeolithic is, without any doubt, the Swabian Jura in southwest Germany. On the base of a Middle Palaeolithic occupation by Neanderthals, and after a short hiatus, occurs the Early Upper Palaeolithic (Aurignacian), related with an astonishing radiocarbon record yielding very early dates older than 40.000 cal. BP (Higham et al. 2012). As well the Gravettian starts in the Swabian Jura early, i.e. way beyond 30.000 cal. BP. After a hiatus of about 8.000 radiocarbon years, representing the stage of the LGM (Late Glacial Maximum), the evolved Magdalenian occurs with its typical Central European characteristics. Of particular interest is the Aurignacian because it yields examples of the oldest Palaeolithic figurative artworks and musical instruments in the world. In four cave sites situated at two tributary valleys of the Danube, the Ach and the Lone, (Geißenklösterle, Hohle Fels, Vogelherd, Hohlenstein-Stadel) have been discovered, since 1931, about 50 sculptures of humans, animals and hybrid beings, realized mostly out of mammoth ivory, and secondarily out of bone and stone (Fig. 3). Of particular interest was the recent discovery of the so called venus from Hohle Fels, a figurine made of mammoth ivory which had been found in the lowest Aurignacian level of this site and which represents the oldest female representation in the world (Fig. 3). It is interesting that the only other female representation in Aurignacian mobile art of Europe is located at the site of Krems-Wachtberg in lower Austria, as well in the direct vicinity of the Danube (Neugebauer-Maresch 2007). This artistic record of the Swabian Aurignacian is attended by the presence by about eight flutes, made out of mammoth ivory and bird bones (swan and vulture) (Fig. 3). It is again an interesting observation that the only other upper Palaeolithic find spot yielding a flute in Central Europe, certainly 20.000 radiocarbon years younger, is situated at the site of Grubgraben in Lower Austria, which is as well located near to the Danube. The symbolic record of the Swabian Aurignacian is completed by a huge amount of elements of personal decoration (Wolf 2013) which is in number and varieties much more important than in any other Aurignacian find area in Central Europe, may be in overall Europe.

Since the Middle Palaeolithic, the lithic raw material assemblages of the Swabian Palaeolithic sites are dominated by local chert varieties (Çep et al. 2012) and radiolarite. Nevertheless, with the Aurignacian period, starts the increasing presence of Bavarian Jurassic tabular chert, transported to the sites over a distance of about 100 km, underlines the presence of east-west-contacts along the river Danube and its role as major orientation focus (Fig. 4). The very typical Bavarian tabular chert exists in two varieties, the light grey-dark grey striped Abensberg-Arnhofen type and the more homogeneous Baiersdorf type (Böhner 2012). Additionally, some isolated artefacts of a red jasper, the so called Bohnerzjaspis, which is related with only two or three outcrop spots south of the actual city of Freiburg, extend the contacts of the Ach- and Lone valley sites far to the west and confirm the east-west axis. Nevertheless, there are some problems of identification of this material type, as it can be mixed up with local varieties of Bohnerz chert, occurring in the Swabian Jura itself. Ongoing trace element analysis (Bressy & Floss 2006) tends to resolve this problem. In summary, raw material contacts as well to the west as to the east confirm a high degree of residential mobility along the Danube and bring into contact two major areas of Palaeolithic occupations, that of the Swabian Jura and that of Bavaria (see Uthmeier 2004). On a higher level, these results could even confirm the hypothesis of the colonization of Central Europe along major river systems, i.e. the Danube, recently described as the so called Danube corridor hypothesis (i.e. Conard & Floss 2000, 478), according to which early anatomically modern humans would have used this stream as an important axis of orientation, in the context of their dispersal to Europe.

In the Swabian Gravettian, the use of Bavarian tabular chert and probably of Upper Rhine Bohnerz jasper continues and presents, in comparison to the Aurignacian, significantly higher amounts (Burkert & Floss 2006, Floss & Kieselbach 2006). Again it is interesting to test these lithic results by the artistic record. The only Gravettian female figurines of Central Europe are located immediately near to the Danube: The "red lady" of Weinberghöhlen near Mauern (Altmühl valley, Bavaria) and, of course, the very famous venus of Willendorf (Lower Austria) (Fig. 5). If we add the female figurines of the Moravian sites in the Czech Republic, i.e. Dolni Vestonice, which are also situated not very far from the Danube, the observed recorded is even strengthened.

In the Magdalenian period, the east-west-contacts along the Danube are going on, again demonstrated by a high amount of artefacts made of Bavarian tabular chert (Burkert & Floss 2006). These lithic results are again reinforced by observations concerning the artistic record which are even more striking than the above named Aurignacian and Gravettian examples. We observe striking stylistic similarities between limestone

Figure 4 – Circulation of Upper Palaeolithic lithic raw materials along the Rhine and along the Danube. Red: Aurignacian; Yellow: Gravettian; Blue: Magdalenian (after Burkert & Floss 2006. Basic map Bordon, modified by Ch. Hoyer)

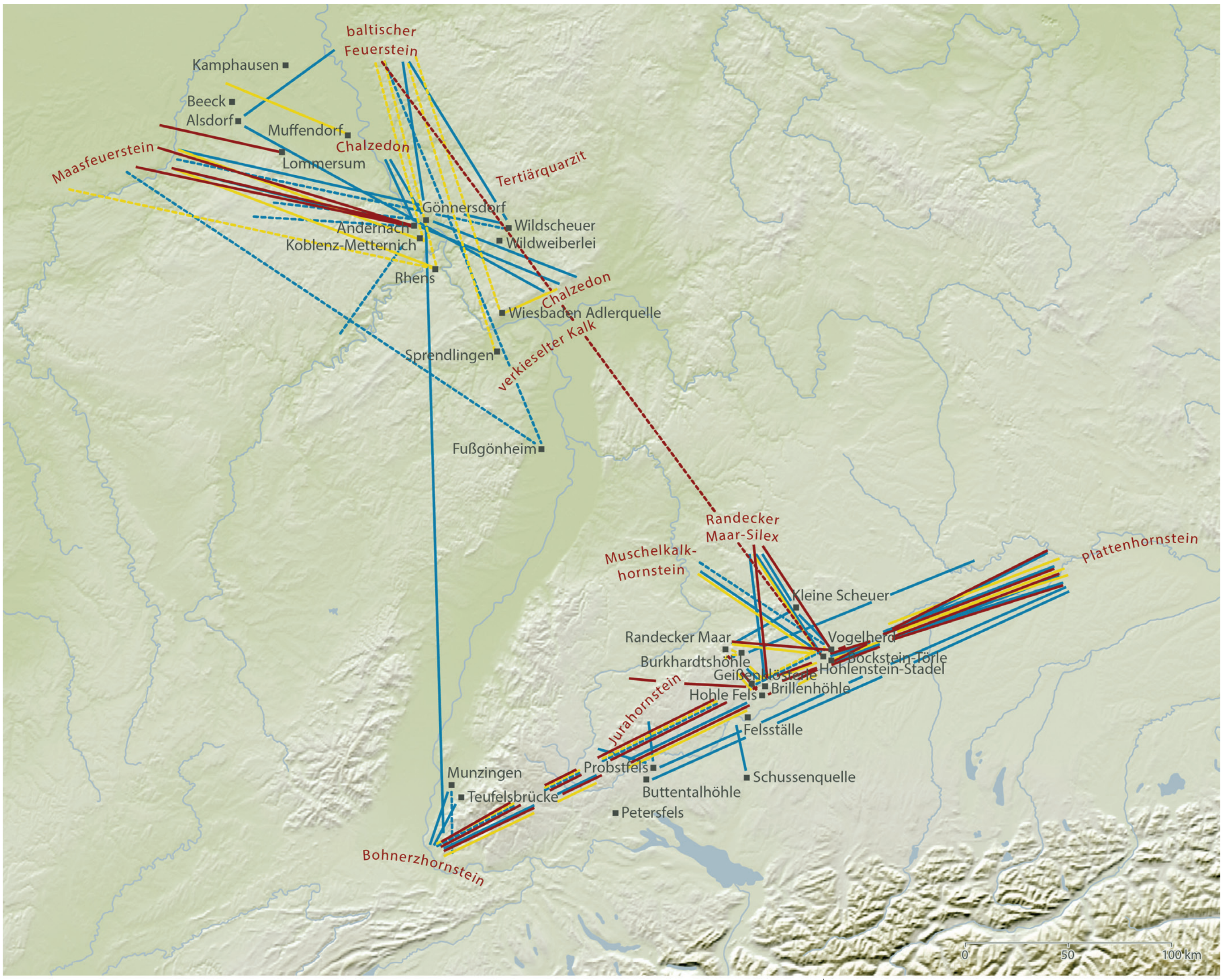


Figure 5 – Aurignacian and Gravettian female figurines along the Danube (from left to right Hohle Fels (Swabian Jura), Weinberghöhlen (Bavaria), Willendorf and Stratzing (Lower Austria)

pebbles and tablets painted with double rows of red dots, which occur in a totally identical type in two cave sites along the Danube and distant of about 100 km: The Hohle Fels in the Swabian Jura and the Obere Klause in the Altmühl valley of Bavaria (Bosinski 1982, Floss & Conard 2001) (Fig. 6). These examples can only be explained by common traditions. The Hohle Fels lithic raw material spectrum contains Bavarian tabular chert whose outcrops are exactly located in the area of the Obere Klause in Bavaria. In this case, direct contact is more than probable.

7 – The Rhine

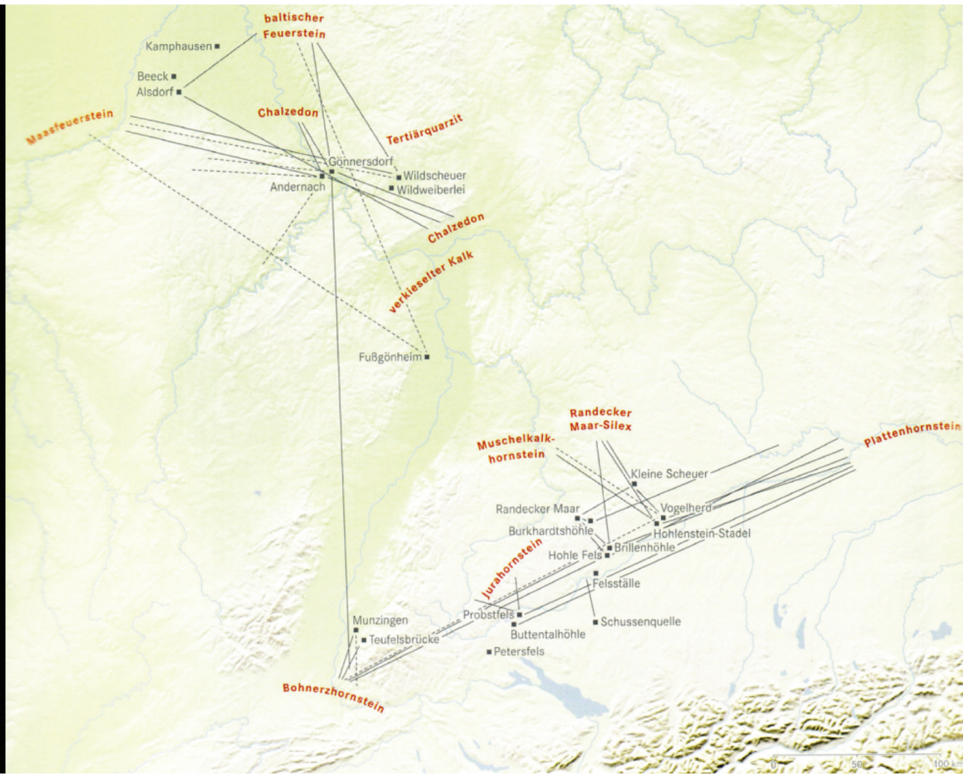
With a length of 1.240 km, the Rhine belongs to the longest European rivers. Its source is situated in the Swiss Alps and by far the longest part of the river is located in Germany, partly constituting the French-German frontier. The river leads into the North Sea in the Netherlands. The most important Palaeolithic find areas near to the river Rhine are located in the Middle Rhine Neuwied basin and in the Mainz basin. Magdalenian sites in the Neuwied basin, i.e. Gönnersdorf and Andernach, and Gravettian sites in the Mainz basin, i.e. Mainz-Linsenberg and Sprendlingen, yield Mediterranean molluscs testifying supra-regional exchange networks (Floss 1990, 1994, 2000b). Gönnersdorf and Andernach represent may be the most spectacular Magdalenian housing structures all over Europe. The artistic record is amazing and contains hundreds of engraved schist "plaquettes", female figurines and other types of sculptures. The most striking examples of long distance transport of lithics can also be observed in these Magdalenian assemblages (Floss 2000a; 2002a) where respectively some habitations are characterized by west European and some by north European (Baltic) flint (Floss 1994). In contrast, some Gönnersdorf materials point into the south, i.e. a oolithic tertiary chert and a particular type of chalcedony, both originating from the Mainz basin and its surroundings. By far the most striking example of long distance exchange of lithics is testified by three backed elements which had been found in a somewhat younger occupation phase of Gönnerdorf and which have been made of a red jasper whose outcrops are situated about 300 km to the south, near the actual city of Freiburg (Fig. 7). At the Magdalenian site of Götzenhain located east of the Mainz basin, a grey Jurassic chert is also originating from the same geological setting south of Freiburg (Terberger *et al.,* 2013). In summary, it is evident that the river Rhine constitutes in the western part of Germany the same role as an important axis of communication, as it is the case for the Danube in southern Germany.

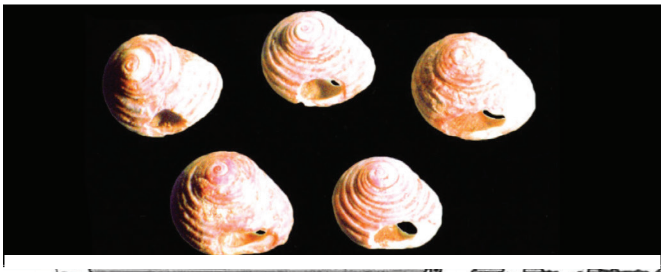
Figure 6 – Very similar Magdalenian painted limestone slabs with double rows of red dots (left Hohle Fels, Swabian Jura), right Obere Klause (Altmühl valley, Bavaria)

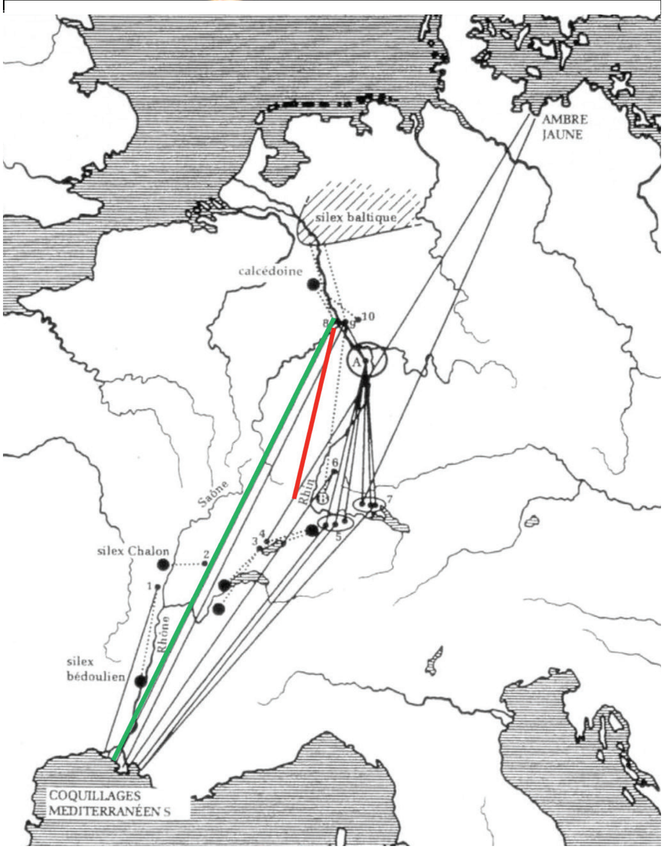
8 – The Rhône

The Saône-Rhône river system in Eastern France is an important landmark for Palaeolithic territories and human migrations (Floss 2002b). In the Late Middle Palaeolithic, the transition zone of Western Europe MtA assemblages and Central Europe KMG assemblages is located in Eastern France in the area of the Saône-Rhône corridor. In the Rhône valley itself, a particular type of Late middle Palaeolithic occurs which is characterized by elongate lithic points. The most eastern Châtelperronian sites, i.e. Germolles and St. Aubin in Burgundy, are situated just at the western banks of the river Saône (Floss 2003b). The Protoaurignacian, initially recognized in Northern Italy and the Mediterranean parts of France, is now more and more identified in regions up the river Rhône, i.e. in Northern Burgundy (Arcy-sur-Cure). Finally, the most eastern Solutrean site at all, is the eponymous site of Solutré, again located only few kilometres west of the river Saône. It is undeniable that the important north-south orientated Saône-Rhône-rift, flanked by mountainous areas with glacial conditions in the Pleistocene, i.e. Massif Central, French Jura, the Alps, is one of the most decisive factors influencing the palaeo-geographic landscape of Western and Central Europe.

But how can the hypothesis of the Rhine-Saône-Rhône system as major axis of communication be tested? Again, the identification of non-local lithic raw materials and personal ornaments is decisive. As we had already explicated in the context of the river Rhine, the Rhine-Saône-Rhône corridor is marked by the presence of a supra-regional exchange network concerning Mediterranean mollusc shells used for beads, occurring i.e. in Middle Rhine Gravettian and Magdalenian sites (Floss 2000b) (Fig. 8). This record could recently be enriched by the presence of marine mollusc shells in Protoaurignacian sites in southern France (K. Douka, personal comm.). In terms of the lithic record, the southern Burgundy Grottes de la Verpillière in Germolles, excavated since 2006 by the Tübingen team, got, in the course of these last years, more and more into focus. The Germolles site contains two caves. Whereas the grotte de la Verpillière I is known since the 1860ies, the second cave, grotte de la Verpillière II, has been discovered by our team in 2006. Both caves yield deposits dating from the transitional period of the Middle to the Upper Palaeolithic (Micoquian, MtA, Châtelperronian, Aurignacian, Gravettian). In terms of the lithic raw materials, in all levels prevails local flint originating from the so called argiles à silex. In minor portions,

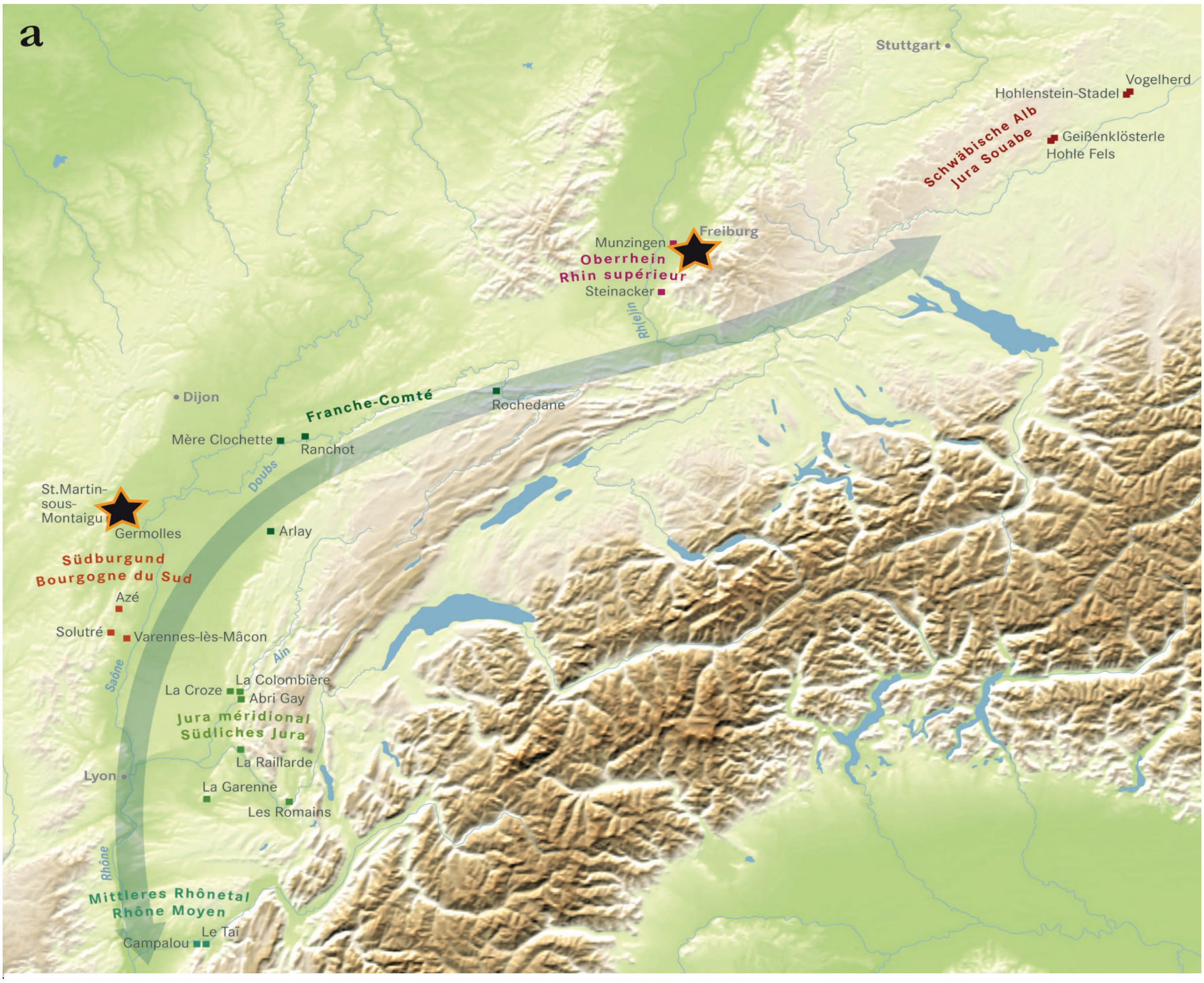






occur different varieties of local chert. A particular variety is a black tabular chert whose outcrops are situated in the area of the very important open air site of Saint Martin-sous-Montaigu, located only few kilometres west from Germolles. Also pebbles have been used (quartz, quartzite) originating from terraces of the river Saône its tributary, the Orbize. Very rarely, we observe single artefacts which have been made of non-local materials. The most striking example concerns two artefacts of Aurignacian type from Verpillière I cave: A retouched blade fragment is made, without any doubt, of a pale grey banded Jurassic chert and a typical Aurignacian carinated core is made of a yellow-reddish jasper. Both materials, banded chert and jasper, originate from the same outcrops south of the actual city of Freiburg im Breisgau in the very southwest angle of Germany, at a distance of about 250 km from Germolles (Fig. 9). The Germolles assemblages contain also a smooth banded lacustrine chert, whose outcrops could be situated at the Mont-les-Etrelles in Franche-Comté, representing a destination which would fit perfectly with the general direction of the Saône-Rhine corridor.

The lithic and the mollusc record conveying a clear message, it is again the question how the artistic traditions could eventually confirm the given hypothesis. In this regard, spotlight is put on the Aurignacian ivory sculptures of the Swabian Jura and the parietal art from Grotte Chauvet. Both assemblages yield, in type and even in their portion, nearly the same represented animal species, dominated by mammoth, lion and horse (Fig. 10). These associations are seemingly typical for Aurignacian art, whereas in younger contexts other species, i.e. bovids and reindeer, get more important. In summary, it is not at all excluded that the Aurignacian assemblages of the Swabian Jura and Grotte Chauvet share, at least in a broadly defined sense, common cultural traditions. Without the Rhine-Saône-Rhône corridor as a major axis for migrations and exchange, these observations of a common cultural heritage seem to be completely impossible.



Left

Figure 7 – Three backed artifacts made of red jasper at Gönnersdorf (southwest corner, final palaeolithic). The raw material is originating from outcrops south of the city of Freiburg im Breisgau, about 300 km from Gönnersdorf (data from Floss 1994)

Figure 8 – The Rhine-Saône-Rhône axis illustrated by Mediterranean mollusk shells found in Gravettian and Magdalenian sites in Central Europe (data from Floss 1994, 2002b)

Above

Figure 9 – Circulation of lithic raw materials along the Rhine-Saône-Rhône axis, illustrated by two artifacts from the Grotte de la Verpillière I at Germolles (Burgundy), left: Carinated core (Aurignacian) made of a red - yellow jasper and a sample from its probable outcrop near the city of Freiburg; right: retouched blade (probably Aurignacian) from a banded grey chert and a sample from its probable outcrop, also near the city of Freiburg.

Figure 10 – Representations of parietal art from Grotte Chauvet-Pont d'Arc and from portable art from the Swabian Jura in comparison (Photos DRAC Rhône-Alpes and University of Tübingen, Hile Jensen)

9 – Conclusions

Rivers bear a great potentiality in being coordination features for Palaeolithic hunter-gatherers. They are constitutive elements of Upper Palaeolithic hunter-gatherer societies and an integral part of their cultural landscape. Understanding the role of focal rivers in Palaeolithic land use patterns requires a careful exploration of their specific natural and cultural characters. It was the aim of this paper to test these hypotheses by three examples of major European rivers: The Danube, the Rhine and the Rhône.

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Lithic raw material exploitation and circulation in Préhistory. A comparative perspective in diverse palaeoenvironments
Liège, ERAUL 138, 2014, p. 25-35

1.2. The contribution of obsidian characterization studies to early prehistoric archaeology

Résumé
Cet article détaille le rôle caractéristique que peut jouer l'obsidienne dans les études d'archéologie préhistorique ancienne. Nous allons tenter d'examiner l'apport des débats récents sur le développement cognitif de l'hominidé archaïque, la complexité sociale, la question de la mobilité néanderthalienne et comment l'approvisionnement en obsidienne met en lumière le processus de colonisation à l'échelle globale. Méthodologiquement, on pense qu'en adoptant un cadre global pour la chaîne opératoire, intégrant les données élémentaires des artefacts avec leurs caractéristiques techno-typologiques, on pourra maximaliser le potentiel interprétatif de nos données et fournir des moyens plus puissants pour reconstituer les réseaux passés d'interactions, ou de *'communities of practice'*.

Abstract
This paper details the interpretative role obsidian characterisation studies can play in earlier prehistoric archaeology. It reviews recent contributions to debates on early hominin cognitive development and social complexity, the question of Neanderthal mobility, and how obsidian sourcing is shedding light on colonisation processes globally. Methodologically it is suggested that by adopting a more holistic *chaîne opératoire* analytical framework, which integrates an artefacts' elemental data with its techno-typological attributes, we can maximise the interpretative potential of our data, and provide a more powerful means of reconstructing past networks of interaction, or 'communities of practice'.

Keywords: obsidian characterisation, Palaeolithic, hominins, Neanderthals, cognition, mobility, colonisation, communities of practice

1 – Obsidian characterisation studies in the 21st century

Over the past 50 years obsidian sourcing has become a well established method, one of the great success stories of archaeological science (Carter *in press*; Freund, 2013). In the Old World scholars the studies of Colin Renfrew and colleagues in the1960s represents the field's seminal work, not only for their methodological innovations, but also for the fact that they were using this technique to ask some major research questions of global archaeological significance (Renfrew *et al.*, 1965, 1966, 1968, *inter alia*). This is a hugely important point to remember, namely that obsidian sourcing for Renfrew was a *means to an end*. The work was not just about reconstructing source histories and raw material distributions, but to use these data to interrogate emergent societal complexity and to propose society-specific modes of behaviour (Renfrew 1975). Ultimately however, there were problems with the claim that different distribution patterns could be equated with distinct modes of exchange, and by extent different types of society (Hodder and Orton 1976: 138). This led to something of a lull in sourcing studies, with few large scale projects in the region during the 1970's and 80's (though see Williams-Thorpe *et al.*, 1984a, 1984b). This radically changed in the 1990's with a new wave of Eurasian projects whose results provide us with rich histories of raw material exploitation, and the ability to chemically discriminate the products of the region's major obsidian sources (Cauvin *et al.*, 1998; Chataigner *et al.*, 2003; Cherry *et al.*, 2010; Delerue 2007; Frahm 2012; Gratuze 1999; Le Bourdonnec 2007; Oddone *et al.* 1999; Poupeau *et al.*, 2010; Tykot 1996, *inter alia*).

This increase in obsidian characterisation studies is a global phenomenon, with the

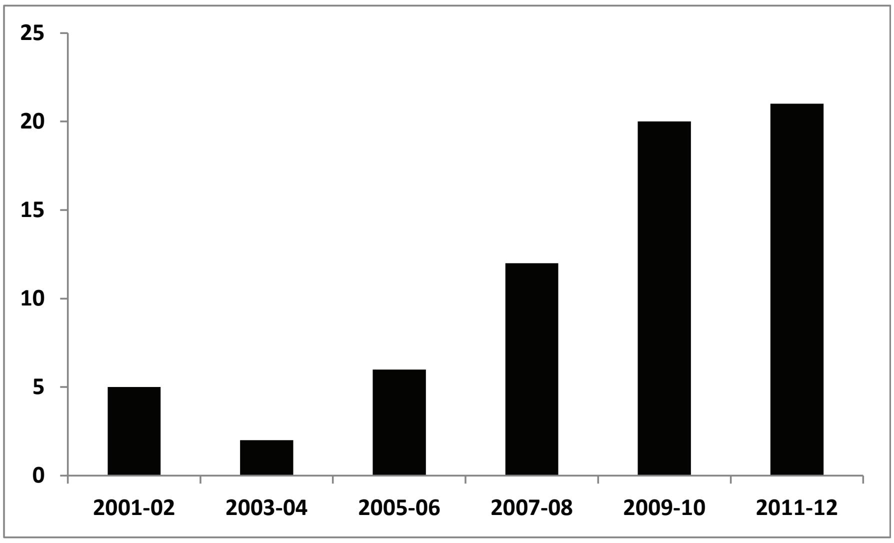

Figure 1
Number of obsidian characterisation papers published in *Archaeometry* and the *Journal of Archaeological Science* over the past decade.

Table 1 – Obsidian distribution in early prehistory by units of social networking (ESA/MSA = Earlier/Middle Stone Age; L/MP = Lower/Middle Palaeolithic [adapted from Moutsiou 2011: Table 7.4, 2012: Figure 1, with data added from Golovanova *et al*., 2010; Le Bourdonnec *et al*., 2012]); *depending on HLK-East, Olduvai Gorge obsidian source.

	Local	**Mesolocal**	**Regional**	**Extended**	**Exotic**
	0-10 km	10-50 km	50-100 km	>100 km	>200 km
ESA East Africa	5	3		2(1)*	0(1)*
LP Eurasia	2	2	1	2	
MSA East Africa	9	8	9	2	
MP Eurasia	2	7	3	4	2

production of a significant number of journal articles over the past decade (Fig. 1 [see also Freund, 2013, Figure 1]), in part relating to the development of portable XRF instruments that enable he analysis of museum-based collections and much larger samples (Nazaroff *et al*., 2009; Golitko *et al*., 2010; Phillips and Speakman 2009; Sheppard *et al*., 2011, *inter alia*). There are also powerful new means of geo-spatially analysing our data, through GIS and Social Network Analysis (Chataigner and Barge 2008; Contreras 2011; Golitko *et al*., 2012; Tripcevich 2007; Taliaferro *et al*., 2010, *inter alia*). These methodological developments are opening new areas of research and a return to questions of old. Here I shall focus on this work's contribution to our understanding of earlier prehistoric societies.

2 – Obsidian characterisation and early hominin studies

Stone tools of course represent one of our primary forms of evidence for reconstructing earl human behaviour (Braun and Hovers 2009). Technological studies, use-wear and cut-mark analyses shed light on Australopithecine and early *Homo* subsistence (McPherron *et al*., 2010), while the study of flaking techniques and raw material choice have allowed scholars to re-evaluate early hominin cognitive skills, showing Oldowan hominids to be more much more complex characters than originally thought (Roche *et al*., 1999; Stout *et al*., 2010, *inter alia*; Toth, 1985). In this context obsidian sourcing studies is providing crucial information on not only the range of these early hominins' movement / home-range, but also their cognitive development in terms of planning, forethought and curation *vis-à-vis* raw material choice, procurement and use (cf. Braun and Hovers 2009; Goldman-Neuman and Hovers 2009).

Recent studies by Ambrose (2012), and Moutsiou (2011, 2012), provide important new insights into Earlier Stone Age / Lower Palaeolithic raw material procurement practices in Africa and Eurasia (for a non-obsidian perspective see Braun *et al*., 2008). These obsidian sourcing data enable us to reconstruct early hominin mobility and provide indices of behavioural complexity. For Moutsiou (2011: 64), a major issue concerning the earliest use of obsidian was to understand whether the transport distances involved fell "within the daily foraging radii of hunter-gatherer life, or if its acquisition required specially organised trips." Drawing on data from anatomy, primatology and ethnography, Moutsiou defines five spatial units of hominin networking: local, mesolocal, regional, extended and exotic, measured at distances of 0-10 km, 10-50 km, 50-100 km, >100 km, and >200 km respectively (Tab. 1). The earliest data suggests that late Australopithecines, *Homo habilis* and *Homo erectus/ergaster* tended to only procure relatively local raw materials. For the Oldowan, maximum site-to-source distances are usually in the range of 15-20 km, and 11-17 km for the Acheulean (Ambrose 2012: 64 [see also Braun *et al*. 2008; Moutsiou 2012: 86]). For example, at the Olduvai Gorge most stone tools were made from igneous and metamorphic rocks that were available within 2-4 km of the site, suggesting that at this early date we are primarily dealing with very small territorial ranges, with largely self-sufficient and introspective social groups. Obsidian thus tends only to be found at those early hominid sites close to a volcanic source. For example, at Melka Kunture in Ethiopia obsidian is well represented in the Oldowan stone tool assemblages, the material characterised as coming from the Balchit source only 7 km distant (Negash *et al*., 2006; Piperno *et al*., 2009). Similar patterns are noted amongst Acheulean assemblages from Kenya and the Caucasus, with raw material transport usually in the 15-30 km range, as for example at the Armenian sites of Arzni and Dzhraber (Moutsiou 2011: 168, Table 3.13), while at Kaletepe- Deresi in central Turkey, the occupation sits directly atop an obsidian source (Slimak *et al.*, 2008)

Characterisation studies do however provide us with limited evidence for obsidian having been moved over significantly larger distances (Tab. 1). Arguably the most striking evidence comes from the HWK-East site, Olduvai Gorge where two pieces of obsidian were recovered from strata associated with *Homo habilis* remains dated 1.9 – 1.7 million years old (Leakey 1971: 89, 264). This represents the earliest evidence for obsidian use in the world, yet the closest sources are thought to be at least 100 km away in Kenya (Moutsiou 2011: 256); indeed the original excavators claimed it may have come from over 270 km (Hay 1976: 185). Of slightly later date is the Acheulean site of Gadeb in Ethiopia where there handaxes made of obsidian that came from at least 160 km away (Clark and Kurashina 1979; Moutsiou 2011: 313), while at Kudaro I in Georgia obsidian was similarly transported over 100 km, presumably by *Homo erectus* (Moutsiou 2011: 308).

To summarise, for the Earlier Stone Age and Lower Palaeolithic of Africa and Eurasia, most cases involved early hominins accessing obsidian from sources no further than 7 – 30 km away, i.e. at the local and mesolocal levels to use Moutsiou's terms. The data suggests that obsidian procurement was a relatively straightforward process, accomplished within general hunting and foraging practices, i.e.; there is no need to believe that it was either a special activity or one that involved exchange (Ambrose 2012: 64). That said, these are not insignificant data, because even when operating at the local and mesolocal level, they still indicate that early hominins were capable of recognising that the tool they had just made in one location would be useful at a later time and carried with them, or while moving through the landscape they could appreciate that a stone would be useful at a future date to make tools. In both instances we are talking about curation, i.e. foresight and planning, a level of behavioural intelligence quite above that of modern chimpanzees (Toth 1987: 781-782), or other tool making/using apes (cf. Mercader *et al.*, 2002; Toth *et al.*, 1993).

So what is the significance of those few cases where obsidian was transported at the extended and exotic level, as at the Olduvai Gorge, Gadeb, and Kudaro I? In these instances Moutsiou (2011: 316-323, 2012: 88-94) argues that the acquisition of raw materials required something far more behaviourally complex than the 'embedded procurement' of obsidian within habituated subsistence hunting and foraging practices. Instead, it is argued that the tools or materials could only have circulated over such distances via exchange, and by extent interaction with members of other social groups. For Moutsiou (2011: 316) these practices – the distant movement of raw materials via exchange networks, and the curation of such exotic resources – represent "a signature of hominins behaving in an essentially modern way", i.e. engaging in activities that had hitherto only been associated with *Homo sapiens*. The ability of these early hominins to create and maintain social networks to access distant materials, and to retain feelings of relatedness to these other characters '*in absentia*', implies a far greater behavioural complexity than many had previously accorded *Homo habilis* and *Homo erectus/ergaster*. Moreover, Moutsiou (2012: 93) claims that at this point the obsidian would have played just as much of a role in mediating these social relations, as it represented a resource for tool-making. These claims are quite radical, as the idea of exchange, and materials acting as media for establishing social relations, are themes that until recently we again would only have associated with modern human behaviour, i.e. something we could only really talk about from the later Middle Stone Age onwards. Here we view an area of early prehistoric research, where obsidian characterisation studies are clearly making an enormous impact.

3 – Neanderthal Mobility and Cognitive Development

By extent, sourcing studies are making important contribution to long-standing debates concerning Neanderthal mobility and social complexity. While recently the former issue has been approached via isotopic studies (Richards *et al.*, 2008) and zooarchaeological data (Delagnes and Rendu 2011), it has been lithic procurement studies that have contributed most to the discussions upon territoriality and cognitive development, as for example the oft-quoted works of Geneste (1989) and Féblot-Augustins (1993; see also Wilson 2007). The fact that Neanderthal tool kits were dominated by local raw materials led many to suggest that they had relatively low mobility, and small daily ranges (Richards *et al.*, 2008: 1251). Conversely, Mellars (1996: 148-151) places greater emphasis on the minority component of tools from these assemblages that were made of raw materials ranging from 20-30 km, up to 80-100 km, data that led him to view Neanderthals as not only far-ranging in their movement, perhaps seasonally moving over long distances, but also engaging in "some form of exchange relationships with neighbouring groups" (see also Kaufmann 2002). This view is now held by an increasing number of scholars based on lithic analyses across Eurasia, with some cases of raw materials/tools moving up to 400 km from their source (cf. Slimak and Giraud 2007; Spinapolice 2012).

Obsidian characterisation studies have provided a number of case studies where such long-distance movement is attested, as for example with the recent analyses of artefacts from the Mezmaiskaya Cave in the Russian Caucasus, and Ortvale Klde in NW Georgia, that demonstrated the procurement of obsidian from sources in excess of 225 and 125 km respectively (Golovanova *et al.*, 2010; Le Bourdonnec *et al.*, 2012). In turn, a late Neanderthal assemblage from the Czech site of Kůlna contained a small quantity of obsidian from the Carpathian sources, almost 400 km distant (Féblot-Augustins 1997; Moutsiou 2011: 155-156). In sum, the Eurasian Middle Palaeolithic provides us with an increased proportion of sites that attest to extended and exotic level scales of obsidian movement compared to what we view in the Earlier Stone Age / Lower Palaeolithic (Moutsiou 2012: 86-87, Figure 1). As before, it can be inferred that here too we are dealing with circulation of obsidian through exchange, with the likelihood that some of the distant material had significance above and beyond its use-value.

While the Middle Palaeolithic data of Eurasia is mainly associated with Neanderthals, the Middle Stone Age assemblages from Africa relate to Anatomically Modern Humans (cf. Ambrose 2012: 64-65; Negash and Shackley 2006; Negash *et al.*, 2011; Vogel *et al.*, 2006). The fact that a number of sites from East Africa (pre 125,000 BP) had small quantities of obsidian from long-distance sources, was at one point viewed as a reflection of significant changes in human behaviour, and by extent an index of the appearance of *Homo sapiens* (Ambrose 2012: 64). Yet as we have detailed above, the distant circulation of raw materials and/or tools has a much older heritage (Moutsiou 2012: 91-94). Admittedly the relative proportion of sites with obsidian from sources in the extended and exotic ranges is greater than that for the preceding Earlier Stone Age (**Table 1**), but the difference is not that great; nor, importantly, is it radically different from the behavioural patterns of Neanderthal populations in contemporary Eurasia.

4 – Late Pleistocene / Early Holocene Migration and Colonisation

The final area of early prehistoric archaeology that obsidian sourcing is contributing to, is the study of Pleistocene and early Holocene colonisation processes, both terrestrial, and maritime. Of particular use to this discussion is the work of Civalero and Franco (2003) that employed obsidian characterization to chart the peopling of Patagonia in South America. Focusing on technical strategies and raw material use, they were able to propose a three-phase model, of: exploration, then colonisation, followed by full occupation. This is a particularly helpful means of conceptualising population movements; the idea in part being that an ever increasing quantity of obsidian will begin to circulate as external populations move into a source area. Characterisation studies appear to detail much the same processes in the late Pleistocene / early Holocene peopling of the Aegean islands. The initial stage of maritime forays into the Cyclades from the nearby Greek mainland are attested by tiny quantities of Melian obsidian from the Upper Palaeolithic cave sites of Klisoura, Franchthi and Ulbrich (Galanidou 2003: 107-108; Koumouzelis *et al* 2003: Table 3; Renfrew and Aspinall 1990). The second phase, represented by the first Early Mesolithic communities in the Cyclades (Sampson *et al.*, 2010) led to a steady increase in the quantity of obsidian being procured by mainland populations during the Early Holocene, after which we view a major surge in the raw materials' circulation after a full settlement of the islands during the Late Neolithic (Torrence 1986: 13-15, 135-36). Current work is now using obsidian characterisation studies to document the pace and direction of population movement into the same islands from the opposing Anatolian coastline (Milić, 2014). It has long been appreciated that obsidian sourcing studies were a productive line of enquiry for charting prehistoric population movement (Green 1962), a field of inquiry now truly coming into its own as a number of recent case studies attest. These include the analysis of mid-Holocene return migrations from Colorado to New Mexico (Arakawa *et al* 2011), plus a plethora of studies using obsidian sourcing to detail the migration of people, languages and material culture into island SE Asia, the Pacific islands and New Zealand (Kirch 1988; Reepmeyer *et al* 2011; Sheppard *et al* 2011; Specht 2002; Summerhayes and Allen 2007, *inter alia*).

Another region where obsidian characterisation analyses stand to make a major contribution to reconstructing colonisation processes is NE Asia, not least the debates surrounding the peopling of Japan, the Kuril Islands and the Americas (cf. Grebennikov *et al* 2010; Kuzmin 2011, Kuzmin *et al.,* 2008; Phillips 2010; Phillips and Speakman 2009, *inter alia*). For example, the recovery of small quantities of Japanese obsidian from Kyushu Island from Upper Palaeolithic sites on the opposing Korean peninsula might be viewed as evidence for early late Pleistocene exploration of the archipelago by mainland peoples c. 25,500 BP (Kim *et al* 2007; Kuzmin 2010: 148; Matsufiji 2003). Finally, it is also important to highlight where obsidian sourcing studies have led to conclusions that argue *against* migration as a means of explaining culture change. For example, Torrence and Swadling (2008) argue that the spread of the Lapita Culture into New Guinea and New Britain involved the introduction of new objects and practices through a pre-existing maritime obsidian exchange system, rather than being the result of an influx of new people as previously claimed.

5 – From Composition to Character: Integrated Sourcing Studies

While obsidian sourcing studies provide us with a powerful means of contributing to the above debates, I often worry that we are not maximising the interpretative potential of our data. Too often when talking of *characterisation* we are in fact only considering elemental *composition*. Over the past few years I worked with a number of collaborators to produce a more integrated archaeometric approach to characterisation studies, beginning with a series of analyses at the Anatolian Neolithic site of Çatalhöyük (Carter *et al* 2006, 2008; Carter and Shackley 2007, *inter alia*), plus the Cretan site of Malia (Carter and Kilikoglou 2007), and continued today through our work at the *McMaster Archaeological XRF Lab* (MAX Lab [http://maxlab.ca]).

First and foremost, the methodology that we employ in the MAX Lab characterisation studies involves the reintroduction of an archaeological aesthetic. Firstly we talk of 'artefacts', not 'samples'. Secondly, we acknowledge that these artefacts have far richer 'characters' than their geo-chemistry, whereby we consider how they were made, their typological form, date, context etc (for a comparable approach see Briois *et al* 1997). Raw material characterisation is thus located within a *chaîne opératoire* analytical framework, because we believe that specific raw material and technical choices were culturally constructed, and by extent will reflect a particular prehistoric group's cultural traditions.

One research question that our lab is currently investigating is to what extent obsidian exchange networks of the late Pleistocene and early Holocene facilitated the spread of agriculture from the Near East into Anatolia. The idea that 'Neolithisation' was articulated via pre-existing obsidian exchange systems is not new (Cauvin 2000); our aim was to try and reconstruct more specifically the inter-community networks through which such new practices might have spread. In order to do this, we were interested in a more nuanced understanding of how obsidian was circulating amongst these people, through considering not only which raw materials were involved, but also the specific modes by which they were 'consumed' (procured-worked-used-discarded).

Previously, representations of obsidian distribution patterns in the Epi-Palaeolithic and earliest Neolithic had simply documented the dissemination of source-specific products across space, an example of which we reproduce in Figure 2 (see also Cauvin and Chataigner 1998; Roaf 1990: 14, *inter alia*). We argue that such maps implicitly lead the viewer to believe that everyone using the same raw materials was somehow linked, yet this need not be the case at all. We can all imagine how different people at the same time could have procured, exchanged and worked obsidian in a number of different ways, yet such distinctions in procurement and consumption are masked if our characterisation studies consider chemical composition alone. One of our recent projects addressed these issues via the characterisation of 120 artefacts from the Terminal Pleistocene – Early Holocene site of Körtik Tepe in southeast Anatolia (11th – 10th millennia cal BC), a study that melded elemental data with techno-typological attributes and contextual considerations (Carter *et al.*, 2013). When these data were located within a broader consideration of how contemporary (Pre-Pottery Neolithic A) populations were employing the same raw materials, it was possible to distinguish at least two regional traditions within what had hitherto been represented as a singular raw material distribution 'zone' (Fig. 3). In essence our research aimed to reveal distinct 'communities of practice', i.e. common traditions of raw material choice / technical practice amongst contemporary populations (Knappett 2011: 98-123). Following debates from the sociology of technology it can be argued that such closely shared practices imply a significant level of on-the-ground interaction between populations, traditions that would emerged and been maintained through inter-marriage and other deeply binding socio-economic relations. We feel that it is through these social networks that new ideas – such as farming – would have spread. For instance, in our Near Eastern / southeast Anatolian case study, the pressure-blade tradition most closely related to early agriculturalists, whereas the bladelet technologies were part of a contemporary, neighbouring group of populations who largely retained a hunter-gatherer lifestyle. These distinctions in economic practices and lithic traditions was only truly appreciated through a more detailed and nuanced form of characterisation study, what we would refer to a 'thick description' approach (Geertz 1973: 3-30; Hodder 1990: 66-79).

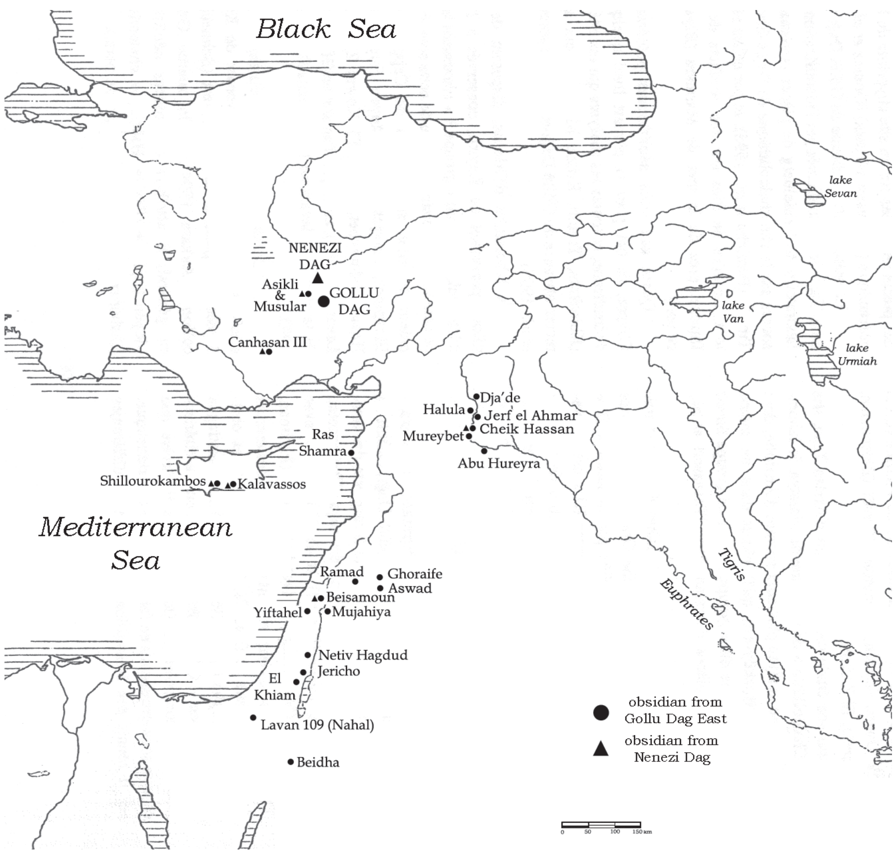

Figure 2 – Typical source product distribution map: circulation of obsidian from East Göllü Dağ and Nenezi Dağ during the Pre-Pottery Neolithic B, 7,500-7,000 cal BC (reproduced from Carter *et al.*, 2005: Figure 12.6d).

The elucidation of such communities of practice through *chaîne opératoire* characterisation studies also offers a powerful means of engaging with other research questions, not least the aforementioned focus on reconstructing the routes and populations involved in colonisation processes.

5 – Endnote

Over the past decade obsidian characterisation studies have finally begun to live up to the intellectual standards set by Colin Renfrew in the 1960's, and are now making a significant impact in the study of early prehistory. Our work can continue to make major contributions to debates on human behaviour, from early hominin social complexity, to Neanderthal mobility, colonisation processes, and the spread of new cultural traditions, but arguably *only* if we meld our hard and social science approaches and shift from a fixation upon composition, to a far richer notion of characterisation.

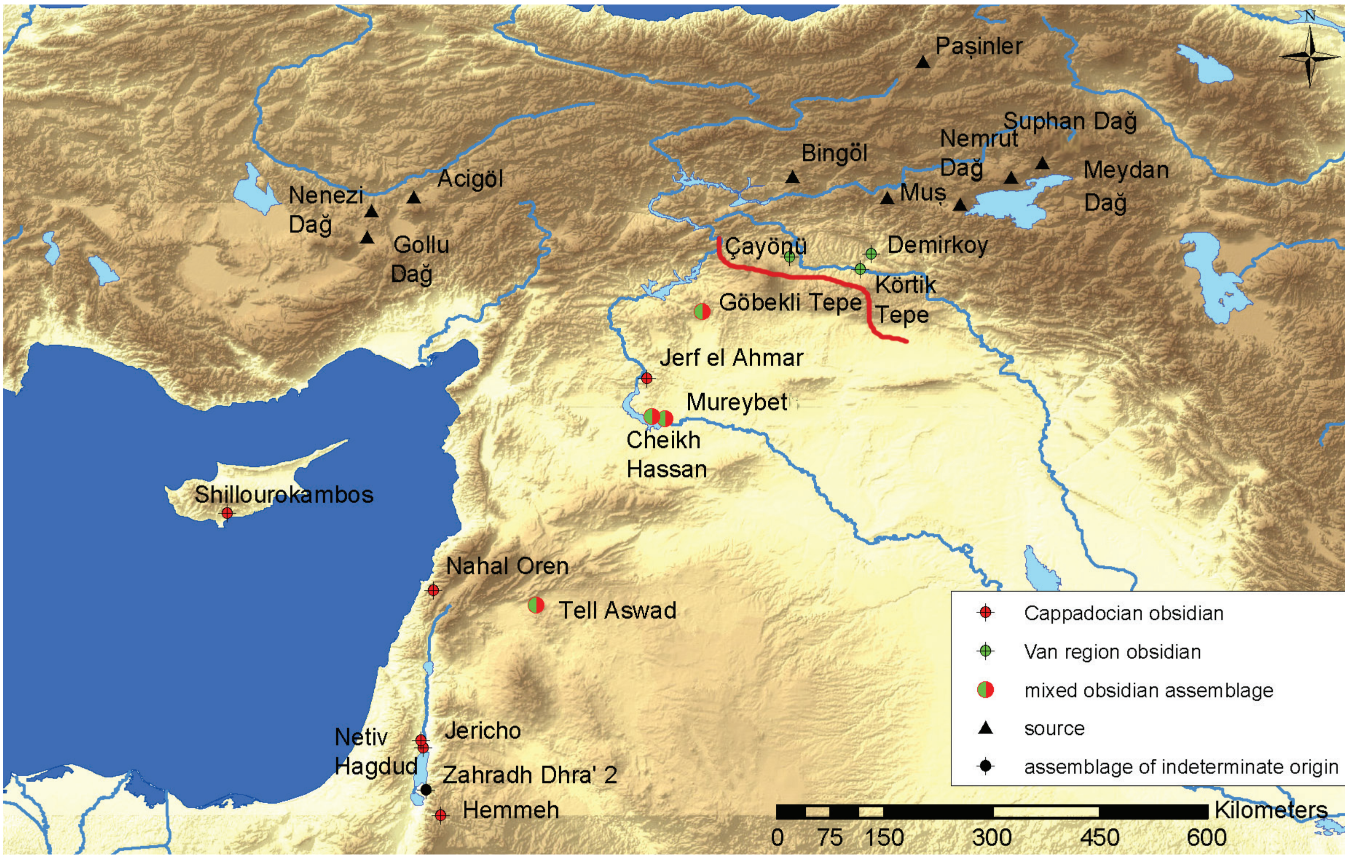

Figure 3 – The distribution of Anatolian obsidian during the Pre-Pottery Neolithic A, 10,000-8,300 cal BC; the red line represents the division between communities consuming these raw materials via bladelet traditions (to the north), and those using the obsidian to make pressure-flaked blades (to the south [from Carter *et al.*, 2013: Figure 10).

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Lithic raw material exploitation and circulation in Préhistory. A comparative perspective in diverse palaeoenvironments
Liège, ERAUL 138, 2014, p. 37-45

1.3. The Mesolithic Project Ullafelsen in Tyrol (Austria)

Résumé
La recherche systématique de terrain à propos de la préhistoire de l'Holocène dans les Alpes tyroliennes a débuté dans les années 1990 après la découverte d'une momie du Néolithique supérieur connue sous le nom de « Tyrolean Iceman ». L'objectif central de ce projet concerne le site Mésolithique ancien de « Ullafelsen ». Le site de base principal se situe dans la vallée de Fotscher à environ 25 km au sud-ouest d'Innsbruck. Une équipe formée de géologues, botanistes, archéologues et autres chercheurs contribue au projet qui a été soutenu par l' «Austrian Science Foundation» (FWF), à Vienne.

Abstract
Systematic field research about early Holocene Prehistory in the Tyrolean Alps has been started in the early 1990ies after the find of the late Neolithic mummy known as the ' Tyrolean Iceman'. The central focus of the project is the old Mesolithic site 'Ullafelsen'. The prominent felsic bedrock is situated in the Fotscher valley around 25 km southwest of Innsbruck. A team of geoscientists, botanists, archaeologists and other contributed to the project which has been supported by the Austrian Science Foundation (FWF) in Vienna (Schäfer 2011).

Keywords: Alps, Early Holocene, Mesolithic, Beuronian, Sauveterrien, Lithic raw materiel

1 – Introduction

The "Mesolithic Project Ullafelsen" was set up to investigate the man-environment relationship from the late glacial period (called Würmian in the Alps) until the Early Holocene in the western Austrian Alps. In the course of a systematic field work since the early 1990s several Mesolithic sites have been found in the Central Alps and in the Northern Limestone Alps of Tyrol (Austria). The so called Ullafelsen has been identified as the most promising site among our old Holocene finds and will be the main focus of this presentation.

The site is an isolated rock formation in the Fotscher valley in the northern part of the Stubai Alps at an altitude of 1,869 meter above sea level. Between 1994 and 2004 excavations of 25 m² have been executed but parts of the felsic plateau were reserved for future examinations. Many finds and features were found the first time in the Austrian Alps and became the subject of intensive studies until recent times. It was also the first time in Austria that several Mesolithic fireplaces were found at a high subalpine altitude. They were accompanied by – sometimes very high – concentrations of lithic artefacts belonging to several material groups. Very early in the project it became clear that only broad interdisciplinary cooperation would be able to cope with the specific features and finds.

2 – Main starting point for further cooperations

A: Apparently, several of the lithic raw-material groups had no native source in the region of North Tyrol. But where did these silex groups came from – and how did they arrived here? It became clear that the answers to those questions could help to gain insights into the living environment and movements of the Mesolithic people in Alpine regions.

B: Some of the Preboreal and Boreal fireplaces featured well-preserved charcoal. This raised hopes of answering the question: Are there any correlations between the composition of plant species found in the charcoal of the fireplaces and the vegetation (tree line) in the Early Holocene?

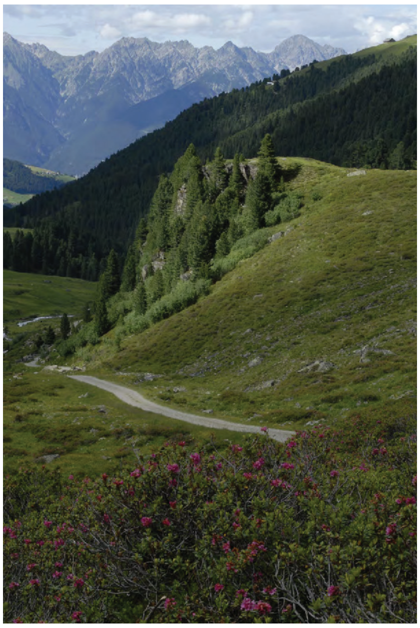


Figure 1
The Ullafelsen (Fotscher valley, Stubai Alps, Tyrol/ Austria) from south (2007) (Photograph: D. Schäfer)

Figure 2
The inner part of the Fotscher valley (with the Ullafelsen in the left lower part of the foto), mainly built up by metamorphic rocks (Para- and Orthogneisses), 2010 (Photograph: D. Schäfer)

Figure 3
Position of the old Mesolithic Ullafelsen site (Fotscher valley, Stubai Alps) in the western part of Austria

C: Specific features were found in several soil profiles. A grey light layer (LL) next to the humus layer of the Holocene was identified as the original living floor for the Mesolithic people of the Ullafelsen. During the first years of the project this layer was seen as the bleached horizon of a podzolisation process. But further inspections suggested that the LL could also be the effect of an aeolian sedimentation process at the very end of the Würmian period. Any answers to this question would provide important insights, not only for the landscape history in the Fotscher valley but also for the interpretation of several soil profiles and the identification of possible manipulations by Mesolithic humans on their living floor.

D: The Fotscher valley shows glacial deposits of several Late-Würmian phases. Being able to date these phases is important for questions related to the Late Würmian sedimentation processes, the availability of parent material for aeolian processes, the growth of vegetation, faunal assemblages and the appearance of the first humans in the valley.

Within the Ullafelsen project we used a broad holistic approach, integrating meteorology, geology and geomorphology, soil science and sedimentology, glaciology, climate and vegetation history, archaeology - including geoarchaeology, use-wear analysis and typology - as well as chert and rock crystal analysis and others.

In the course of the project, and independent of individual interpretations of features discovered in the field, some of the working groups interacted more closely and widened their perception. Looking at the project as a whole, it can be said that the overall knowledge of the man-environment relationship in our working region today is certainly much more than the sum of the individual approaches.

3 – Important findings

1. The Fotscher valley including the Ullafelsen is located between the high precipitation Northern Limestone Alps and the dry Central Alps (fig.3). There are some indications of an especifially favoured position for the Ullafelsen compared to other sites in the region.

2. The Ullafelsen (fig. 1) became ice-free before the Bölling/Alleröd oscillation. There might have been a Late Palaeolithic settlement here but this has not been proved so far.

3. Geological, hydrogeological and geomorphological features of the Fotscher valley (fig. 2) provide the framework for many key aspects, such as possible routes through the valley, cave and rock shelter formations, availability of water and plant resources, sedimentation and erosion processes, rock characteristics and their spatial distribution as an important basis for pedological sequencing, etc. The physical properties of the surface soils in the valley did not allow the preservation of any kind of bones. The only one exception is a rib from an unknown game animal within our excavations at the Ullafelsen site.

4. Most observations and laboratory data obtained so far confirm that the light layer (LL) was the living floor of the Lower Mesolithic occupation of the site (=middle part of fig. 4). Below this layer, a fossil humus horizon could be identified which can only belong to the Bölling/Alleröd complex. Based on these findings, a local stratigraphy between the Late-Würmian period and the Early Holocene could be identified which had hitherto been completely unknown in our region. Current fieldwork concentrates on the chronological and spatial occurrences of the light layer in the valley. This is a difficult undertaking as aeolian processes did not stop abruptly at the beginning of the Holocene and because Aeolian accumulated silty sediments might have been redeposited.

5. The current vegetation in the inner part of the valley shows an altitude zonation primarily influenced by the climate but also by human and animal activities. Today's treeline is largely defined by a long-standing mountain pasture economy. During the second half of the Preboreal period, the closed tree line did not reach the Ullafelsen but came close. At that time, the plateau of our site was mostly used by Early Mesolithic hunters and gatherers. It seems that in the middle of the Boreal period the Ullafelsen was covered by a closed forest which ended the hunting-strategic interests of the Mesolithic people. We have no evidence to date from the Late Mesolithic at our site.

6. Altogether, 14 fireplaces (F) could be identified within the excavation area (fig 5 with fireplace F2). One of the fireplaces (F5) was used later to deposit waste chert material while F3 (and possibly others) can be correlated with the production of tar. Therefore a central part of this fireplace was covered intentionally with a mixture of LL material and sediments containing charcoal from the surrounding area to produce oxygen-reduced conditions for this special fire. Before was done a kind of levelling the surface. Many tar particles were found as single find spots (fig 6) but also detected on the surface of several artefacts. It was the first time in the Alps that such adhesive material could be identified.

7. From the C14 data of the fireplaces one can establish a chronological breakdown for the Ullafelsen area. The fireplaces in the central northern part were used only during the first half of the Boreal period in contrast with fireplaces in the central southern and southwestern parts of the excavation area which were only used in the second half of the Preboreal period. Nevertheless, we have to wait for more detailed intra-site interpretations before finalizing the database of the refitted artefacts.

Figure 4
Ullafelsen, square C9, N- Profile with the typical stratigraphic sequence (in the mid with the 'light layer' (2012)
(Photograph: D. Schäfer)

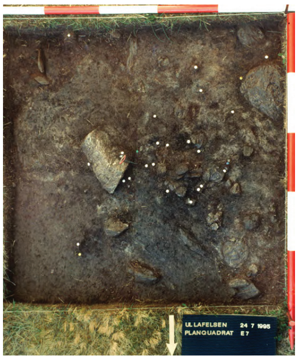


Figure 5
Ullafelsen, The fireplace F2 (1995)
(Photograph: D. Schäfer)

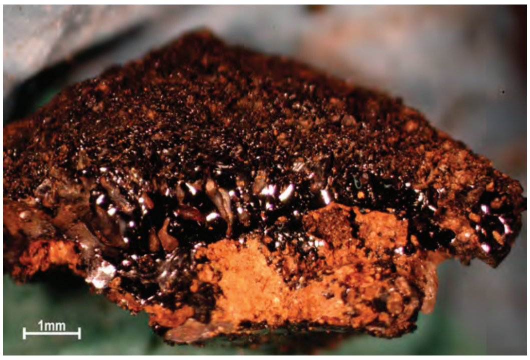


Figure 6
Ullafelsen, Mesolithic tar remains
(Photograph: A. Pawlik)

8. Altogether nearly 7900 three-dimensionally documented stone artefacts were found at the site. They are dominated by microlithic chips 2 and 3 mm in length. Only 14% of the artefacts reach more than 10 mm in length. This wealth of small artefacts highlights not only the efforts of the excavation participants but also an important feature of the Ullafelsen site, i.e. repeated retouching und re-using processes. Combined with quantitative analyses of those chips which were the results of water-screening (in sub-units of ¼ m²), these finds underline the dominance of extremely small artefacts in the vicinity of fireplaces F9/F10 and F4/F5.

9. The Fotscher valley itself offers only rough quartz of very low quality which was used very rarely (fig. 7). Therefore the usual lithic raw material had to be transported from a) regional and b) supra-regional sources (fig. 8). The rock crystal which was used at the Ullfelsen (fig. 9) is very similar to outcrops in the neighboring Zillertal and Tuxer Alps within the western Tauern Window in the Central Alps (BK in fig. 8). Radiolarites from the Northern Limestone Alps have their primary sources in the eastern part of the Karwendel and the Rofan mountain, 40 to 50 km northeast of our site (fig. 10; NK in fig. 8). The most distant raw material comes from the southern Franconian Alb (Upper Jurassic cherts) in Bavaria (fig. 11; FA in fig. 8) demonstrating a linear distance of about 200 km to the Ullafelsen site. Some of it is famous Abensberg- Arnhofen hornstone. More than 1/3 of the analysed cherts comes from the Val di Non area in northern Italy (fig. 12; SA in fig. 8), evidence that the central passes of the Alps were crossed during the very early Holocene.

10. Previous horizontal mapping results of our artefacts show a differentiation or clustering of specific artefact raw materials within our excavated area (fig 13). After finishing this map Stefano Bertola continued his analyses and the results will be refined in the near future.

11. Typo-technological differences between the Early Mesolithic stages of the south-Alpine Sauveterrian and the south German Beuronian can also be seen in the Ullafelsen inventory: Several very small bladelets with typical backs are made only from south alpine cherts. Because those types are not very common in the Beuronian, one can see them as a Sauveterrian element in the Ullafelsen inventory. On the other hand a single long and narrow trapeze in our inventory does not exist as a type within the Sauveterrian but is a special form in the south German Beuronian. This piece is made from hornstone from the Franconian Jura in

Figure 7
Ullafelsen, Mesolithic artefacts of rough local quartz varieties (Q in figure 8) (Photograph: D. Schäfer)

Bavaria. From what we know to date, one can see our site as a transitional area with influences from both traditions.

12. The inventory of the Ullafelsen shows most classic features of an Early Mesolithic site: mainly microlithic tool fragments, plus edge-retouched micropoints, backed bladelets as mentioned, triangles, segments, a trapeze, retouched pieces, scrapers, truncations, burins and borers. There is also evidence of the microburin technique and several cores and refitted flakes show blank form productions

Figure 8
The position of the Ullafelsen (U) southwest of Innsbruck and the evidence of the lithic raw material groups used at this site: Q (local quartz); BK (mountain crys- tal); SA (south alpine silex); NK (silex of the Northern Calcareous Alps); FA (silex of the Franconian Alb)

Figure 9
Ullafelsen, Mesolithic artefacts; raw material: mountain crystal [BK in figure 8] (Photograph: D. Schäfer)


1 cm
b
a

Figure 10 (Left)
Ullafelsen, Mesolíthíc artefacts; raw material: silex of the Northern Calcareous Alps (a: Chiemgau formation; b: Ruhpoldíng formation [NK in figure 8]
(Photograph: D. Schäfer)

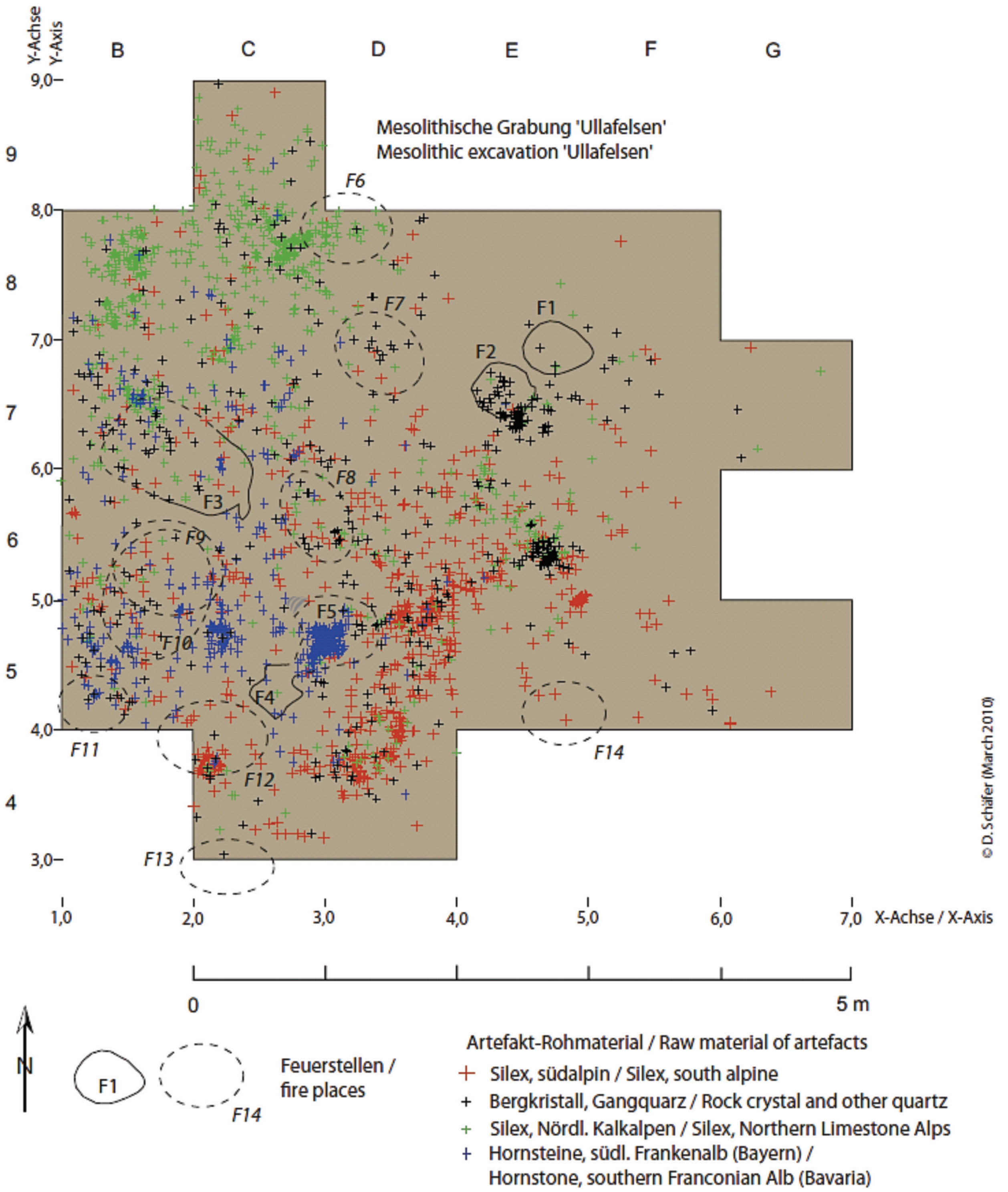
Figure 11 (Above)
Ullafelsen, Mesolithic artefacts; raw material: Upper Jurassic hornstone from the Franconian Alb (Bavaria) [FA in figure 8]
(Photograph: D. Schäfer)

Our complete use-wear analysis of all modified artefacts and of several non-modified flakes (done by A. Pawlik) indicates work on bones or antlers, woodwork, hafting and retooling, work on hide and leather as well as on unspecified harder material. Detailed mapping of single artefacts allowed us to distinguish several working areas and to integrate these with other insights into the inventory. They all point to the Ullafelsen as a base camp for hunting activities.

4 – Discussion

The old Mesolithic site Ullafelsen (Tyrol) has been highlighted as a key site in the Eastern Alps of Austria. The inner organization of the site, raw material characteristics and their trans- port into the valley, the systematic production of tar for rehafting/retooling and surprising results of extended use wear analyses demonstrate fundamental possibilities in alpine archaeological project studies.


E6:432
1 cm
D5:39



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[www.hochgebirgsarchaeologie.at]

Figure 12 (Left)
Ullafelsen. Mesolíthíc artefacts; raw materíal: south alpie chert (Scaglía varíegata/Scaglía rossa from the Valle di Non area (Trentino, Italy) (Photograph: D. Schäfer)

Figure 13 (Above)
Ullafelsen, horizontal stratigraphic distribution of several artifact raw material groups (including analyses until 2010)

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M. Yamada & A. Ono
Lithic raw material exploitation and circulation in Préhistory. A comparative perspective in diverse palaeoenvironments
Liège, ERAUL 138, 2014, p. 47-69

1.4. Carpathian Obsidians: State of Art

Résumé
Ce document donne un résumé actualisé des études sur l'obsidienne en Europe centrale, en rapport avec les sources dites des Carpates. L'histoire de la recherche pour les sources géologiques et les données de distribution archéologiques sont présentées accompagnées des informations sommaires sur l'analyse instrumentale. L'enquête est nécessairement biaisée et incomplète, mais le stockage d'informations dans une base de données interactive largement accessible, prévu dans le cadre du Fonds national de recherche scientifique (OTKA-100385) peut aider à promouvoir la recherche. La collecte de données de distribution fondée sur une recherche archéologique lithique et une caractérisation instrumentale du matériau comparatif et des artefacts d'obsidienne archéologiques nous permet de délimiter les principales caractéristiques de distribution et les zones d'approvisionnement en interactions possibles. L'importance historique des obsidiennes des Carpates est particulièrement remarquable au cours de la période paléolithique, où les sources d'obsidienne C1-C2-C3 ont été les sources d'obsidienne uniquement disponibles, connues et utilisées par les hommes préhistoriques sur le continent européen (sans compter les sources en Géorgie et en Arménie). Il est nécessaire de rappeler que la collecte des données est loin d'être achevée, notamment en région orientale des sources d'obsidiennes. La caractérisation des sources d'obsidiennes des Carpates est faisable en utilisant plusieurs méthodes. Récemment, un progrès essentiel a été apporté par l'utilisation de méthodes non destructives, ce qui est impératif dans l'étude des relations commerciales de longue distance.

Abstract
This paper gives an actual summary of obsidian studies in Central Europe, related to the so-called Carpathian sources. History of research for the geological sources and the archaeological distribution data are presented together with summary information on instrumental analysis. The survey is necessarily biased and incomplete but storing information in a widely accessible interactive database, planned in the framework of the National Scientific Fund (OTKA-100385) may help to promote research. Collecting distribution data based on archaeological lithic research and instrumental characterisation of comparative material and archaeological obsidian artefacts allow us to delineate main distribution features and possible interacting supply zones. The historical importance of Carpathian obsidians is especially evident in the Palaeolithic period, when C1-C2-C3 obsidian sources were the only available mainland obsidian sources known and utilised by prehistoric people in Europe (apart from sources in Georgia and Armenia). It is to be remembered that data collection is far from completed, especially to the East of the obsidian sources. Source characterisation of Carpathian obsidians is feasible using several methods. Recently an essential advance was brought about using non-destructive methods that is imperative in the study of long distance trade connections.

Keywords: obsidian, Central Europe, Carpathian obsidian sources, distribution

1 – Introduction

Obsidian is a success story in Central European lithic provenance studies. The beauty, rarity and adaptability of the material for the purpose of making stone tools made it popular and widely know both in prehistory, folklore and archaeological / anthropological special studies.

The well-known expression of Hungarian tales "*az üveghegyen túl*" (=over the glass mountains) and the many popular names it was given by peasants, mainly shepherds and other herdsmen (varjúkova (=crow-flint), csalakova (=pseudo-flint) show that obsidian was noticed and known by people of the not-so-remote past of the region as well.

2 – Obsidian, the raw material of legends and that of prehistoric stone tools

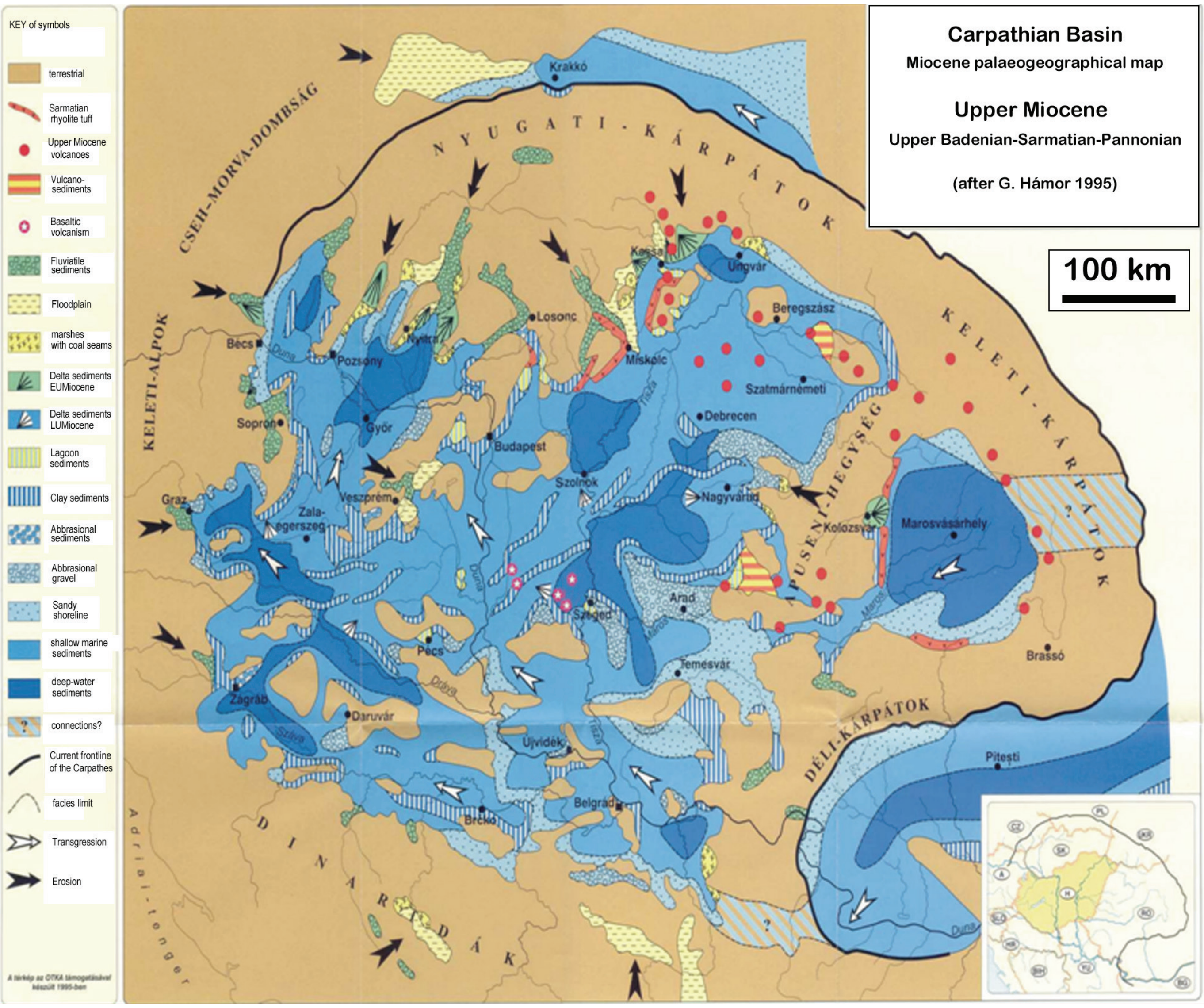
Obsidian is a special kind of rock and gemstone in many ways. Though it looks like a mineral on the strength of its homogeneity, it is a volcanic rock with generally very high silica (SiO_2) content. Obsidian is formed from rhyolitic lava by quenching, i.e., the very fast, practically instantaneous cooling and solidification of the magma (Taylor 1976). These circumstances can be most easily met at volcanic islands surrounded by large water bodies like sea or ocean, occasionally lakes and ice sheet. The result is a solidified rock with no apparent mineral phases. The glass, by the advance of geological times, will crystallize starting from the surface and turn into felsitic volcanic rock with growing number of crystallites and, later, crystals of zeolite and feldspar. The initial part of this process, the formation of the hydration rind, is the basis of obsidian hydration dating (OHD) widely used for, mainly relative dating of obsidian artefacts, especially in stable stratigraphical conditions (Friedman & Smith 1960).

Depending on the composition of the magma, however, the glass can be fairly stable over millions of years.

It may strike you first how we can speak of obsidian volcanism in the centre of Europe, the most continental part of the continent. Looking at the palaeogeographical maps of the Neogene period, however, (Hámor 2001) we can see that during large part of the Neogene when the actual image of the current Carpathian Basin was formed, the territory was covered with large water bodies, remains of the Tethys Ocean of the Mesozoic, turning gradually into a huge with brackish water called Paratethys (Fig. 1).

Apparently, the formation of obsidian requires special conditions; however, these conditions are typically met in young volcanic regions of the tectonically active zones like the Circum-Pacific region or the Mediterranean islands. Collecting information on obsidian worldwide, H. Pollmann (1999) compiled distribution maps for geological obsidian sources all over the World. As his work was mainly directed at collecting bibliographical information, he did not, and could not make a critical assessment of

Figure 1 – Palaeogeographical situation in Central Europe, during the Late Miocene period, after Hámor 1995).



his sources – this task should be handled by the experts of the individual regions themselves.

Such a critical review was accomplished by the author in 2004 on the occasion of the 34th International Symposium on Archaeometry, Zaragoza, Spain (Biró 2004, 2006) for the territory of Hungary and the Carpathian Basin.

Summing up fast, in the so-called Carpathian Region we have to consider 3 main obsidian sources, termed in archaeometrical practice Carpathian 1 (Slovakian obsidian), Carpathian 2 (Hungarian obsidian) and Carpathian 3 (obsidian in the NW ('Transcarpathian') parts of the present Ukraine) (Fig. 2).

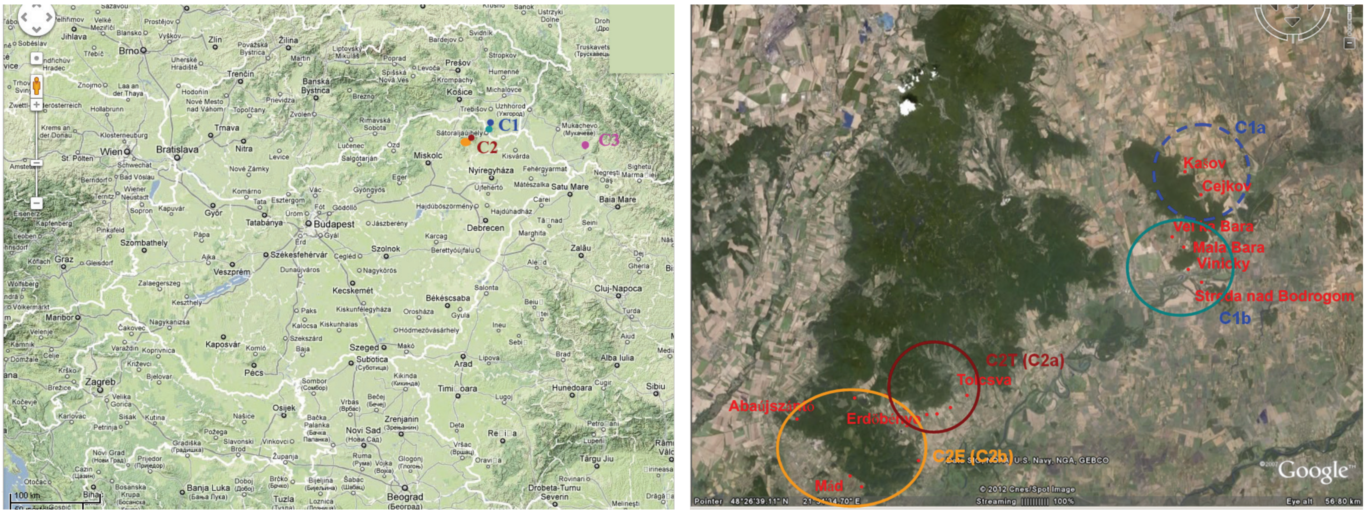
In the following, we shall present here the scientific – geological, archaeological and archaeometrical – analysis of these entities.

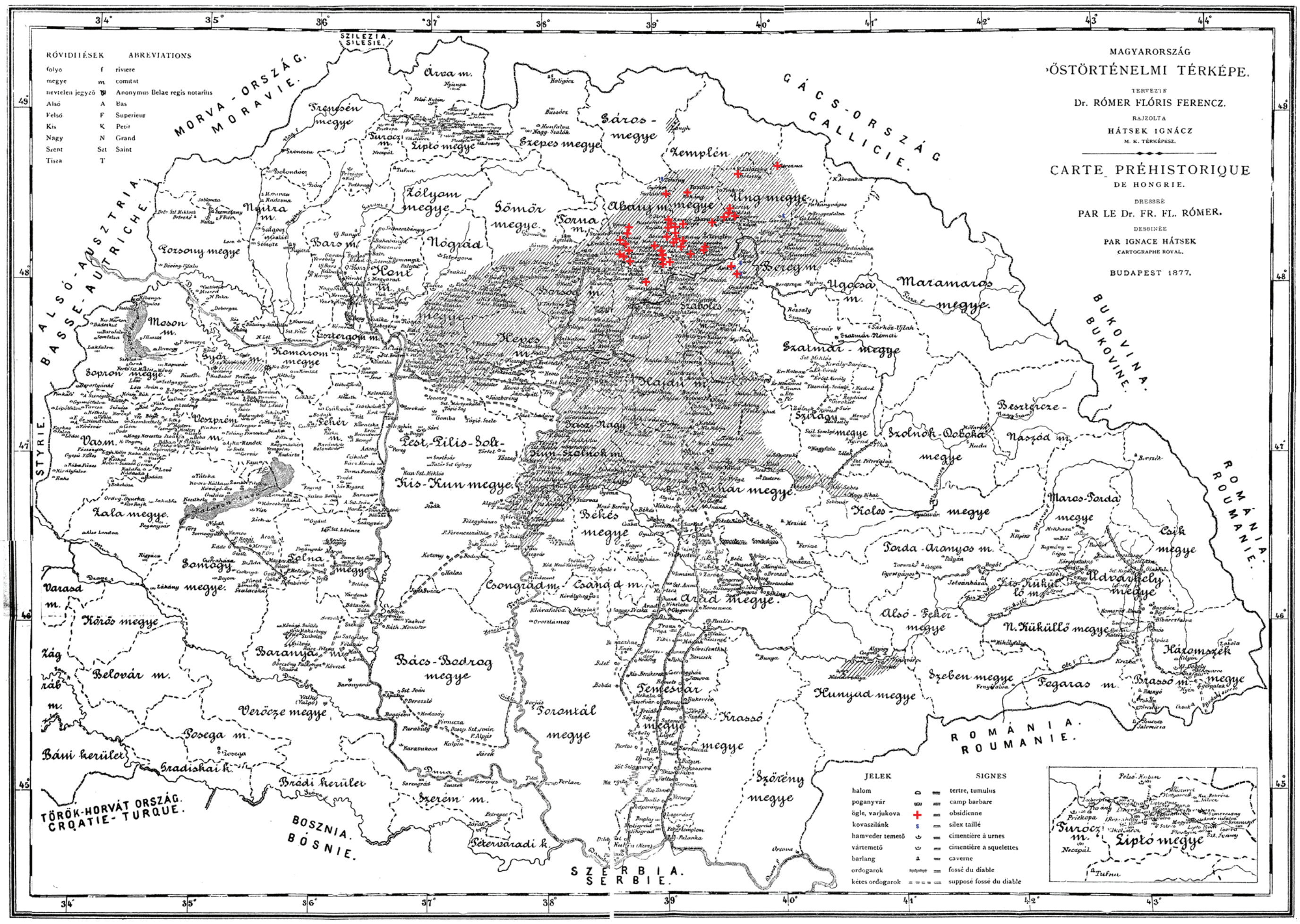
3 – Early localisation and distribution studies

The attention and interest of geologists and prehistorians was attracted to the subject already in the 19th century; partly by early mineralogical and geological descriptions (Fichtel 1791, Beudant 1822) and partly by archaeological and petroarchaeological pioneering studies (Rómer 1867, Szabó 1867, 1878). Flóris Rómer produced the first distribution map of archaeological obsidian on the occasion of the World Archaeological Congress held in Hungary in 1876 (Rómer 1878; Fig.3). On the same conference, J. Szabó compared, from a geological point of view, the obsidians known from that-time Hungary to those from Greece (Szabó 1878). The next great achievement was that of Gy. Szádeczky, (Szádeczky 1886) who gave a detailed geological and geographical description of the obsidian sources, a situation resembling more to possible prehistoric conditions than the modern situation. The next great wave of interest in obsidian and prehistoric trade was encountered in the 1930-ies. Summary maps from the heart of the obsidian region (Janšák 1935) and possible "import" regions Poland (Kostrzewski 1930), Transylvania in Romania (Roska 1934, Fig. 4) were compiled. Roska specifically mentioned possible connections to salt-trade and pottery imports, the latter in the second part of his communication (Roska 1936).

A renewed interest was met in the 1950-ies in Hungary (Gábori 1950, Vértes 1953) for obsidian use in the Palaeolithic period. Both authors emphasised the importance of long distance trade in the Palaeolithic period and its social connotations.

Figure 2 – Carpathian obsidian sources.
Fig. 2a: Carpathian 1, 2, and 3 obsidians; Fig. 2b: location of known Carpathian 1 and 2 sources





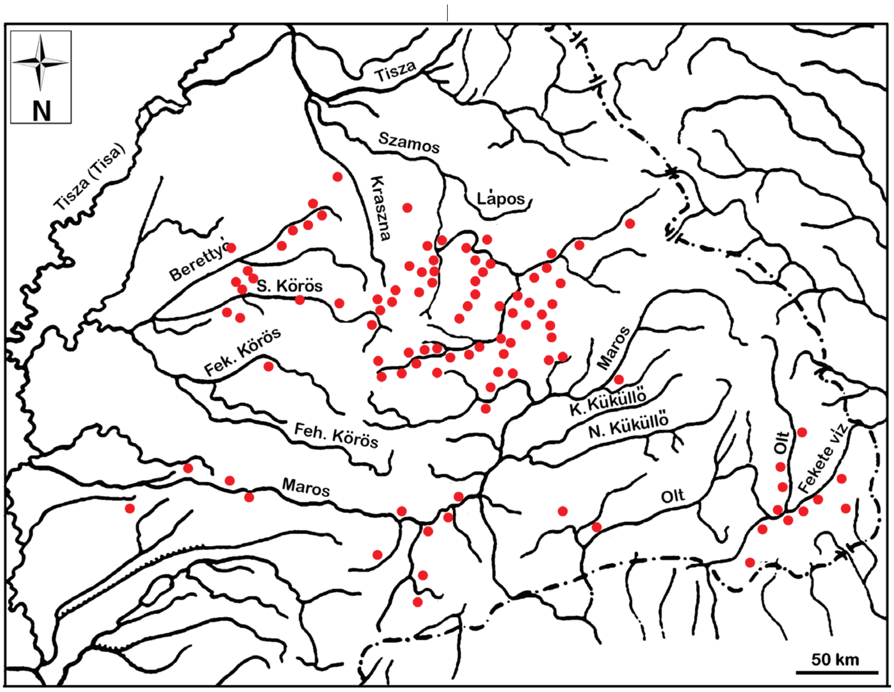


Figure 3 – Distribution map of obsidian from the Carpathian Basin compiled by F. Rómer in 1876

Figure 4 – Archaeological distribution of obsidian in Transylvania, compiled by M. Roska (1934)

4 – Petroarchaeology and archaeometry of obsidian

As a part of the spread of analytical methods in archaeology in the sixties and seventies of the last century, obsidian became a favourite subject for provenance studies on international scale. Following the first communications on the so-called "Mediterranean" obsidian regions (term applied in rather wide sense in various works of C. Renfrew and his collaborators), more and more techniques were successfully applied on sourcing obsidian starting with OES (Cann & Renfrew 1964), later on using NAA (Gordus *et al.,* 1968) and FTD (Bigazzi & Bonadonna 1973). The first successful geochemical characterisation of the Central European (Hungarian and Slovakian) obsidians was realised by NAA (O. Williams and colleagues, Warren & al. 1977, Williams & al. 1984.). Anglo-Saxon archaeometrical research introduced the name "Carpathian obsidian" for these sources with the ease of visitors from far away and grouped known sources accordingly (C1, C2). The name is misleading in many ways; none of the sources are actually in the Carpathian Mountains, though all of them are in the region of the Carpathian Basin, embraced by the above mentioned mountainous range, the (Eastern) Alps and the Dinarides. Further source of misunderstanding, Carpathian is a valid geochronological stage in regional geological system within the Miocene (Haas ed. 2001); the obsidians, however, were formed in a more recent stage, the so-called Sarmatian period (also in the Miocene). We keep the term 'Carpathian' for obsidians here on the strength of priority and to avoid further misunderstanding, noting the problems presented above.

Soon after the successful characterisation by Neutron Activation, the source-characteristic geochemical differences were also detected by EDS and XRF techniques (Biró *et al.,* 1986, 1988) and further sub-groups could be ascertained. Among the C2 (Hungarian) obsidians two variants could be differentiated clearly; C2T type (Tolcsva environs) and C2E (Mád-Erdőbénye environs). The three types can be separated with a trained eye macroscopically as well. C1 is clear / transparent, with shiny glassy surface, black in blocks; C2T (Tolcsva type) is opaque, even in relatively thin slice, black or sometimes reddish (mahogany obsidian); C2E is also opaque but dark graphite grey, often striped. All of them are known from archaeological context, on regional and even long distance range, too, but C1 is far the most popular version.

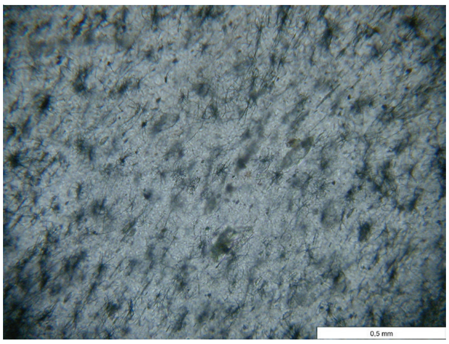


Figure 5
Thin section of C1 obsidian from the Lithotheca collection (L 88/11, Bodrogzsadány 5.)

The observed differences persist in other physical and chemical features as well. The thin section of C1 is clear, with isotropic matrix and few crystallites (Fig. 5) . C2 from Tolcsva and Mád both have more crystallites in the matrix, and there is a felsitic / striped texture observable in the glass. Moreover, the formation of hydration layer is seemingly much faster in the C2 types, very striking in the pieces of Palaeolithic context (Biró & Pozsgai 1982).

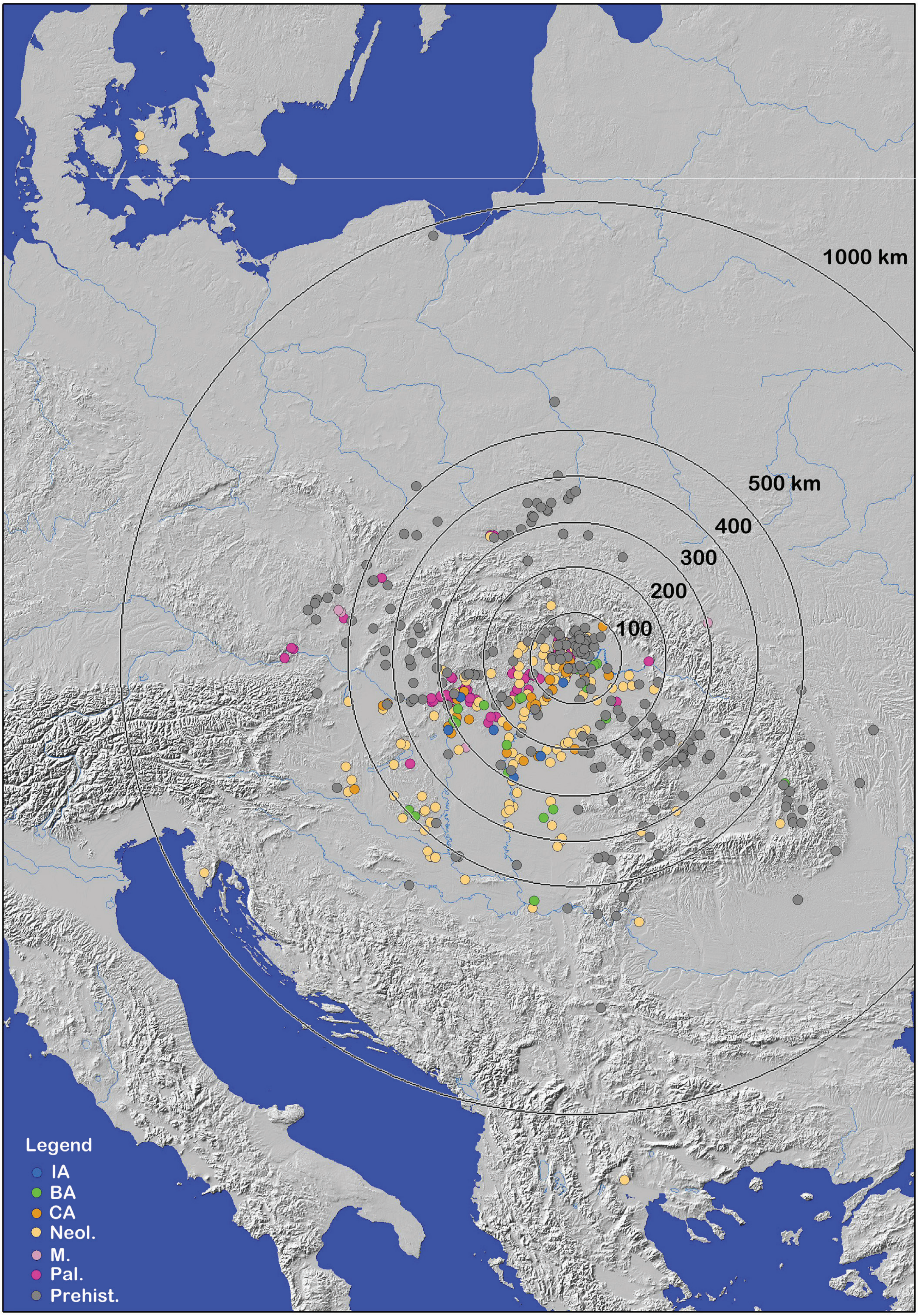
This feature in itself suggests - and we know from various geochemical studies - that the C1 obsidian is closer to the "glass optimum", has more silica and basically less other main components, esp. iron.

Geochemical characterisation of Carpathian obsidians, differentiating the main groups and all of them from other potential concurrent European sources was successful using a number of techniques. Apart from neutron activation analysis, which is still the most accepted routine method, measuring the main components and some trace elements by electron energy dispersive spectrometry (EDS, Biró *et al.,* 1986) and X-ray fluorescence (XRF, Biró *et al.,* 1988), as well as ion beam analytical techniques (PIXE-PIGE, Elekes *et al.,* 2000, Biró *et al.,* 2000c) proved equally successful and are more available for us and less destructive.

Very important contribution to the characterisation of Carpathian obsidians is the determination of the age of formation, i.e., geological age, by fission track dating (FTD, G. Bigazzi in Biró *et al.,* 2000b). It can help in cases when the geochemical composition is undistinguishable like certain C2 types interacting, on the basis of main composition, with one of the Sardinian sources and C1 type, interacting with the highest quality Central Anatolian obsidians. The relatively old age of Carpathian obsidians would clearly identify them in problematic cases; however, no suspect interacting piece was located so far, though we cannot exclude the possibility.

5 – Recent Hungarian contribution to obsidian studies

Following the afore mentioned distribution studies the author started to collect data relevant to obsidian distribution from literature as well as personal survey of the archaeological collections (Biró 1981, 1984). Effort was made to implement objective and instrumental methods for analysis. Unfortunately, most of the methods were destructive at least to some degree and while the historical information obviously justified the damage in debitage relatively close to the source areas, for more distant and unique pieces it was necessary to adopt an effective but non-destructive methodology. Our efforts fortunately met with technical possibilities using PIXE-PIGE techniques (Elekes *et al.,* 2000, Biró *et al.,* 2000c, Rózsa *et al.,* 2000) and PGAA, a non-destructive multi-element technique for geochemical characterisation (Kasztovszky & Biró 2004, 2006, Kasztovszky *et al.,* 2008). Initial application of this technique showed it to be adequate and sensitive enough for obsidian characterisation in view of comparative material from all known sources of Europe. Reference samples were obtained by personal trips to sources as well as kind donations and exchange of samples by means


1000 km
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of the comparative raw material collection of the Hungarian National Museum (Lithotheca, Biró & Dobosi 1990, Biró *et al.,* 2000a). Regular field surveys supported our source database, including special new reference material as the extremely rare red obsidian in our region (Biró *et al.,* 2005) and confirmation and characterisation of the long-debated obsidian sources in Ukraine (C3 type, Rosania *et al.,* 2008). Archaeological interpretation of obsidian distribution data was evaluated from chronological and quantitative aspects (Dobosi 2011 for Palaeolithic distribution and routing; Biró 1998, 1998a for Neolithic stages and Biró 2009 for an essay on overall assessment of Prehistoric obsidian use in Central Europe, by chronological periods and directions).

In this work we can rely on obsidian reported from archaeological sites without instrumental analyses as well as pieces actually analysed by various analytical techniques. The results are stored in a database. The localities are georeferenced, at least on the level of the village (not necessarily on the level of the site proper). The distances from the sources are calculated in direct linear distances – "as the crow flies" (ACF) and represented on topographical maps with concentrical circles set at 100 kms from the source (Fig. 6). I was trying to estimate the importance of directions in the spreading of obsidian artefacts, but there are some objective difficulties in realising this plan as yet.

We must be aware, that the database is far from being complete as yet and the level of information on sites, percentages and analyses is very different regionally. Therefore, the current view of distribution in different time periods is strongly biased by the standpoint of the analyst, the SW direction (from the aspect of the obsidian sources, present-day Hungary) is over-represented in many ways. Also, quite a lot of obsidian artefacts reported in archaeological technical literature lack detailed context or modern interpretation.

It is planned, in the framework of a current National Scientific Grant program, to make data interactively available but we still have to solve many problems for that. For the time being, the author has a relatively representative (though, also not complete)

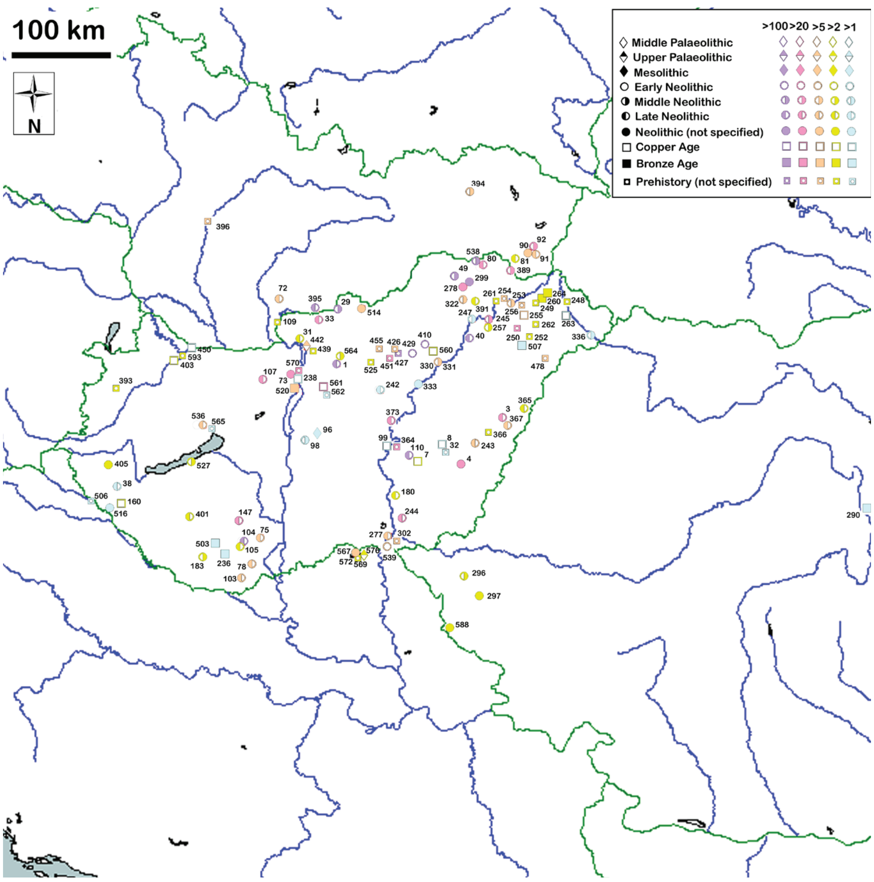


Figure 6 – Left page
Carpathian obsidian distribution by chronological periods and ACF distances from the sources

Figure 7
Quantitative and chronological aspects of obsidian distribution. Sites analysed personally by the author, Lithotheca database

set of information on the distribution of archaeological obsidian from the territory of Hungary mainly. It is presented in the framework of the recently accepted and established chronological scheme for the Carpathian Basin (Visy *et al.,* eds. 2003)(Table 1a & b) (Fig. 7).

The main features of obsidian distribution are summarised below. For the synthesis, I have used former collection of data (mainly Biró 1981, 1984), inventory data of HNM collections (e.g., Table 2), personal petroarchaeological macroscopic studies and analytical data published so far.

6 – Palaeolithic and Mesolithic obsidian distribution

Flakes from terraces of the Hornad river, allegedly Lower Palaeolithic were mentioned by L. Bánesz (1967). As there is no stratigraphical control to this claim, only terrace morphology, we have to treat this datum with caution.

It seems that the first authentic and well-dated instances of obsidian use in the Carpathian Basin date back to Middle Palaeolithic. In Hungary, finds from the Subalyuk Cave are especially important from this respect, with good stratigraphy and sound petroarchaeological characterisation of the lithic industry (Vendl 1939). The Middle Palaeolithic finds from Legénd in the Cserhát Mts. are especially noteworthy in respect of early obsidian use, as the site contains all known Carpathian 1-2 obsidian types including red obsidian (Markó & Péntek 2004).

We can suppose that obsidian reached and surpassed the Danube, a major geographical barrier, in the same period (Pilisszántó II rock shelter, Vértes 1965).

Middle Palaeolithic obsidian use was reported from the territory of Transcarpathian Ukraine around the sources of C3 obsidian (Maly Rakovets (Rokosovo), Ryzhov *et al.,* 2005).

Obsidian is known to be present on all the Early Upper Palaeolithic, mainly to the East of the Danube, as we have no authentic Aurignacian or Szeletian sites to the West of the Danube. The former "Transdanubian Szeletian industries" were more recently classified Middle Palaeolithic (Gábori-Csánk 1993) and contain no obsidian with the exception of the atypical raclette from the Pilisszántó II. rock shelter.

The spreading of the Gravettian culture is more evenly distributed within Hungary and most of the important sites have at least a handful of obsidians. Along the Danube, we have evidence of obsidian distribution till the Vienna Basin. It is also known that obsidian was equally popular on the territory of Slovakia (with the most important obsidian sources) and the territory of Poland, till at least Cracow environs. We have less authentic data on the situation to the East of the sources as yet (Fig. 8.).

The quantitative analysis / frequency data we have from Hungary indicate that obsidian was not a dominant raw material even on the territories close to the sources like Bodrogkeresztúr and Arka (Biró 1984). From Eastern Slovakia, however, we know obsidian dominated large sites with considerable workshop activity like Cejkov and Kašov (Bánesz 1967) where obsidian dominated the lithic assemblage.

We have only sporadic information on the Mesolithic spread of obsidian in the Carpathian Basin, as the number of known authentic sites is very little. Obsidian was described from the Mesolithic site Koroncó along the Danube (Gallus & Mithay 1942). Recently, several sites were discovered and published from the Jászság region. The raw material basis of these communities was mainly local, with sporadic occurrence of obsidian and Transdanubian radiolarite (Kertész 2003 p. 94). In Slovakia, around the sources, however, we have data on sites basically supplied with obsidian (Barca, Prošek (1959). (Fig. 8).

Table 1 (a) – ratio of obsidian and other raw material type groups on the investigated sites

		I.	II.	III.	IV.	V.	VI.	VII.	total	obs %
SITE 299	Encs Kelecsény	775	105	0	0	0	0	24	904	85,73
SITE 429	Füzesabony Gubakút	660	241	5	0	1	0	36	943	69,99
SITE 410	Mezőkövesd Mocsolyás	623	226	2	0	4	0	521	1398	44,56
SITE 1	Aszód Papi földek	615	1234	200	2	402	3	1532	3988	15,42
SITE 538	Hidasnémeti Kis köteles	585	1177	0	0	3	0	19	1784	32,79
SITE 395	Kolary Kolary	369	50	0	0	21	0	22	462	79,87
SITE 29	Szécsény Ültetés	251	112	23	0	22	0	30	438	57,31
SITE 49	Felsővadász Várdomb	172	400	0	0	7	0	56	636	27,04
SITE 104	Zengővárkony	155	0	20	2290	8	0	119	2596	5,97
SITE 427	Kompolt Kistéri tanya 14	144	172	3	0	6	1	129	455	31,65
SITE 110	Öcsöd Kováshalom	109	2566	997	3	8	13	649	4345	2,51
SITE 244	Hódmezővásárhely Gorzsa	99	24	14	94	10	31	49	321	30,84
SITE 33	Csesztve Stalák	98	214	4	0	100	0	34	453	21,63
SITE 389	Sátoraljaújhely Ronyvapart	97	27	0	0	0	0	1	125	77,60
SITE 107	Csabdi Télizöldes	88	52	156	0	11	1	105	413	21,31
SITE 147	Lengyel	57	3	53	460	3	0	24	600	9,50
SITE 92	Slavkovce	56	3	0	0	0	0	7	66	84,85
SITE 364	Tiszaföldvár Téglagyár	56	25	6	0	22	0	31	140	40,00
SITE 278	Ináncs Dombrét	55	57	0	0	1	0	5	118	46,61
SITE 561	Pécel Majorhegy	50	14	22	3	9	0	429	527	9,49
SITE 3	Berettyóújfalu Herpály	41	12	0	0	79	0	26	159	25,79
SITE 250	Nyíregyháza Ságvári TSz	40	6	0	0	0	0	0	46	86,96
SITE 451	Nagyút 4, Göbölyjárás II. M-3 /12	31	18	0	0	1	0	18	68	45,59
SITE 80	Gönc Gát	30	94	0	0	16	0	11	151	19,87
SITE 4	Mezőberény Bódishát	29	17	0	2	18	1	14	81	35,80
SITE 245	Tiszalök Hajnalos	28	8	0	0	0	0	4	40	70,00
SITE 73	Budapest Aranyhegyi út	22	8	159	0	16	0	29	235	9,36
SITE 570	Budapest Nánási út 69	22	157	112	0	23	0	677	994	2,21
SITE 373	Szolnok Tűzköves	21	580	41	0	0	2	41	685	3,07
SITE 254	Balsa Fecskepart	19	1	0	0	4	0	0	24	79,17
SITE 539	Tiszasziget	18	21	49	1	4	4	36	133	13,53
SITE 442	Vác Csipkés	18	201	18	0	22	0	109	368	4,89
SITE 569	Szabadka-Ludasi tó H1-A (Hulló-tanya)	17	4	14	1	1	1	37	75	22,67
SITE 367	Berettyóújfalu Szilhalom	17	9	0	0	50	0	4	80	21,25
SITE 394	Sarisske Michalany	17	20	0	0	2	0	99	138	12,32
SITE 455	Visonta K-II 1A	16	19	1	0	1	0	7	44	36,36
SITE 520	Budapest Albertfalva	15	12	31	0	7	0	522	588	2,55
SITE 255	Kemecse Sarvaj birtok	14	8	0	0	0	0	0	22	63,64
SITE 72	Santovka	14	149	9	0	33	0	19	224	6,25
SITE 478	Nyírlugos Erzsébet-hegy	11	0	0	0	0	0	0	11	100,00
SITE 103	Villánykövesd	11	0	3	30	4	0	2	50	22,00
SITE 75	Kismórágy Tűzkődomb	11	0	4	37	0	0	7	59	18,64
SITE 302	Deszk Vénó	11	2	9	3	19	0	39	83	13,25
SITE 243	Szeghalom Várhely	10	2	0	0	1	1	0	14	71,43
SITE 514	Salgótarján Ipari Park II.	10	5	0	0	2	0	5	22	45,45
SITE 426	Kompolt Kistéri tanya I (15)	10	69	3	0	1	0	138	221	4,52
SITE 396	Trencianske Bohuslavicze	9	0	1	0	0	0	0	10	90,00
SITE 90	Malé Raskovce	9	13	0	0	1	0	8	31	29,03
SITE 277	Tápé Lebő	9	4	10	5	1	1	22	52	17,31
SITE 253	Tiszavasvári Köztemető	8	2	0	0	0	0	0	10	80,00
SITE 330	Tiszavalk Négyes	8	6	0	0	0	0	0	14	57,14
SITE 91	Izkovce	8	5	0	0	63	0	8	84	9,52
SITE 322	Megyaszó Nagyrépás hill	7	28	0	0	1	0	5	41	17,07
SITE 536	Veszprém Jutasi út (ld. Felszabadítók)	7	0	63	0	0	0	85	156	4,49
SITE 256	Nagyhalász Pusztatemplom	6	0	0	0	1	0	0	7	85,71
SITE 78	Babarc	6	0	0	2	0	0	4	12	50,00
SITE 567	Szabadka-Ludasi tó H2-A (Hulló-tanya)	6	4	53	9	0	2	106	181	3,31
SITE 260	Rétközberencs Paradomb	5	0	0	0	0	0	0	5	100,00
SITE 297	Freidorf (Timisoara)	5	1	0	0	0	0	2	8	62,50
SITE 257	Tiszavasvári Keresztfal x	5	5	0	0	0	0	0	10	50,00
SITE 296	Satchinez	5	1	0	0	1	2	3	12	41,67
SITE 7	Békésszentandrás	5	1	0	0	5	0	2	13	38,46
SITE 366	Darvas Kisbogárzó	5	4	0	0	5	0	0	14	35,71
SITE 248	Kisvarsány	4	2	0	0	1	0	2	9	44,44
SITE 576	Nosza Gyöngypart	4	1	1	4	0	30	12	53	7,55
SITE 393	Gór Kápolnadomb	4	0	190	3	0	0	276	482	0,83
SITE 249	Gégény	3	0	0	0	0	0	0	3	100,00
SITE 252	Nyírszőlős Izabella u. 121	3	0	0	0	0	0	0	3	100,00
SITE 264	Kisvárda	3	0	0	0	0	0	0	3	100,00
SITE 572	Szabadka-Ludasi tó H1-C (Hulló-tanya)	3	1	1	0	0	1	9	15	20,00
SITE 439	Vác Szék-hegy	3	12	23	0	4	0	5	47	6,38
SITE 568	Szabadka-Ludasi tó H2-B (Hulló-tanya)	3	1	17	0	0	2	26	49	6,12
SITE 588	Foieni Cimitir	3	9	3	6	1	35	51	109	2,75
SITE 403	Ikrény M-1 546 tripód	3	0	108	0	13	0	31	161	1,86

SITE 401	Kaposvár Gyertyános	3	1	48	67	0	0	60	179	1,68
SITE 593	Ménfőcsanak Széles földek	3	3	82	0	2	0	111	202	1,49
SITE 180	Szegvár Tűzköves	3	90	60	0	0	1	49	203	1,48
SITE 527	Balatonszemes Bagódomb	3	2	210	0	0	0	40	255	1,18
SITE 261	Timár Béke TSz	2	1	0	0	0	0	0	3	66,67
SITE 262	Apagy Nagyharaszti tanya	2	0	0	0	0	0	1	3	66,67
SITE 109	Vámosmikola Harmospuszta	2	0	2	0	0	0	0	4	50,00
SITE 287	Cozmeni	2	0	0	0	2	1	1	6	33,33
SITE 81	Hrcel Nad banou	2	0	0	0	4	0	0	6	33,33
SITE 564	Verseg Zsolnai oldal	2	5	0	0	0	0	0	7	28,57
SITE 560	Szentistván Mádi rét, MOL-24	2	7	0	0	0	0	0	9	22,22
SITE 525	Vámosgyörk MHAT telep	2	6	1	0	0	0	3	12	16,67
SITE 183	Szentlőrinc Szentlőrinc	2	0	7	5	0	0	1	15	13,33
SITE 391	Szerencs Taktaföldvár	2	12	0	0	0	0	4	18	11,11
SITE 160	Nagykanizsa Sánc	2	0	46	19	1	0	68	136	1,47
SITE 105	Pécsvárad Aranyhegy	2	0	6	222	0	0	2	232	0,86
SITE 31	Verőcemaros Magyarkút	2	168	89	0	8	0	16	283	0,71
SITE 405	Gellénháza Városrét	2	6	1043	5	3	0	352	1414	0,14
SITE 247	Tiszadob Sziget	1	0	0	0	0	0	0	1	100,00
SITE 251	Oros Fölvár	1	0	0	0	0	0	0	1	100,00
SITE 258	Tiszabercel Ráctemető	1	0	0	0	0	0	0	1	100,00
SITE 259	Nagyhalász TSz Gépáll.	1	0	0	0	0	0	0	1	100,00
SITE 265	Tiszalök Kisfás, Bereczki d.	1	0	0	0	0	0	0	1	100,00
SITE 32	Gyomaendrőd Gyoma 117	1	0	0	0	0	0	0	1	100,00
SITE 331	Tiszavalk Tetes	1	0	0	0	0	0	0	1	100,00
SITE 333	Kisköre Gát	1	1	0	0	0	0	0	2	50,00
SITE 336	Szamossályi Szamossályi	1	1	0	0	0	0	0	2	50,00
SITE 8	Gyomaendrőd Endrőd 108	1	0	0	0	1	0	0	2	50,00
SITE 99	Tiszabög Kincsem	1	0	0	0	1	0	0	2	50,00
SITE 263	Nagydobos Petőfi TSz	1	1	0	0	0	0	2	4	25,00
SITE 290	Leliceni Leliceni (Csikszentlélek)	1	0	0	0	2	0	1	4	25,00
SITE 592	Karmacs ??	1	0	1	1	0	0	2	5	20,00
SITE 365	Esztár Fenyvespart	1	0	0	0	8	0	1	10	10,00
SITE 507	Nagykálló Telekoldal	1	8	0	0	0	0	2	11	9,09
SITE 98	Kunszentmiklós Középszenttamás	1	2	12	0	0	0	3	18	5,56
SITE 503	Kovácsszénája Füstöslik	1	0	0	10	0	0	9	20	5,00
SITE 238	Budapest Medve u.	1	3	3	0	0	0	15	22	4,55
SITE 236	Pécs Nagyárpád	1	0	0	28	0	0	1	30	3,33
SITE 242	Alattyán Vizköz 3	1	34	0	0	1	0	4	40	2,50
SITE 450	Ménfőcsanak Bevásárlóközpont	1	0	9	0	0	0	31	41	2,44
SITE 562	Pécel M0 Kelet, 02	1	7	8	0	3	0	86	106	0,94
SITE 96	Kunpeszér Felsőpeszéri út	1	78	12	2	0	0	22	115	0,87
SITE 565	Litér Papvásárhegy	1	0	185	0	0	0	2	188	0,53
SITE 38	Zalaszentbalázs Szőlőhegyi mező	1	5	202	7	3	3	193	414	0,24
SITE 506	Muraszemenye Aligvári mező	1	0	511	7	0	0	483	1004	0,10
SITE 516	Petrivente Újkúti dűlő	1	0	1200	28	1	7	2649	3913	0,03

Key:

I.	obsidian
II.	hydrothermal and limnic silicites
III.	Transdanubian radiolarite
IV.	Mecsek radiolarite
V.	“Northern” flint
VI.	“Southern” flint
VII.	other raw materials

Table 1a – Archaeological sites with obsidian from the Lithotheca database. Table 1a: main raw material groups;

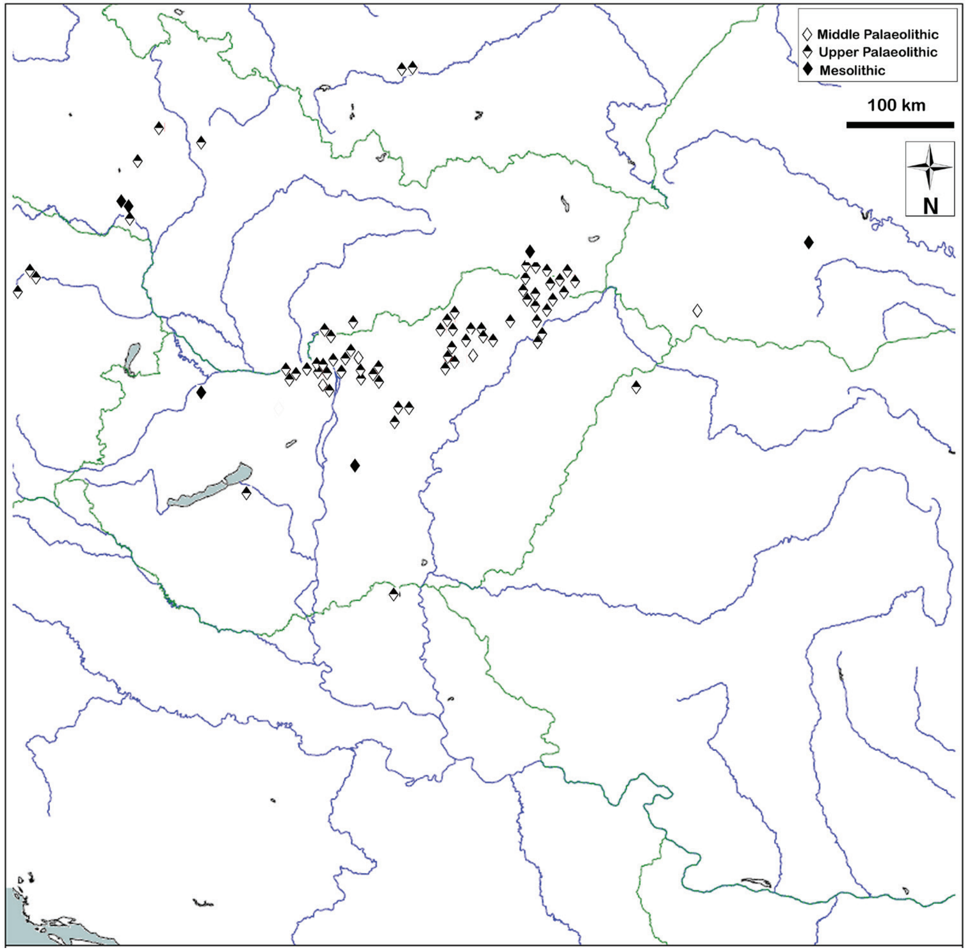
Table 1 (b) – ratio of obsidian and obsidian types on the investigated sites

		Obs. Total	C1	C2E	C2T	total	Obs. %
SITE 299	Encs Kelecsény	775	751	0	24	904	85,73
SITE 429	Füzesabony Gubakút	660	640	1	19	943	69,99
SITE 410	Mezőkövesd Mocsolyás	623	609	1	13	1398	44,56
SITE 1	Aszód Papi földek	615	580	11	24	3988	15,42
SITE 538	Hidasnémeti Kis köteles	585	565	1	19	1784	32,79
SITE 395	Kolary Kolary	369	357	1	11	462	79,87
SITE 29	Szécsény Ültetés	251	244	1	6	438	57,31
SITE 49	Felsővadász Várdomb	172	160	1	11	636	27,04
SITE 104	Zengővárkony Zengővárkony	155	153	0	2	2596	5,97
SITE 427	Kompolt Kistéri tanya 14	144	143	0	1	455	31,65
SITE 110	Öcsöd Kováshalom	109	104	1	4	4345	2,51
SITE 244	Hódmezővásárhely Gorzsa	99	99	0	0	321	30,84
SITE 33	Csesztve Stalák	98	97	0	1	453	21,63
SITE 389	Sátoraljaújhely Ronyvapart	97	94	0	3	125	77,60
SITE 107	Csabdi Télizöldes	88	86	0	2	413	21,31
SITE 147	Lengyel Lengyel	57	56	0	1	600	9,50
SITE 92	Slavkovce Slavkovce	56	56	0	0	66	84,85
SITE 364	Tiszaföldvár Téglagyár	56	55	0	1	140	40,00
SITE 278	Ináncs Dombrét	55	51	1	3	118	46,61
SITE 561	Pécel Majorhegy	50	48	0	2	527	9,49
SITE 3	Berettyóújfalu Herpály	41	38	0	3	159	25,79
SITE 250	Nyíregyháza Ságvári TSz	40	40	0	0	46	86,96
SITE 451	Nagyút 4, Göbölyjárás II. M-3 /12	31	30	0	1	68	45,59
SITE 80	Gönc Gát	30	25	0	5	151	19,87
SITE 4	Mezőberény Bódishát	29	27	1	1	81	35,80
SITE 245	Tiszalök Hajnalos	28	22	2	4	40	70,00
SITE 73	Budapest Aranyhegyi út	22	21	0	1	235	9,36
SITE 570	Budapest Nánási út 69	22	21	1	0	994	2,21
SITE 373	Szolnok Tűzköves	21	21	0	0	685	3,07
SITE 254	Balsa Fecskepart	19	17	1	1	24	79,17
SITE 539	Tiszasziget Tiszasziget	18	18	0	0	133	13,53
SITE 442	Vác Csipkés	18	14	2	2	368	4,89
SITE 569	Szabadka-Ludasi tó H1-A (Hulló-tanya)	17	16	0	1	75	22,67
SITE 367	Berettyóújfalu Szilhalom	17	17	0	0	80	21,25
SITE 394	Sarisske Michalany Sarisske Michalany	17	17	0	0	138	12,32
SITE 455	Visonta K-II 1A	16	16	0	0	44	36,36
SITE 520	Budapest Albertfalva	15	15	0	0	588	2,55
SITE 255	Kemecse Sarvaj birtok	14	14	0	0	22	63,64
SITE 72	Santovka Santovka	14	14	0	0	224	6,25
SITE 478	Nyírlugos Erzsébet-hegy	11	11	0	0	11	100,00
SITE 103	Villánykövesd Villánykövesd	11	11	0	0	50	22,00
SITE 75	Kismórágy Tűzkődomb	11	10	0	1	59	18,64
SITE 302	Deszk Vénó	11	11	0	0	83	13,25
SITE 243	Szeghalom Várhely	10	10	0	0	14	71,43
SITE 514	Salgótarján Ipari Park II.	10	10	0	0	22	45,45
SITE 426	Kompolt Kistéri tanya I (15)	10	9	0	1	221	4,52
SITE 396	Trencianske Bohuslavicze Trencianske Bohuslavicze	9	0	9	0	10	90,00
SITE 90	Malé Raskovce Malé Raskovce	9	9	0	0	31	29,03
SITE 277	Tápé Lebő	9	9	0	0	52	17,31
SITE 253	Tiszavasvári Köztemető	8	8	0	0	10	80,00
SITE 330	Tiszavalk Négyes	8	8	0	0	14	57,14
SITE 91	Izkovce Izkovce	8	8	0	0	84	9,52
SITE 322	Megyaszó Nagyrépás hill	7	7	0	0	41	17,07
SITE 536	Veszprém Jutasi út (ld. Felszabadítók)	7	7	0	0	156	4,49
SITE 256	Nagyhalász Pusztatemplom	6	6	0	0	7	85,71
SITE 78	Babarc Babarc	6	6	0	0	12	50,00
SITE 567	Szabadka-Ludasi tó H2-A (Hulló-tanya)	6	6	0	0	181	3,31
SITE 260	Rétközberencs Paradomb	5	5	0	0	5	100,00
SITE 297	Freidorf (Timisoara)	5	5	0	0	8	62,50
SITE 257	Tiszavasvári Keresztfal x	5	2	3	0	10	50,00
SITE 296	Satchinez Satchinez	5	5	0	0	12	41,67
SITE 7	Békésszentandrás Békésszentandrás	5	5	0	0	13	38,46
SITE 366	Darvas Kisbogárzó	5	5	0	0	14	35,71
SITE 248	Kisvarsány Kisvarsány	4	4	0	0	9	44,44
SITE 576	Nosza Gyöngypart	4	0	3	1	53	7,55
SITE 393	Gór Kápolnadomb	4	4	0	0	482	0,83
SITE 249	Gégény Gégény	3	3	0	0	3	100,00
SITE 252	Nyírszőlős Izabella u. 121	3	3	0	0	3	100,00
SITE 264	Kisvárda Kisvárda	3	3	0	0	3	100,00
SITE 572	Szabadka-Ludasi tó H1-C (Hulló-tanya)	3	3	0	0	15	20,00
SITE 439	Vác Szék-hegy	3	3	0	0	47	6,38
SITE 568	Szabadka-Ludasi tó H2-B (Hulló-tanya)	3	3	0	0	49	6,12
SITE 588	Foieni Cimitir	3	3	0	0	109	2,75
SITE 403	Ikrény M-1 546 tripód	3	3	0	0	161	1,86

SITE 401	Kaposvár Gyertyános	3	3	0	0	179	1,68
SITE 593	Ménfőcsanak Széles földek	3	3	0	0	202	1,49
SITE 180	Szegvár Tűzköves	3	3	0	0	203	1,48
SITE 527	Balatonszemes Bagódomb	3	3	0	0	255	1,18
SITE 261	Timár Béke TSz	2	2	0	0	3	66,67
SITE 262	Apagy Nagyharaszti tanya	2	2	0	0	3	66,67
SITE 109	Vámosmikola Harmospuszta	2	2	0	0	4	50,00
SITE 287	Cozmeni Cozmeni	2	2	0	0	6	33,33
SITE 81	Hrcel Nad banou	2	2	0	0	6	33,33
SITE 564	Verseg Zsolnai oldal	2	2	0	0	7	28,57
SITE 560	Szentistván Mádi rét, MOL-24	2	2	0	0	9	22,22
SITE 525	Vámosgyörk MHAT telep	2	2	0	0	12	16,67
SITE 183	Szentlőrinc Szentlörinc	2	2	0	0	15	13,33
SITE 391	Szerencs Taktaföldvár	2	1	0	1	18	11,11
SITE 160	Nagykanizsa Sánc	2	2	0	0	136	1,47
SITE 105	Pécsvárad Aranyhegy	2	2	0	0	232	0,86
SITE 31	Verőcemaros Magyarkút	2	2	0	0	283	0,71
SITE 405	Gellénháza Városrét	2	2	0	0	1414	0,14
SITE 247	Tiszadob Sziget	1	0	0	1	1	100,00
SITE 251	Oros Fölvár	1	1	0	0	1	100,00
SITE 258	Tiszabercel Ráctemető	1	1	0	0	1	100,00
SITE 259	Nagyhalász TSz Gépáll.	1	1	0	0	1	100,00
SITE 265	Tiszalök Kisfás, Bereczki d.	1	1	0	0	1	100,00
SITE 32	Gyomaendrőd Gyoma 117	1	0	0	1	1	100,00
SITE 331	Tiszavalk Tetes	1	1	0	0	1	100,00
SITE 333	Kisköre Gát	1	1	0	0	2	50,00
SITE 336	Szamossályi Szamossályi	1	1	0	0	2	50,00
SITE 8	Gyomaendrőd Endrőd 108	1	1	0	0	2	50,00
SITE 99	Tiszabög Kincsem	1	1	0	0	2	50,00
SITE 263	Nagydobos Petőfi TSz	1	1	0	0	4	25,00
SITE 290	Leliceni Leliceni (Csikszentlélek)	1	1	0	0	4	25,00
SITE 592	Karmacs ??	1	1	0	0	5	20,00
SITE 365	Esztár Fenyvespart	1	1	0	0	10	10,00
SITE 507	Nagykálló Telekoldal	1	1	0	0	11	9,09
SITE 98	Kunszentmiklós Középszenttamás	1	1	0	0	18	5,56
SITE 503	Kovácsszénája Füstöslik	1	1	0	0	20	5,00
SITE 238	Budapest Medve u.	1	1	0	0	22	4,55
SITE 236	Pécs Nagyárpád	1	1	0	0	30	3,33
SITE 242	Alattyán Vizköz 3	1	1	0	0	40	2,50
SITE 450	Ménfőcsanak Bevásárlóközpont	1	1	0	0	41	2,44
SITE 562	Pécel M0 Kelet, 02	1	1	0	0	106	0,94
SITE 96	Kunpeszér Felsőpeszéri út	1	1	0	0	115	0,87
SITE 565	Litér Papvásárhegy	1	1	0	0	188	0,53
SITE 38	Zalaszentbalázs Szőlőhegyi mező	1	1	0	0	414	0,24
SITE 506	Muraszemenye Aligvári mező	1	0	1	0	1004	0,10
SITE 516	Petrivente Újkúti dűlő	1	1	0	0	3913	0,03

Table 1b – ratio of obsidian and obsidian types on the investigated sites. The quantitative data on the relevant sites are mapped on Fig

Figure 8 – Palaeolithic and Mesolithic obsidian distribution map



7 – Neolithic obsidian use and distribution

The Early Neolithic brought about essential changes. Obsidian-dominated lithic industries appeared on the Great Hungarian Plain and the marginal zones of the Körös-Cris complex (Bácskay & Biró 1983, Bácskay & Simán 1987, Starnini 1994, 2001). This abundance of obsidian is still observable in the roughly contemporary earliest LBC industries (Biró 1987, 2002, Biró in press for Mezőkövesd-Mocsolyás and Füzesabony-Gubakút site monographs). Though most of these assemblages have been studied only by macroscopic inspection and relatively few of them were actually tested by instrumental analytical methods we can say that they were based on Carpathian sources as no outliers were found so far in the territory of Hungary. As the Neolithisation process had undoubtedly very strong connections to the Balkans and we can suppose not only "trade" contacts but direct migrations as well, it is historically not unlikely that Eastern Mediterranean obsidian had an essential advance towards the North: obsidian analysis data however do not support this as yet.

Other raw materials, notably Balkan/Banat flint has already been observed in Körös context (Kaczanowska *et al.,* 1981). We still lack authentic information on the Northern limits of the spreading of Melian obsidian and the southern (South-Western) advance of Carpathian obsidians (Fig. 9).

By the Middle Neolithic, the situation seems to, sort of, stabilised in the Carpathian Basin. The good quality local resources were known and in use by the established Neolithic population inside the Carpathian Basin, especially Hungary (Biró 1998). Obsidian supplied the lowland area, so to say, its natural supply zones, together with hydrothermal and limnic siliceous rocks travelling most likely on the same routes with minor amounts of long distance imports. (Biró 1998a Figs. 3-4). The areas to the West of the Danube and along the floodplain were supplied basically with Transdanubian siliceous rocks, in the first place, radiolarite and the occurrence of obsidian on the western parts of the country was rather an exception than a tendency (e.g., Balatonszemes, Biró 2007). By the end of the Middle Neolithic period, it seems that the best quality obsidian sources

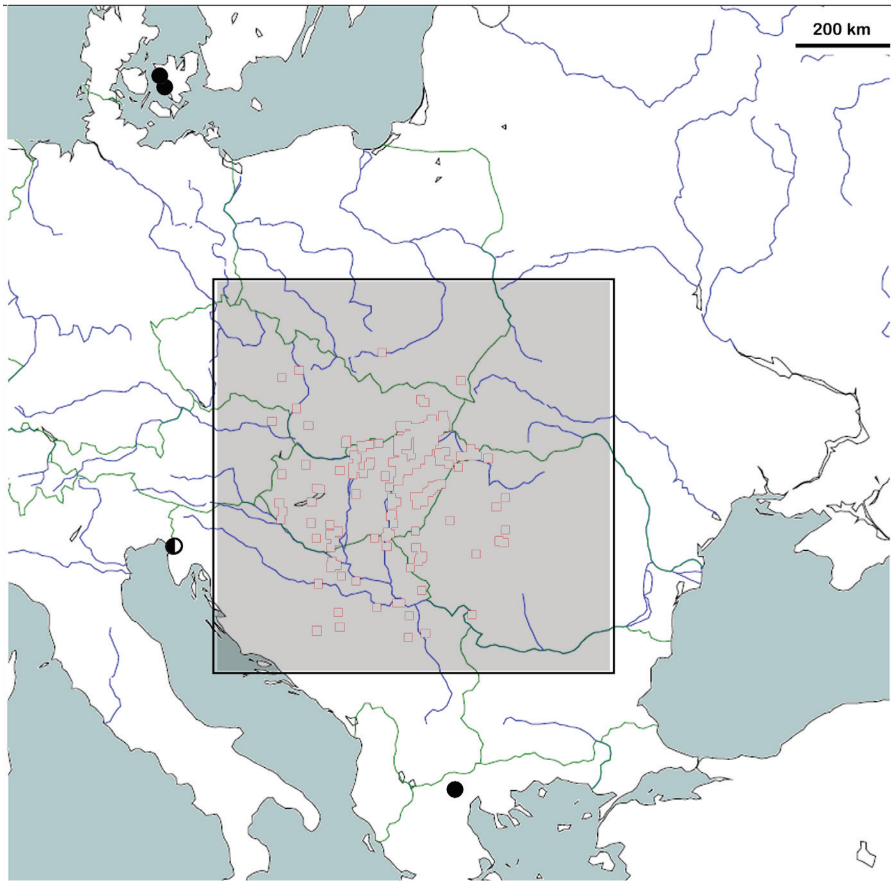


Figure 9a
Neolithic obsidian distribution map

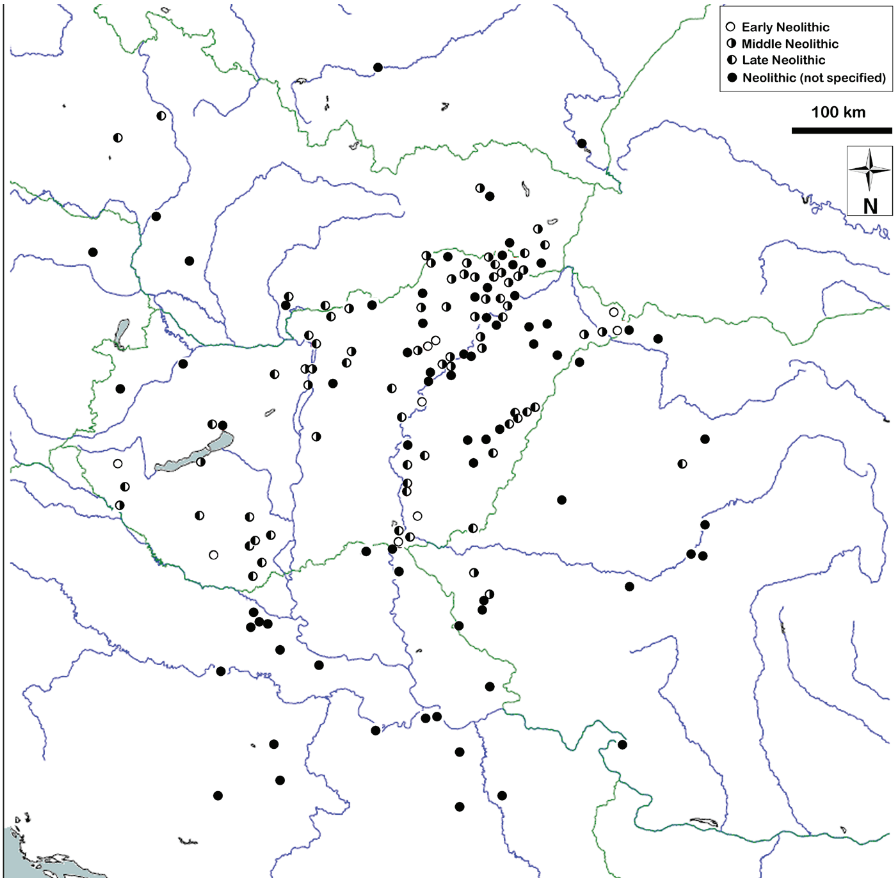


Figure 9b
Neolithic obsidian distribution map

were practically exploited. This is mainly apparent in the size of the pieces used. The depot find of giant obsidian cores from Nyírlugos can be tentatively dated to Middle Néolithic period (Fig.10) though in the very first publication, on the strength of the large (flint) blades found in Early/Middle Copper Age graves, J. Hillebrand associated them with the Copper Age. (Hillebrand 1928). Analogous finds from Bükk Culture settlement context (Kašov-Čepegov, Bánesz 1991; Szécsény-Ültetés, Biró 1987) and the lack of large obsidian tools after the Neolithic seem to speak for a MN context (Fig 9).

The Late Neolithic period brought about essential changes in obsidian raw material management. The most striking features are:

- a seemingly “low obsidian” area on the place of the former evenly distributed Alföld region, roughly corresponding to the Tisza culture area
- a marked advance on behalf of the Lengyel (and Csőszhalom) cultures towards the obsidian sources
- the appearance of distribution centres along the fringes of the Lengyel Culture distribution area as well as some Vinča culture centres (Aszód, Csabdi, Zlkovce; on the south, Vinča, Zengővárkony, Samatovci etc.). In these localities, obsidian microblade production was intensive and by individual number of chipped stone finds, the ratio of obsidian could surpass 10 %.

Most of the obsidian implements of this period are of extremely small size and the production of microblades typically start on the settlements from the stage of micro-cores with essential amount of cortex. All these phenomena indicate that the

Figure 10
Nyírlugos, obsidian core depot find

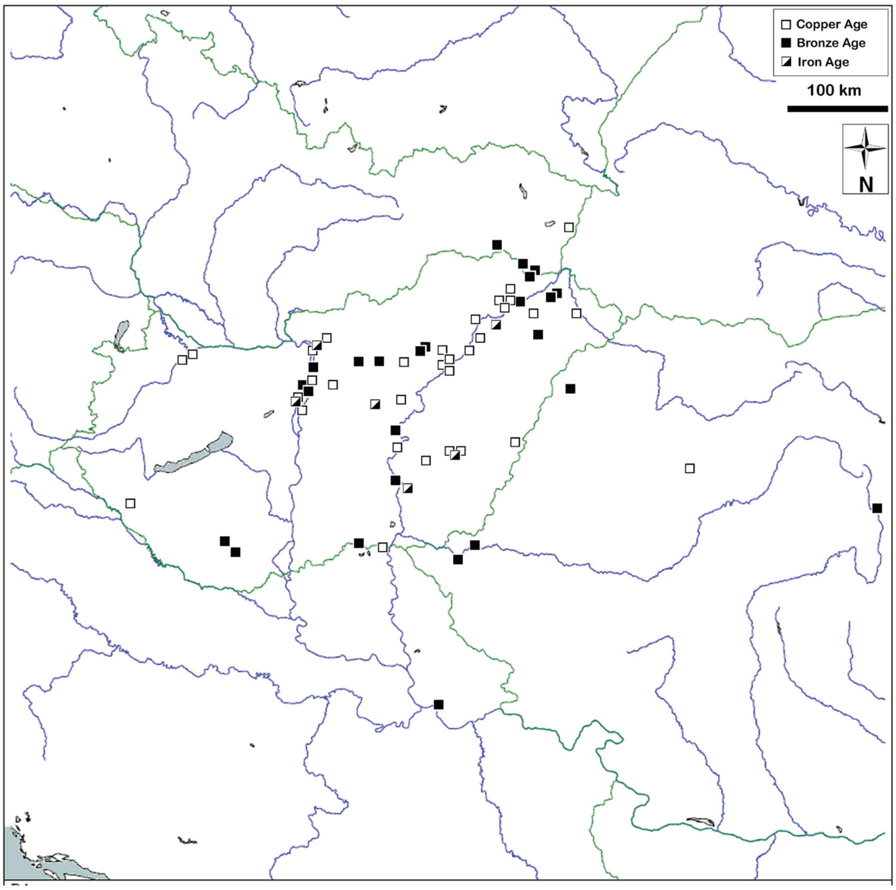
obsidian sources were considerably depleted (probably, still during the late phase of the Middle Neolithic). Some of the most distant instances of obsidian distribution can be connected most probably to the Late Neolithic (Denmark, p.c. by D. Liversage, Mandalo, Greece (Kilikoglou *et al.*, 1996), Grotta Tartaruga, Istria, Williams *et al.*, 1984), though not all of the finds are from absolutely stable stratigraphical context.

By the end of the Late Neolithic period we can observe the inflow of good quality flint raw material in large quantities, partly from Poland (Jurassic Cracow flint, Chocolate flint) but mainly from the north-east; Volhynian flint and Prut flint. The large flint blades from Copper Age graves originate from these sources. Obsidian is still present, but the main form of utilisation seems to change. (Fig. 11). We can come across, very frequently, projectile points of bifacial triangular type as well as trapezoid bladelets, also known in the function of projectiles. It is rather difficult to estimate the role of obsidian in the very young chipped industries. Its importance and high prestige is documented in the Csongrád-Felgyő grave retouched blade (Fig. 12), probably the last really important long obsidian blade known so far from Hungary.

Recently there is more attention drawn to Bronze Age and younger lithic industries. We can say that as long as the authentic primary utilisation of chipped stones can be observed (currently the limit is somewhere in the LBA/EIA finds), obsidian is present though quite often in secondary use. The details of Late Prehistoric obsidian use in the Carpathian Basin will need much more studies in the future (*Table 2: obsidian artefacts in the prehistoric collection of the Hungarian National Museum. Data from the HNM inventory register*).

Figure 11 – Copper Age and more recent obsidian distribution map

Figure 12 – Large obsidian blade from the early bronze age pit-grave culture Csongrád-Felgyő grave Ecsedy 1979



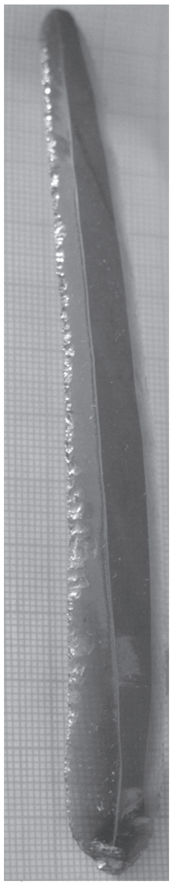


Table 2 – Obsidian artefacts in the prehistoric collection of the Hungarian National Museum. Data from the HNM inventory register

Site name	Körös Culture	Szatmár group	AVK (Alföld LBC)	Bükki Culture	Tisza Culture	Neolithic	Neolithic total
Abaújszántó						10	10
Aggtelek				1		3	4
Aggtelek, Baradla-barlang				4			4
Ároktő						1	1
Baskó						5	5
Berettyóújfalu						1	1
Bodrogkeresztúr					9	21	30
Bódvaszilas						1	1
Budapest						3	3
Büdöspest-barlang				1			1
Bükk-hegység						1	1
Dévaványa					1		1
Edelény				22			22
Érpatak						1	1
Hencida						1	1
Hódmezővásárhely	1						1
Hollóháza						3	3
Kenézlő						1	1
Kisbárapáti						1	1
Kisköre					1		1
Kisköre, Gát			1		2		3
Korlát				11		50	61
Koroncó						1	1
Krasznokvajda			6				6
Megyaszó						8	8
Mikóháza						1	1
Miskolc, Herman Ottó-barlang				19			19
Mórágy						13	13
Nagyecsed			1				1
Nagyszalánc						4	4
Örvényes						1	1
Pazdics						5	5
Poroszló						1	1
Rakamaz						1	1
Regéc						9	9
Sárazsadány				8		2	10
Sátoraljaújhely				1		3	4
Sonkád		11					11
Szamossályi			1				1
Szeged					16		16
Szeleta-barlang						7	7
Szihalom						4	4
Szilvásvárad				1			1
Szinyér						6	6
Tállya				2			2
Tiszafüred			3				3
Tiszalúc, Sarkad-puszta						1	1
Tiszanána			1				1
Tiszavalk			7				7
Tiszavalk, Tetes			1				1

Uppony			1				1
Velejte						9	9
Zajta		1					1
Zalkod						1	1
Zsáka					2		2

Site name	Tisza-polgár Culture	Bodrog-keresztúr Culture	Hunyadi-halom Culture	Boleráz Culture	Baden Culture	Copper Age	Copper Age total
Alsópetény						1	1
Érd						1	1
Jászladány		4					4
Magyarhomorog		9					9
Polgár, Basa-tanya						6	6
Poroszló					1		1
Sárazsadány	7						7
Szabolcs						2	2
Szigetcsép					3		3
Tahitótfalu				1			1
Tarnabod						2	2
Tiszafüred, Majoroshalom			2				2
Tiszakeszi						1	1
Tiszalúc, Sarkad-puszta			33				33
Tiszavalk, Tetes		6					6
Tokaj						1	1

Site name	Early Bronze Age	Bell-beaker Culture	Hatvan Culture	Füzes-abony Culture	Late Bronze Age	Bronze Age	Bronze Age Total
Bodrogszerdahely						3	3
Dunakeszi		1					1
Edelény					1		1
Füzesabony				1			1
Nagykálló						3	3
Pancsova						1	1
Szihalom			16				16
Tószeg, Laposhalom	2					2	4
Vámosgyörk						1	1

Site name	La Tene Culture	Scythian	Late Iron Age	prehistory	no data	Sum Iron Age + uncertain
Aggtelek				4		4
Baskó				11		11
Berettyóújfalu				15		15
Bodrogkeresztúr-Kutyasor					3	3
Bojt					1	1
Dunaújváros				1		1
Felsőtárkány				1		1
Fony					1	1
Gyomaendrőd				1		1
Győr				1		1
Hatvan				1		1
Kisürögd				4		4
Komárom				1		1
Kosd	1					1
Magyarhomorog					1	1

Megyaszó					30	30
Mélosz				4		4
Mikóháza				1		1
Mohács				1		1
Nagykörű				3		3
Nagykövesd				2		2
Nyíri				10		10
Peskő-barlang					2	2
Polgár					4	4
Polgár, Basa-tanya					15	15
Polgár, Csőszhalom					6	6
Sátoraljaújhely					4	4
Százhalombatta			1			1
Szelevény				41		41
Szentes		1				1
Szihalom					1	1
Szilvásvárad, Istállóskő-barlang					1	1
Szolnok				1		1
Tápiószele		1			1	2
Tarnabod					7	7
Tiszaigar				11		11
Tiszakeszi					1	1
Tiszatarján				1		1
Tiszavasvári		4				4
Tószeg					2	2
Varsó				1		1
Zsujta				1		1

8 – Extending the scope: the prehistoric border-lines

Distribution data were collected and surveyed several times. (Biró 2004, 2006). Seemingly, we have to count on three basic sources lying in the adjacent regions of South-East Slovakia, North-East Hungary and Western Ukraine (Fig. 2). From the Hungarian provenance data we could see a basic dominance and popularity of Slovakian (C1) obsidian, a regional role of Hungarian (C2T, C2E) obsidians. According to what we know so far, the Ukrainian (C3) obsidian was used only locally.

The three main type groups can be differentiated macroscopically as well, controlled and verified several times by various analytical methods, e.g., EDS, PIXE-PIGE or PGAA. On *Fig. 13*, (Fig. 13) the known distribution of C1-C2E-C2T types is presented, as we know today, on the basis of macroscopic inspection (see also Table 1b) and instrumental analysis.

Interaction of Carpathian obsidian types is a common feature, both for all C1-C2E-C2T types together and C1-C2T and C1-C2E interactions. It is less frequent that the Hungarian (C2) obsidians occur on their own or coupled with each other (C2E-C2T interactions).

Knowing the archaeological distribution data it became more and more pressing to focus on the limits of Carpathian obsidian distribution and possible interaction zones with obsidian coming from other parts of the Mediterranean region, i.e. the Western Mediterranean (Italy) and the Eastern Mediterranean (Greece and Anatolia).

Instrumental obsidian characterisation data already justified the presence of Carpathian obsidian in the sphere of both: i.e., Grotta Tartaruga (Williams *et al.,* 1984) and Mandalo (Kilikoglou *et al.,* 1996). To know the limits more exactly, we could organise with the help of international collaboration projects the investigation of essential

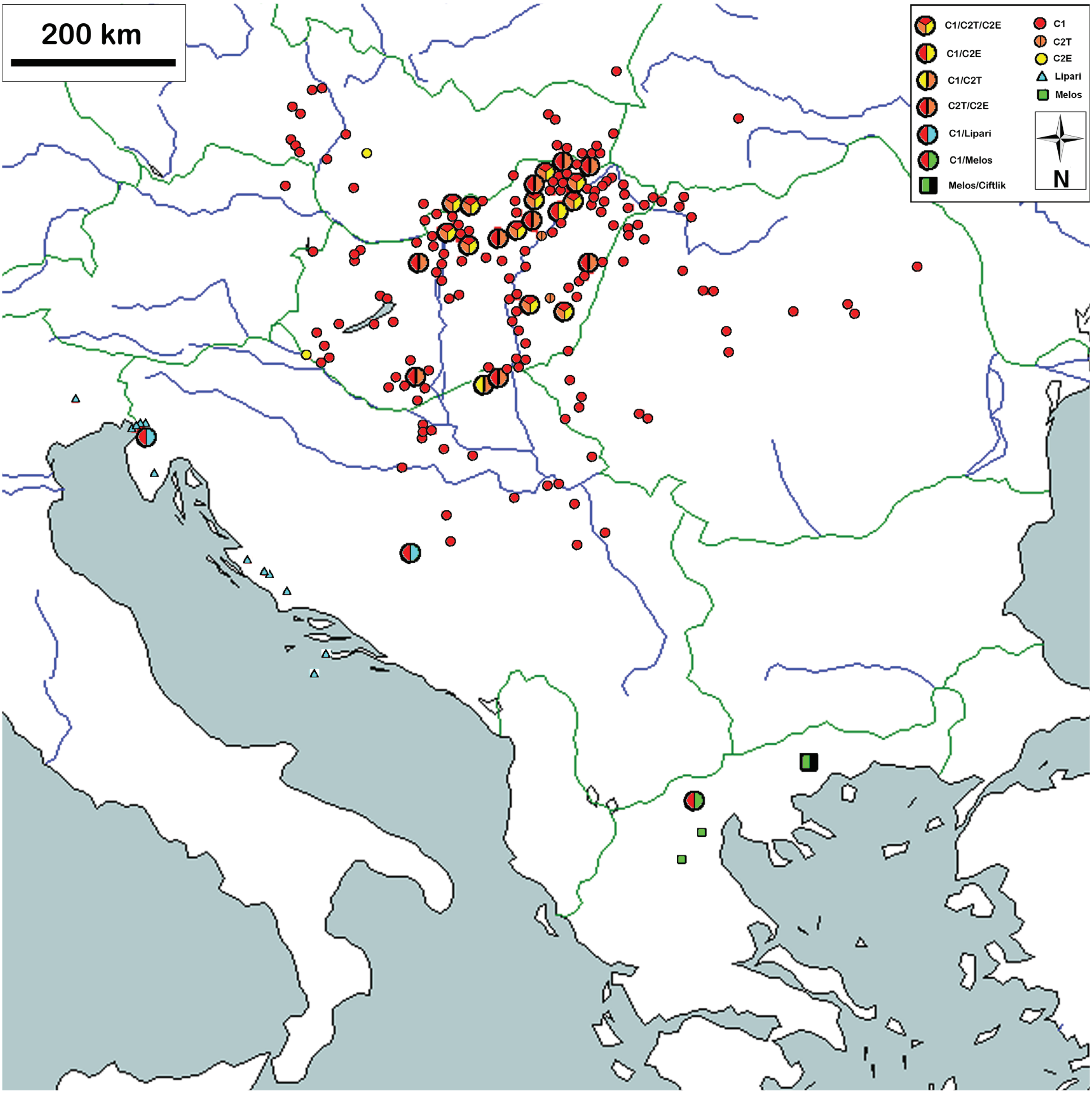


Figure 13 – Interaction of various obsidian types with C1-C2 obsidians on archaeological sites

number of archaeological obsidian finds from most of the neighbouring countries (Croatia, Serbia, Romania, Ukraine and Poland) and we are trying to cover more. The most recent summary was presented on the 39th International Symposium on Archaeometry, Leuven (May 2012, Kasztovszky *et al.,* 2012). Accordingly, we can see interaction zones of the Carpathian (mainly C1) obsidian towards the SW and SE borders of the distribution zone; interaction with Lipari obsidians was observed on the territory of former Yugoslavia (currently: Croatia and Bosnia) at the Neolithic site Obre (Kasztovszky *et al.,* 2009, Kasztovszky & Tezak-Gregl 2009). Towards the SE, the only Thessalian piece (Mandalo) raises the possibility of an interaction zone between Carpathian and Melian obsidians. Towards the North (NW, NE) we can expect no interactions; here, the question is the extent of obsidian transport and the authenticity of the pieces. The furthermost pieces reported in this direction are from Zealand, Denmark (approx. 1400 km ACF from the sources); we had no possibility to study these pieces as yet.

9 – Conclusion

Obsidian was an attractive and much desired commodity in prehistoric times and it is a popular and successful subject for the research of prehistoric societies. Non-destructive methods and representative comparative sample collection help to make our work more efficient.

There are, though, some important things to keep in mind:

1. we still do not know the exact location of the most important C1 sources (=material of Cejkov and Kašov workshops (Bánesz 1967), probably that of the Kašov and Nyírlugos giant cores, Bánesz 1991, Kaminska & Duda 1985).
2. obsidian distribution and obsidian trade is only one element of a most versatile and colourful prehistoric network of connections and should be interpreted accordingly among 'sourceable' and 'non-sourceable' goods.

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Abbreviations used in the text

ACF	'As the crow flies' - Linear distance from site to source
C1	Carpathian 1 (Slovakian) obsidian
C2	Carpathian 2 (Hungarian) obsidian
C2E	Carpathian 2 (Hungarian) obsidian, Mád-Erdőbénye sub-group
C2T	Carpathian 2 (Hungarian) obsidian, Tolcsva sub-group
C3	Carpathian 3 obsidian from Transcarpathian Ukraine
EDS	Energy Dispersive Spectrometry
FTD	Fission track Dating
HNM	Hungarian National Museum
NAA	Neutron Activation Analysis
OES	Optical emission spectroscopy
OHD	Obsidian Hydration Dating
PGAA	Prompt Gamma Activation Analysis
PIGE	Proton Induced Gamma Spectrometry
PIXE	Proton Induced X-Ray Spectrometry
XRF	X-Ray Fluorescence Spectrometry

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Lithic raw material exploitation and circulation in Préhistory. A comparative perspective in diverse palaeoenvironments
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1.5. Paleolithic of Ukraine: The main diachronic and spatial trends of lithic raw materials exploitation

Résumé

Les matières premières lithiques représentent un des besoins essentiels de la population préhistorique, c'est ainsi que les dynamiques de l'exploitation de la matière première dans le Paléolithique en Ukraine doivent être étudiés dans les contextes des spécifiques du territoire, du paysage, du climat et d'autres particularités environnementales, ainsi que les rythmes de colonisation de cette région.

Les caractéristiques environnementales de la région que nous allons évoquer ici sont déterminées par la permanence des conditions climatiques continentales, la netteté des diminutions au sud et à l'ouest, tant au Pléistocène que de nos jours. Les ressources biologiques et minérales sont d'une importance considérable dans les périodes du Paléolithique inférieur, moyen et supérieur. Mais elles ne sont pas réparties de manière égale sur tout le territoire. Il est possible de considérer que la région disposant de ressources stables en matières premières corresponde à la région ayant des bio-ressources riches et relativement favorables. Dans une telle situation, elle était plutôt isolée et constituait un noyau solide pendant le Paléolithique. L'inégalité géographique des ressources biologiques et minérales additionnée au rythme des changements environnementaux est détermnine la direction, la dynamique, et l'intensité de la colonisation des terres aux Paléolithiques inférieur, moyen et supérieur. D'étroites relations entre les différents modèles de colonisation et les dynamiques de changement stratégiques en matières premières lithiques peuvent être déterminées.

Les tendances diachroniques et spatiales principales de l'exploitation de la matière première lithique au Paléolithique en Ukraine sont très généralement caractérisées de la manière suivante : le Paléolithique inférieur se caractérise par l'utilisation d'une gamme étendue de matières premières lithiques, de préférence non isotropes, de provenance locale. Durant le Paléolithique moyen, les stratégies sont orientées vers des matières isotropiques locales. Ces stratégies sont typiques du Paléolithique supérieur, mais la géographie des territoires d'occupation et la mobilité paraît plus étendue et considérablement en haute altitude grâce à l'invention de technologie plus sophistiquées et moins opportunistes.

Abstract

Lithic raw materials represents the only one, though substantial, vital needs of prehistoric population, therefore, the dynamic of exploitation of raw materials in Paleolithic of Ukraine cannot be investigated out of context of specificity of territory, landscape, climate and further environment peculiarities, followed by the regularities of colonization of the terrain.

Environmental features of the area under discussion are determined by the permanently continental climatic conditions, the sharpness of which is decreases southwards and westwards both during Pleistocene and nowadays.
Biological and mineral resources definitely were of the vital importance during the Lower, Middle and Upper Paleolithic. But they were not universally represented on the territory of the country. Areas with stable primary sources of raw materials and areas with rich and comparatively well predicted bioresources are basically coinciding. Besides, the areas with stable and predictable vital resources during the Paleolithic were not borderless and when coincide, they form obvious core-like pattern.

Geographical unevenness of biological and mineral resources alongside with rhythmic environmental changes is the basic determinant of directions, dynamic, and intensity of colonization of the terrain in Lower, Middle, and Upper Paleolithic. Sometimes essentially different colonization patterns are correlated with the dynamic of changes of lithic raw materials strategies.

The main diachronic and spatial trends of lithic raw materials exploitation in the Paleolithic of Ukraine can be characterized very generally in the following way.

The Lower Paleolithic is characterized by utilization of wide spectrum of preferably not isotropic lithic raw materials of local provenience. The Middle Paleolithic raw materials strategies are characterized by relying on preferably isotropic lithic raw material of mostly local provenience. The same strategy is typical for the Upper Paleolithic; but the geography of colonized areas and mobility appeared to be essentially extended and considerably higher due to invention of more sophisticated and less expendable technologies.

Keywords: Eastern Europe, Ukraine, Lower, Middle, and Upper Paleolithic, colonization patterns, lithic raw materials exploitation

1 – Introduction

Paleolithic studies on the territory of modern Ukraine were started almost one and half century ago at the Upper Paleolithic site of Gontsy. It is quite remarkably that field works at this site are still continued and very recently provide so valuable find, as remains of new dwelling constructed by mammoth bones. This meaningful instance demonstrates both the inexhaustibility of Ukrainian Paleolithic records and also the permanent state of incompleteness of archaeological database. Nevertheless, available archeological records, alongside with data of allied sciences, provide the essential basis for the reconstruction of processes took place on the territory of the country in prehistory.

One of the important problems of the home Paleolithic studies comprised a row of questions related to the reconstruction of processes of lithic raw materials provenience, acquisition and circulation. These questions, should be admitted, are at the very early stage of development. Although there are instances of comprehensive case studies focused at isolated archaeological assemblages or at small series of exotic rocks, these instances are few and isolated. There are also perfect geological database, concerning various aspects of lithic raw materials, sometimes quite detailed. There are also isolated lists of samples determined by the means of various, sometimes highly technological methods. But there is also the obvious lack of information and shortcomings of available data. Till now is quite evident the urgent need in professional works embraced efforts of archaeologists, petrologists, and scholars of other related branches. Probable reason of this situation likely rooted in extreme richness of deposits with potential lithic raw materials, high variability of these latter, followed by the similarity of their main characteristics.
Therefore, the proposed paper forcedly deals with the most general regularities of lithic raw materials exploitation in Paleolithic of Ukraine.

Some preliminary assumptions should be made prior to the further reasoning. These are the following:

1. the ultimate vital and obligatory needs of Paleolithic man were few, these are: needs in water, food, raw materials for tools, and also in shelter; and
2. stability of Paleolithic life was a function of different aspects of environment, namely: climate, landscape, flora, fauna, water sources, availability and predictability of biological and mineral resources, natural shelters, etc.

If above assumptions are correct, then the two consequences should be formulated, namely:

- lithic raw materials represents the only one, though substantial, vital needs of Stone Age tool-makers and
- the dynamic of exploitation of raw materials in Paleolithic of Ukraine cannot be investigated out of the context of specificity of territory, landscape, climate and further environment peculiarities, followed by the regularities of colonization of the terrain.

2 – General outline of evolution of Ukrainian Paleolithic

The lower limit of the Ukrainian Lower Paleolithic is currently determined by the age of the earliest authentic sites localized in Transcarpathia, which age is ranged around 1 Ma ago. Conditional boundary between the Lower and Middle Paleolithic on the territory of Ukraine is proposed to define at ~300 ky ago, between the Alpine Mindel-Riss and Riss. Archaeologically, this boundary is marked by invention and spreading of Levallois technologies. Conditional boundaries between the periods are not considered as the impenetrable thresholds. Transitional periods between the Lower and Middle, Middle and Upper Paleolithic are proposed to distinguish, with uneven chronological frames between 450-300 and 50-30 ky BP, respectively. It cannot be excluded that proper industries and their bearers can survive beyond these boundaries.

Early (~450/300-~130/100 ky) and late (~130/100-~50/30) stages are distinguished within the frameworks of the Ukrainian Middle Paleolithic.

The most early Lower Paleolithic evidence, that is VIII-th cultural-chronological complex of Korolevo in Transcarpathia, is correlated with OIS 22. The latest Middle Paleolithic sites, known in Crimea, and probably also in the West of Ukraine and in Donbas, are correlated with the end of the OIS 3 and the beginning of the second oxygen-isotopic stage. Thereby, in terminology of geostratigraphy, the Lower and Middle Paleolithic of Ukraine occupy the Upper Eopleistocene and the entire Neopleistocene. Marine oxygen-isotopic scale in its relation to the most common schemes of geostratigraphical subdivision of climatic events in out-glacial zone of the Eastern and Western Europe, and the Alps were used as universal correlation mean for the comparison of chronological position of Ukrainian Paleolithic sites (Fig. 1).

3 – Geographical position of the country and the main regularities of environment

A – Geographical Position as a Factor for Permanently Continental Climatic Conditions

Territory of modern Ukraine includes the essential south-western segment of the East European plain. Landscapes of this area are rather variable and embrace mountainous, hilly elevations, and plains. The preponderant landscapes are flat plains, dissected - mainly in longitudinal direction - by the valleys of large rivers and their tributaries. Several great hydrosystems dissect the plain, these are – from west to east – the Dniester, Southern Bug, Dnieper rivers, and the western tributaries of the Lower Don. Crimean and Carpathian mountains are localized in the extreme south and west of the country.

The major portion of Ukraine covers open terrains eastwards from Carpathians: it means domination of basically continental climate with no mild effects of warm ocean streams.

As a result, effects of continental climate were effective in course of the entire period of Pleistocene, in various extents, of course. It is worth to stress that the continental characteristics of climate are decreases southwards and westwards both during Pleistocene and nowadays (Velichko 2009).

B – Hydrological Peculiarities of Terrain

Should be emphasized the practically even distribution of hydrorecources on the territory of the country. The only exception is represented by the zone of steppe on the extreme south, where smaller rivers are few and not stable. The preponderant majority of rivers in the continental Ukraine have meridian orientation, and this important feature of the hydrographic system was principally formed already towards the end of the Eopleistocene.

Even if to exclude so important roles of large and smaller rivers as water sources, as axis of animal and human migration routs, as limitation frontiers, and as seasonally renewing areas of rich bioresources, one more significant role is still remained. It is a role of transportation channels for lithic raw materials.

The dominating orientation of the major water streams essentially contributes to the systematic North to South transportation of flints from the primary outcrops (Dniester basin, Upper flow of Southern Bug, tributes of Seversky Donets River, a row of left tributaries of Middle Dnieper) and also of flints of moraine origin (mainly Dnieper basin). Large amounts of various kinds of lithics were transported by water-ice streams and accumulated across large areas in course of Pleistocene. For instance, the area of so-called Northern moraine flints (Petrougne 1995) generally coincides with boundaries of continental Pleistocene glaciations.

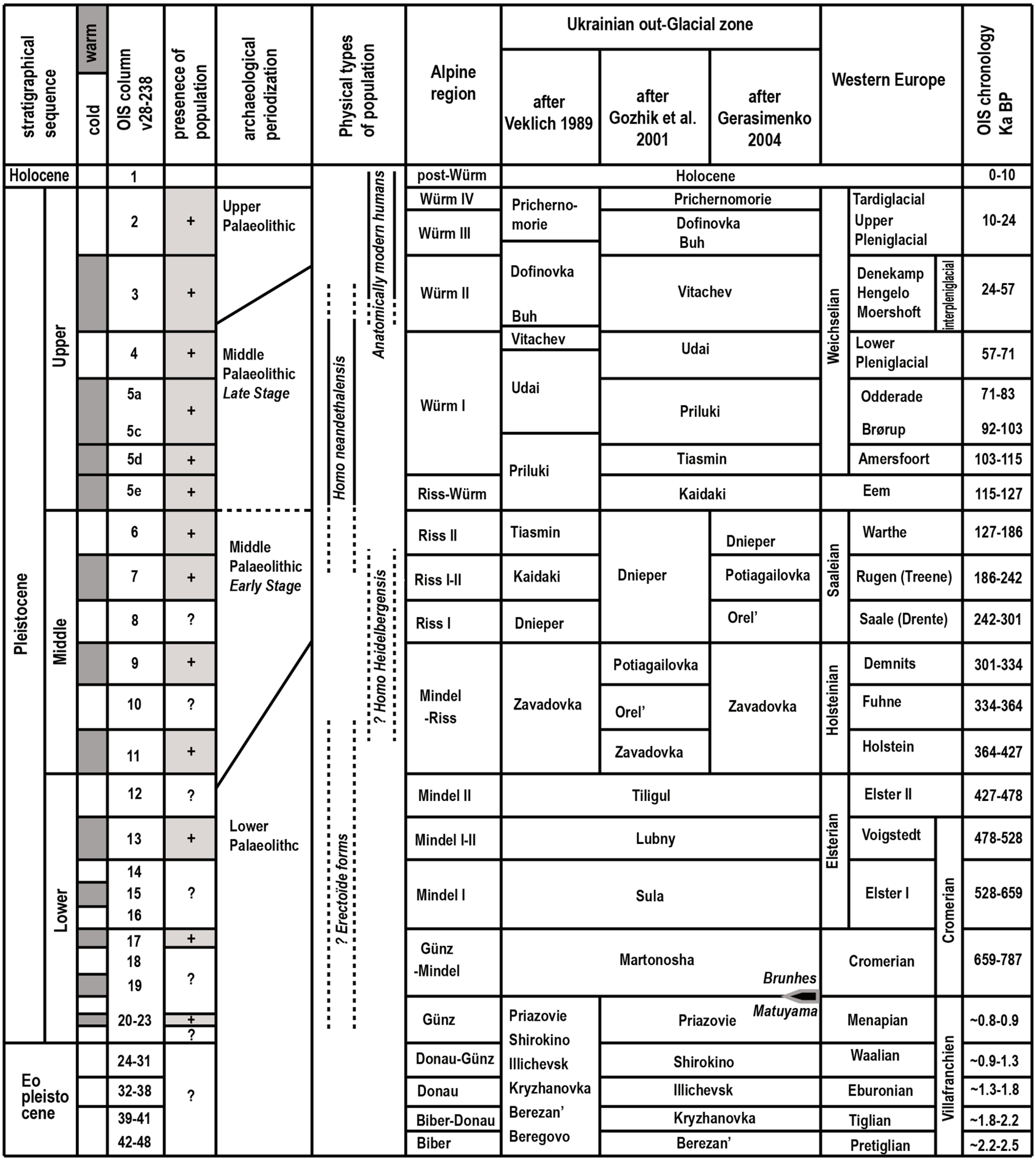


Figure 1
Correlation of stratigraphical horizons, climatic events, and cultural dynamic of the Ukrainian Paleolithic

Thereby, the role of rivers in the creation of secondary deposits of lithic raw materials would hardly be overestimated. But by the other hand, the significance of these secondary deposits for Paleolithic tool-makers should not be overestimated. The intensity of the destruction of primary deposits of flint, as well as quantities and distances of transportation of fragments of siliceous rocks were not constant during the Pleistocene, being the function of global climatic shifts. Therefore, the exposed outcrops of siliceous rocks in landscapes of Middle Dniestr, Podholian upland, Donetsk Ridge and Crimean foothills appeared to be the most reliable and the most easily accessible sources of lithic raw materials during the Paleolithic.

C – Availability of Bioresources: The Most Important Environmental Factors

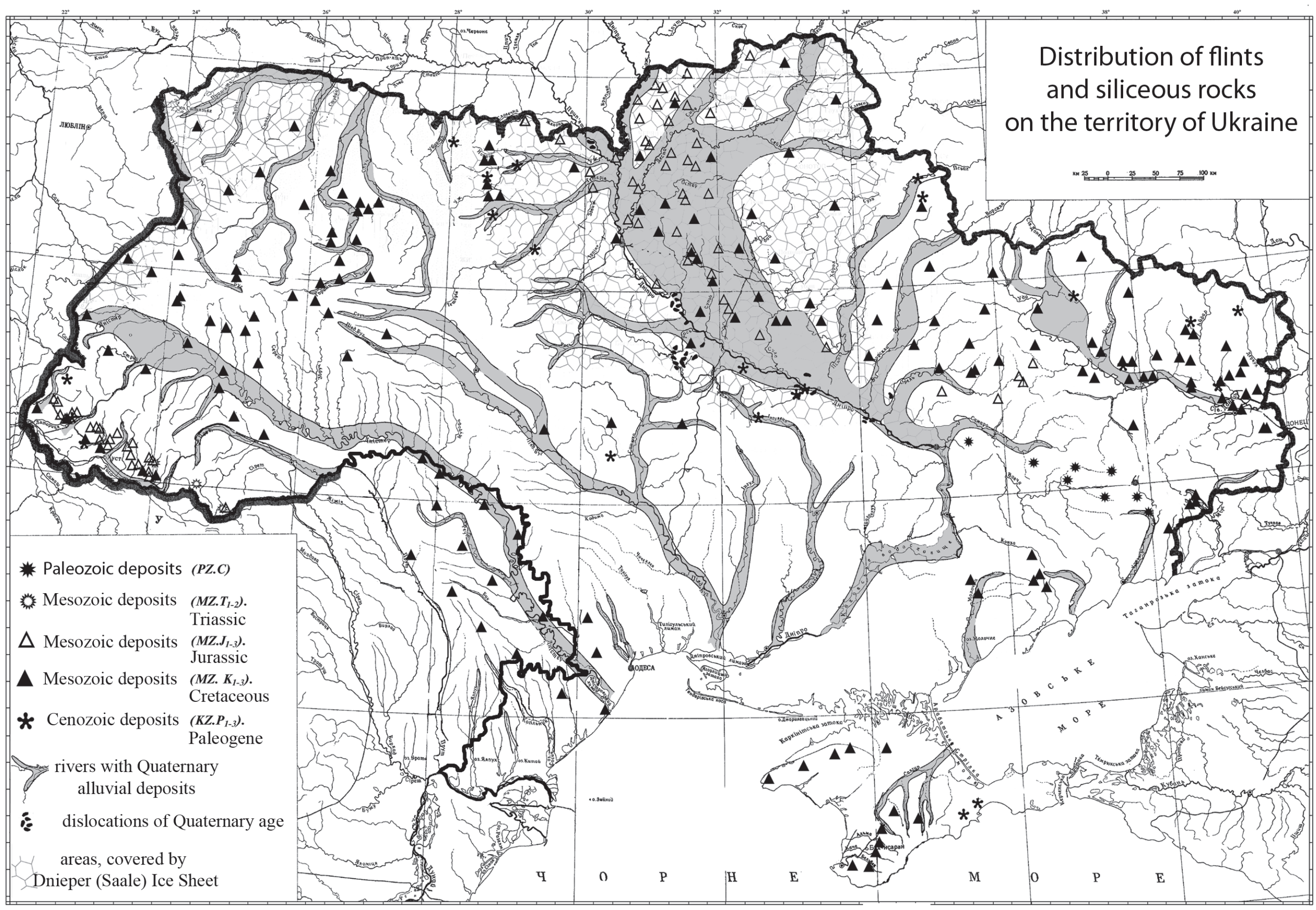
Climatic conditions on the territory of modern Ukraine were not constant during the Paleolithic time, of course (Matviishina 2010). Global climatic changes had resulted in repeated changes of paleolandscapes and compositions of flora and fauna. Environmental shifts and consequent landscape changes directly affect the basic aspects of life activity of the ancient population.

In particular, global and seasonal climatic changes strongly conditioned the availability of bioresources. Three environmental factors are of especial importance in this respect, these are: landscape, continental climate, and snow cover.

Flat landscapes are the most common in Ukraine, and these landscapes are characterized by the worst parameters of predictability and availability of bioresources in comparison with landscape of elevations and foothills. These latter were potentially more productive due to the peculiarities of mosaic landscapes. Hereupon, areas of elevations and foothills were more attractive both for animals and prehistoric population. The factor of continental climate was resulted in sharp difference of daily and annual cycles of temperatures, duration and severity of winters. Degree of continental features was progressively decreased westward and southward. Essential role was also played by the factor of snow cover varying by such characteristics as thickness, duration of conservation, and tightness (Formozov 1990). Spatial pattern of animal habitats and fauna composition was to a great extent corrected by these three environmental factors.

The extreme south and the west of the territory of modern Ukraine were comparatively the most comfort in respect of climate during the Quaternary period. The same areas represents the most biodiversificated zones of crossed foothills and elevation landscapes and, hence, were the most attractive for animals, and, consequently, for humans.

Figure 2
Distribution of flint and siliceous rocks on the territory of Ukraine



Lower Paleolithic	ands	anbs	obsd	qrtz	qtz	slt	snst	crss	qzss	flss	flnt	jspr	radl	argl	rtsn	lmsn	chrt
Korolevo VIII clc	⊕		+	+	+												
Korolevo VII clc	⊕		+														
Korolevo VI clc	⊕		+	+	+	+					+						
Maly Rakovets		+	⊕	+													
Medzhibozh				+	+	+	+			+	⊕						
Luka Vrubleveckaya											⊕						
Neporotovo VI				+							⊕						
Kodak					+		+				⊕						
Gaspra				⊕													

Early stage of Middle Paleolithic	ands	anbs	obsd	qrtz	qtz	slt	snst	crss	qzss	flss	flnt	jspr	radl	argl	rtsn	lmsn	chrt
Korolevo V-б clc	⊕																
Korolevo V-a clc	⊕		+	+		+					+						
Korolevo V clc	⊕		+	+		+					+						
Korolevo IV-a clc	⊕			+	+	+											
Zhitomirskaya											⊕						
Bugliv V: I					+						⊕						
V. Glybochok: III											⊕						
V. Glybochok: III-B											⊕						

Late stage of Middle Paleolithic	ands	anbs	obsd	qrtz	qtz	slt	snst	crss	qzss	flss	flnt	jspr	radl	argl	rtsn	lmsn	chrt
Korolevo IV clc	⊕																
Korolevo III clc	⊕		+	+	+	+	+				+		+	+			
Korolevo II-a clc	⊕		+	+	+	+	+				+						
Korolevo II clc	⊕		+	+	+	+	+				+		+	+			
Korolevo I clc	⊕		+	+	+	+	+				+						
Malyj Rakovec	+		⊕	+	+		+				+						
Cherna X	⊕			+							+						
Pryjma I		+							+		+						
Zhitomirskaya											⊕						
Rikhta											⊕						
Zhornov											⊕						
Tochil'nica											⊕						
Molodova I: 5							(+)				⊕						
Molodova I: 4							(+)				⊕	+					
Molodova V: 12							(+)			+	⊕	+		+			
Molodova V: 11							(+)				⊕	+			+	(+)	(+)
Korman' IV: 12							(+)				⊕						
Stinka 1: lower l.							(+)		+		⊕						
Кетросы: lower l.							(+)				⊕						
Pronyatin											⊕						
Ezupil': III								+			⊕						
Ezupil': II											⊕						
Orel											⊕						
Skubova Balka							+				+						
Nenasytec I				□													
Antonovka											⊕						
Kurdyumovka											⊕						
Belokuz'minovka											⊕						
Kiik-Koba: IV							(+)				⊕						
Zaskal'naya V: II						(+)	(+)				⊕	+					+
Kolosovskaya: II					(+)	(+)	(+)				⊕	+				(+)	+
Kolosovskaya: III					(+)	(+)	(+)				⊕	+				(+)	+
GABO: I											⊕	+					
Prolom I						(+)	(+)				⊕						+
Prolom II: II					(+)	(+)	(+)				⊕					(+)	+

Table 1 – Variability of raw materials used for knapping and tool manufacture at the main Lower and Middle Paleolithic sites of Ukraine.
Key: ⊕ prevailed, + available, (+) not used for regular knapping; cave sites and sites located in foothill areas are shown in gray; ands – andesite, anbs – andesite-basalt, obsd – obsidian, qrtz – quartzite, qtz – quartz, slt – slate, snst – sandstone, crss – "Carpathian sandstone", qzss – quartz sandstones, flss – siliceous sandstone, flnt – flint, jspr – jasper, radl – radiolarite, argl – argillite, rtsn – rottenstone, lmsn – limestone, chrt – flint limestone.

Of course, this regularity has its exceptions and limitations. Nevertheless, it seems to be consistent during the whole Paleolithic, regardless of the nature of global climatic episode, features of floristic cover, type of faunal complex, physical type of man, and development degree of its culture.

D – Availability of Mineral Resources

Peculiarities of geological construction of the country result in proliferation of Cretaceous deposits including siliceous rocks, highly variable in respect of physical properties and quality (Rudenko 2007). Cretaceous siliceous rocks include various combinations of chalcedony, quartz, and opal and characterized by good isotropic properties (Kovnurko 1979). Just these, widespread siliceous rocks, commonly known as flints, were served as the main source of raw materials for manufacture of lithic artifacts during the Stone Age and later periods.

The major part of Paleolithic sites of Ukraine is dated to the Middle Paleolithic and later periods. Flints are crucially predominated in tool kits of the overwhelming majority of Ukrainian Paleolithic sites and localities (Table 1). There are isolated artifacts or series of artifacts made of other kinds of raw materials in assemblages of many sites, indeed. But their content and frequency heavily depend on quantitative and qualitative availability of preferable isotropic rock, which is flint. There are only few exceptions, one of which is denoted as "phenomenon of quartzite industries" on the east of Ukraine. Another, also spatially limited, exception is reported for the mountainous area of Transcarpathia, where the spectrum of used raw materials was wider through the whole period of Paleolithic, and volcanic rocks like andesite and obsidian stably dominate in assemblages.

The territory of Ukraine is rich in lithic raw materials, though their spatial distribution is far from the evenness (Ryzhov *et al.,* 2005). According to geological data (Fig. 2), the potentially important for the Paleolithic man resources of rocks of higher isotropic qualities are especially numerous in Transcarpathia, in River Dniester valley, in the North and North-East of continental Ukraine and in the Crimea.

Outcrops of lithic raw materials are differentiated by their genesis. Extensive areas with exposed primary outcrops of flints variable in respect of age of formation are known in Transcarpathia, in the valley of Upper Dniester, in Podholian upland, in Donetsk Ridge, and in mountainous Crimea. Constant and easy access to these outcrops is ensured by the specificity of mosaic landscapes.

Worthy to emphasize that virtually all exposed flint bearing deposits are bound either to the areas of foothills, or to uplands, or to canyon-like river valleys. To the contrary, accessible outcrops of lithic raw materials are very rare in areas with flat and smooth landscape, where flint-bearing strata often exist but covered by thick pack of subaerial sediments. The only exceptions might be some landscape anomalies, like Kanev glacio-dislocation, or powerful erosions in valleys of larger rivers, cutting the sediments of tertiary age (Ryzhov *et al.,* 2005). Should be specially emphasized that primary outcrops of flint raw materials are almost not known in the Middle and Lower flows of such rivers as the Dnieper and the Southern Bug, save for so-called flints of crystalline shield in river Bolshaya Vys valley, tributary of the Southern Bug (Petrougne 2004).

Secondary occurrences of flints are characterized by wider spatial distribution. Secondary outcrops of gravitation and proluvial-deluvial genesis has obvious local importance, particularly in the context of broken landscapes (Muratov 1973). Secondary outcrops in form of accumulations of siliceous rocks often associate with colluvial and alluvial deposits in the valleys of such great rivers of the East European plain as the Dniester, Southern Bug, Dnieper, Desna, and Seversky Donets. Sometimes these concentrations are especially rich, for instance in area of the Lower Dniester (Petrougne 2004). Origin of secondary outcrops of this type relate to the destructive activities of powerful water flows, that broke up the matrix geological deposits containing siliceous rocks and then move their fragments on quite significant distances.

Quartzite represents a further kind of potential raw materials for Paleolithic toolmakers. It is characterized by similar regularities of spatial distribution. There are areas of high concentration of such material in form of primary deposits, and also areas of secondary outcrops. On the territory of Ukraine quartzite is widely represented, but the largest, and easily accessible deposits are located in the North-Western part of Ukrainian crystalline shield (Semenchenko *et al.,* 1974).

Therefore, predictable primary sources of qualitative lithic raw materials also gravitate toward the South, West, and, partly, the East of Ukraine. This spatial regularity is explained in terms of geological history and landscape peculiarities of terrain: raw materials are far more rich and easily accessible in broken landscapes nowadays as millennia ago.

E – Availability and Predictability of Biological and Mineral Resources: The Most Essential Features

Definitely, the biological and mineral resources were of vital importance in Lower, Middle and Upper Paleolithic. But these resources were not universally represented on the territory of the country. It is worthy to emphasize, that areas with stable primary sources of raw materials and areas with rich and comparatively well predicted bioresources are principally coincide. Besides, the areas with stable and predictable vital resources during the Paleolithic were not borderless and when coincide, they form obvious core-like pattern (Fig. 3).

The ideal, most appropriate for prehistoric population, area should combine a row of characteristics, such as richness and predictability of biological resources, developed hydrographic network, availability of primary outcrops of lithic raw materials. Only a few regions of Ukraine were characterized by such a combination, these are: Crimean foothills, Carpathians foothills, River Dniester valley, and Donetsk Upland.

Core areas with rich and predictable biological and mineral resources were limited not only in space, but also in time. This statement can be illustrated by the relationship between the accessibility to the outcrops of lithic raw materials and the climatic changes. During the warmer periods, especially during its humid phases, the access to secondary (i.e. re-deposited) raw material outcrops was essentially decreased. It depends on the differences of potamic accumulations under the terms of different climatic regimes. The same periods coincides with considerable seasonal (snowy period) difficulties in procurement of raw materials. Flint raw materials became more accessible during the cold periods, both in primary (Crimean and Carpathian foothills, Volhyno-Podolian and Donetsk elevations), and in redeposited outcrops (river alluvium).

In what way the features of colonization of the terrain were defined by the aforementioned regularities, including the availability and abundance of qualitative lithic raw materials?

4 – Patterns of colonization of terrain in diachronic perspective

The earliest evidence of human presence on the territory of country is dated back to the OIS 19-17 and discovered in Ukrainian Transcarpathia, west of Carpathian mountains (Gladilin & Sitlivy 1990). Since that time humans sporadically appeared in the same area and also penetrate east of Carpathians arc, as it witnessed by localities aged to practically each warm stage between OIS 14 and 7. Starting from the OIS 7, the initially lacunar pattern of peopling became more stable in chronological sense, since humans still remain in the area not only during warm episodes, but during cold phases, as well. Period between oxygen-isotopic stages 6 and 3 is characterized by virtually the same fluctuate pattern of peopling, common features of which is the persistent presence of people in some core areas, significant expansion of colonized areas during the more comfort periods, and following reduction of peopled territories during the periods of climatic deterioration.

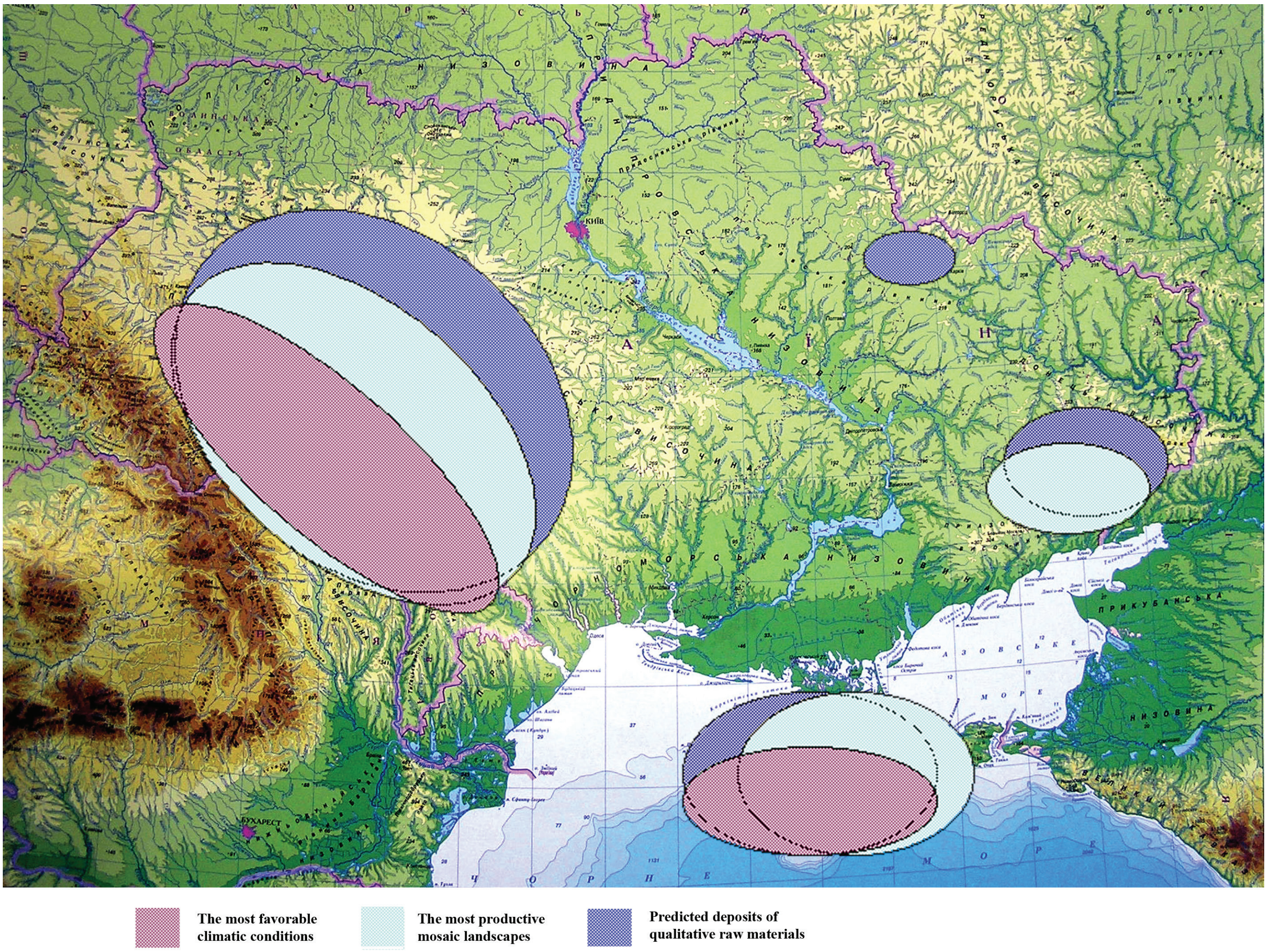


Figure 3 – Core-like pattern of geographical coincidence of the most favorable climatic conditions, the most productive mosaic landscapes, and predicted deposits of qualitative raw materials

The following very general geo-social peculiarities of colonization of the territory of modern Ukraine should be emphasized, namely: gravitation of Lower Paleolithic localities toward the fringe areas of open landscapes of the East European plain, concentration of Middle Paleolithic localities within the frameworks of core-like areas rich in biological and mineral resources, and gradual overcoming of natural restrictions during the Upper Paleolithic.

A – The Lower Paleolithic Pattern

The known Ukrainian Lower Paleolithic localities gravitate mainly towards the sea-shores and mountainous areas in extreme west and south of the country and to gravitate toward the western and southern fringe areas of the East European plain. Till now the only few indisputable Lower Paleolithic localities are recovered on the territory of Ukraine (Fig. 4), though recent discoveries in adjacent areas (Anisiutkin *et al.,* 2012; Shchelinskij *et al.,* 2010) clearly points to the high probability of discovery of new localities in the near future.

It is remarkably that Lower Paleolithic assemblages, though very few in number, are reported as coming from locations separated by hundreds of kilometers and localized in Transcarpathia, in the valleys of the Dniester, Southern Bug, Dnieper, Severski Donets rivers, and in the Crimea (Stepanchuk *et al.,* 2010).

The Lower Paleolithic peopling pattern might be summarized as a multiple pioneering colonization of fringe areas of the East European plain during warm periods and depopulation during cold periods.

B – The Middle Paleolithic Pattern

The Middle Paleolithic localities demonstrate the land colonization pattern obviously differing from the Lower Paleolithic. Middle Paleolithic sites form concentrations and evidently gravitate towards rich in bio- and mineral resources areas of broken landscapes in the South, East, and West of the country (Fig. 4).

The only exception from the rule is represented by the area of the Dnieper basin localized within the Sub-Ridge zone. This area was frequently visited and regularly populated in the Middle Paleolithic, as it revealed by the comparatively numerous localities, but it provides no primary outcrops of lithic raw materials and only flints redeposited by river flow might be collected here. As in the case of more recent periods, the presence of population during the Middle Paleolithic one can explain in terms of extreme density and richness of bioresources in this area.

Available records at hands unanimously witnesses that territories once colonized were not settled permanently during the entire period of the Middle Paleolithic. One can state, that there is significant general tendency of association of human occupations primarily and almost exclusively with more warm periods, and this pattern is specific both for the Lower Paleolithic and for the early stage of Middle Paleolithic of Ukraine.

During the later phase of Middle Paleolithic the situation is somewhat changed. As the data on spatial and chronological position of the late Middle Paleolithic sites of Ukraine reveal, the colonized areas reduce notably and repeatedly during the more dry and cold climatic episodes and, to the contrary, became larger and more densely settled during the periods of amelioration of climate. That is, the number of sites and extents of colonized areas become larger in warmer periods and *vice versa* (Fig. 5), but it is quite new feature that the colonized areas are still survived during the cold climatic phases.

In sum, the Middle Paleolithic peopling pattern might be summarized as a model of permanently settled core areas which are fluctuated responding to environmental changes.

C – The Upper Paleolithic Pattern

The dependence of the pattern of land colonization on the general paleoclimatic situation seems to be determinative on the late stage of the Ukrainian Middle Paleolithic, and also in course of practically entire duration of the Upper Paleolithic. This dependence had resulted in such function as population density, and, hence, the frequency of sites. Number of sites and colonized areas varied in fluctuating way.

These, in many respects caused by nature, fluctuations of the process of peopling of the territory are characteristic both for the Middle and Upper Paleolithic periods, and demonstrate no dependence neither on physical type of population nor on level of development of applied technologies. Permanently peopled zones or core areas were played a role of centers for repeated colonization during climatic amelioration and, per contra, of refugia in periods of population decline resulting from reduction of predictable biological and mineral resources. These core areas gravitate toward the south and the west of modern Ukraine and coincide with the most climatically comfortable and rich in various resources zones.

An Upper Paleolithic pattern of peopling demonstrates no difference with Middle Paleolithic pattern, at least for the period between the first penetrations of AMH in the area till the maximum of the last glacial. A similar picture of climatically caused influxes and effluxes of population is restored for this period (Stepanchuk *et al.,* 2009). Situation was decisively changed only after the LGM time when people appeared to

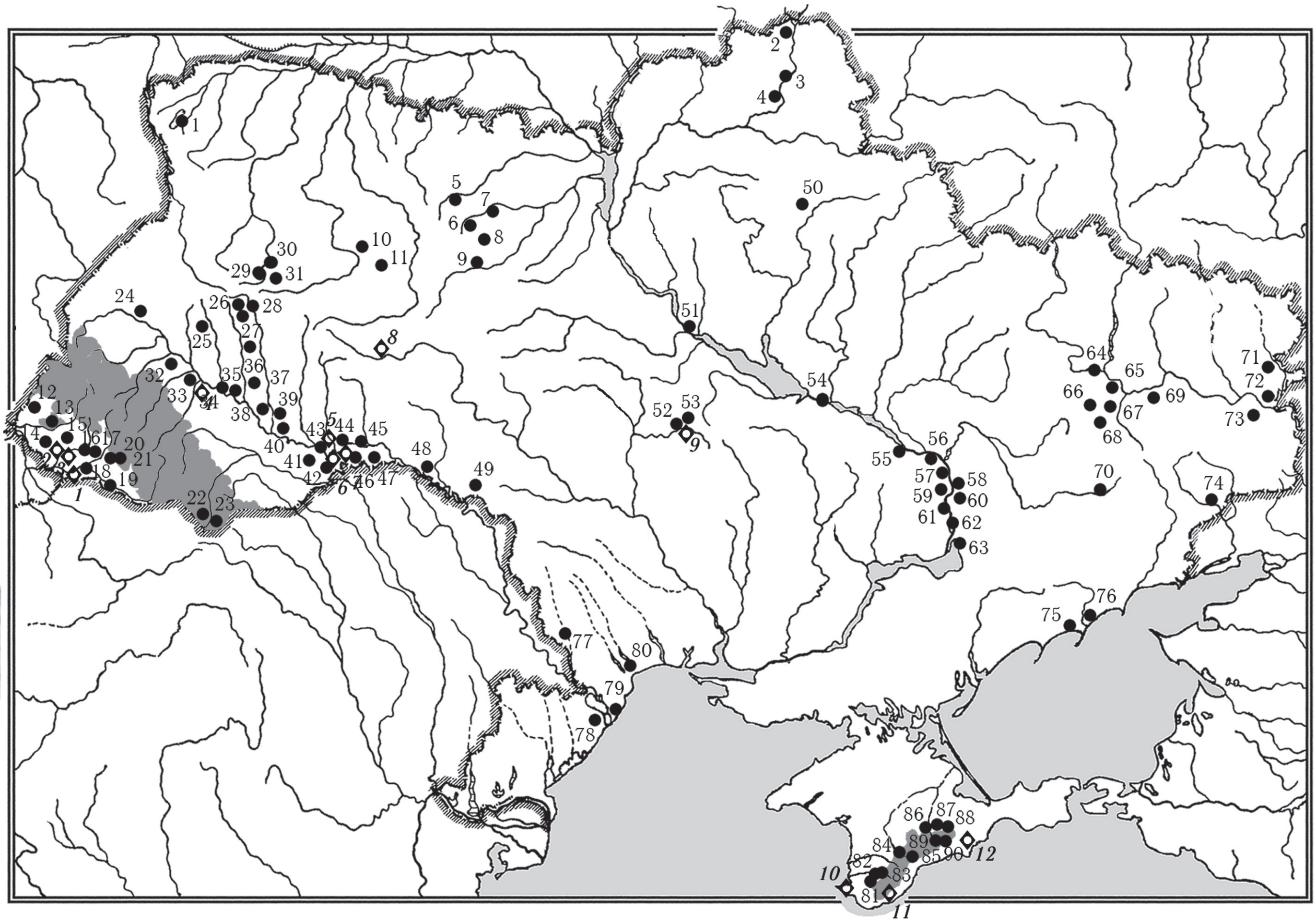


Figure 4 – The most important Lower and Middle Palaeolithic sites and localities of Ukraine

Lower Paleolithic: 1 Koroleve; 2 Malyj Rakovec'; 3 Rokosove; 4 Bukivna IV; 5 Luka Vrublivec'ka (?); 6 Babyn I; 7 Neporotove VI; 8 Medzhybizh; 9 Maslove (?); 10 Mayachnyj: 11 Gaspra; 12 Echki-Dag.
Middle Paleolithic: 1 Verhiv'ya Pryp'yati; 2 Gorihovyj Log, Yazvi, Pidbolottya; 3 Dovgyj Riv; 4 Chulatove III, Komarnya, Arapovychy; 5 Tochyl'nycya; 6 Emylivka I; 7 Ryhta; 8 Gorodysche II, Gorodenka; 9 Zhytomyrs'ka; 10 Spivak, Bilotyn; 11 Zhorniv; 12 Onokivci, Radvanka I, II, Zamkova gora; 13 Mukacheve, Chernets'ka Gora, Tupcha I-III; 14 Zastavne II, Beregove III; 15 Il'nycya; 16 Malyj Rakovets'; 17 Rokosove; 18 Koroleve I, II; Pleshka I, II; Cherna I, II, IV, VIII-X; 19 Shayan II; 20 Hust; 21 Stanovci; 22 Dibrova, Solotvyn I, II; 23 Bila Cerkva; 24 Pryjma I; 25 Berezhany V; 26 Velykyj Glybochok I-III, V; 27 Igrovycya I, Malashivci, Glyadky; 28 Pronyatyn, Ternopil' I, II; 29 Staryj Vyshnevets'; 30 Vanzhuliv I-III; 31 Bugliv V-VIII; 32 Kolodiiv; 33 Ezupil'; 34 Kasperivci VII, Lysychnyky II, Pecherna; 35 Kasperivci I, VI; 36 Dolyna, Pidgajchyky; 37 Bil'che-Zolote; 38 Myhalkiv I, II; 39 Pylypche VII, XIV, Hudykivci I; 40 Pylypche XI, Ustya III; 41 Ketrosy, Stinka 1, 3, 4, Kalynivka, Osypka, Ataky I; 42 Kyshlyans'kyj Yar; 43 Sokil I; 44 Luka Vrublivets'ka; 45 Stara Ushycya; 46 Molodova I, V, Babyn I, III, VII; 47 Korman' IV, Oselivka; 48 Subotivka; 49 Zholubets'; 50 Muhovets'; 51 Kaniv; 52 Maslove, Troyanove, Korobchyne; 53 Andriivka 1, 3, 4, 8; 54 Kremenchuk; 55 Romankove; 56 Gyrlo Samary; 57 Locmans'ka Kam'yanka, Kodak I, II; 58 Nenasytets' I, IV, Remenovo; 59 Skubova Balka, Majorka IV, Tyagynka I-III, Mykil'ske I-III, Vijs'kove, Vovnigy; 60 Orel; 61 Kruglyk, Fedorivka, Ostriv Tavolzhanyj; 62 Vil'nyanka I, IV-VI; 63 Balky I-VII, Uzviz; 64 Izyum; 65 Korniiv Yar; 66 Druzhkivka; 67 Bilokuz'mynivka; 68 Kurdyumivka, Ozeryanivka; 69 Zvanivka; 70 Antonivka; 71 Chugynka; 72 Derkul; 73 Chervonyj Yar; 74 Amvrosiivka; 75 Samsonove, Novoazovs'k, Obryv; 76 Sedove; 77 Bilyaivka; 78 Bilgorod-Dnistrovs'kyj; 79 Baraboj III; 80 Illinka; 81 Starosillya, Holodna Balka, Ulakly; 82 Shajtan-Koba I, IV, stoyanka im. G. A. Bonch-Osmolovs'kogo, Tav-Bodrak I, II; 83 Kabazi I-V, Va; 84 Chokurcha I, II; 85 Kiik-Koba, Vovchyj Grot; 86 Sary-Kaya I-IV, Karabaj; 87 Zaskel'na I-IX, Ak-Kaya I-V; 88 Al'oshyn Grot, Chervona Balka; 89 Prolom I-III; 90 Buran-Kaya III.

be successful in invention of new subsistence strategies which allow them to adapt successfully to virtually all variations of landscapes and resources. Since the LGM time practically the whole territory of modern Ukraine was colonized by hunter-gatherers stably and without lacunas (Zalizniak 2010).

5 – Lithic raw materials strategies in diachronic perspective

A – Lower Paleolithic Raw Material strategies

The predominantly local lithic raw materials were almost exclusively used for toolmaking activity, as it revealed by the data provided by the Lower Paleolithic localities recovered in Ukraine. There are no indisputable instances of exploitation of in any extent remote raw materials. The range of variations of rocks which were used at different localities and in geographically diverse areas, is rather high, although these variations always remain within the frameworks of variability of local rocks (Table 1).

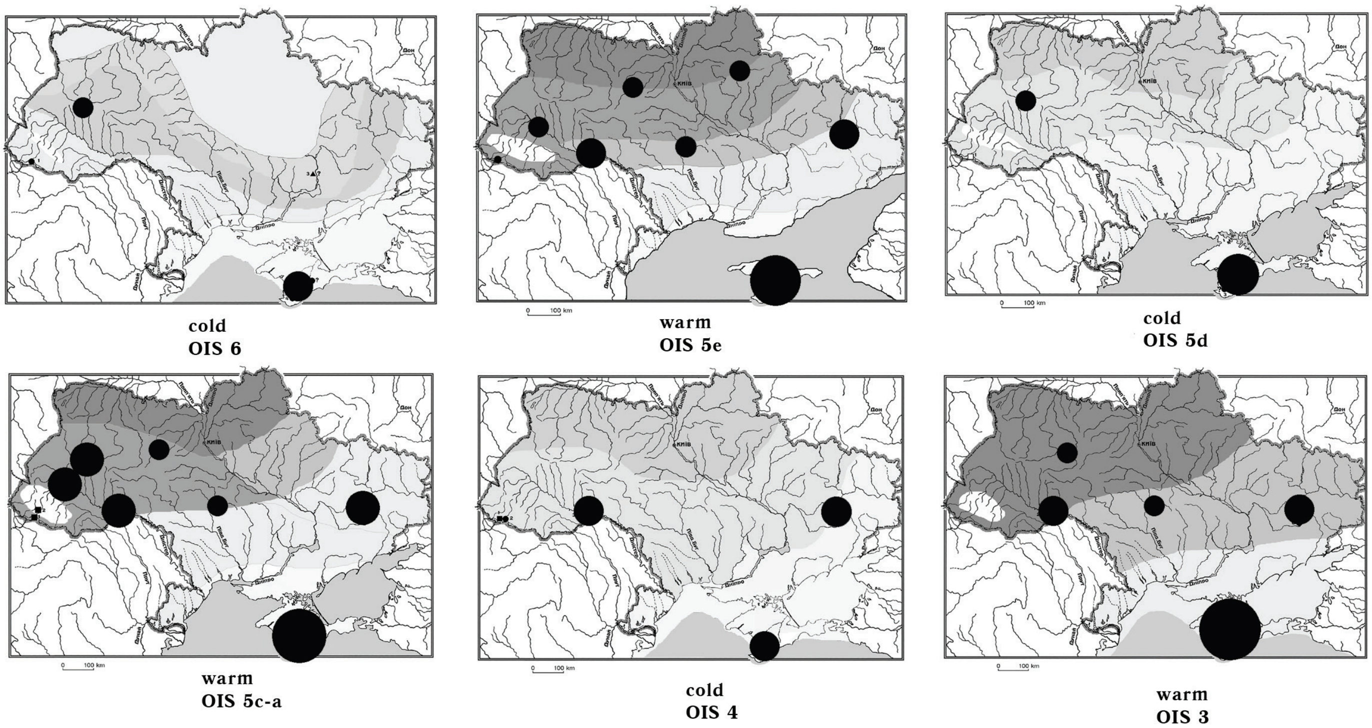


Figure 5 – Correlation of climatic, environmental, and population dynamic at the late stages of Ukrainian Middle Paleolithic. Position and size of black circles correspond to the location of populated areas and intensity of colonization

Regularities of lithic raw materials variability of Lower Paleolithic assemblages equally concern the heavy and light tools.

Worthy to stress that there is likely intentional and well recognizable tendency to avoid more isotropic rocks as raw materials for knapping. It is hard to explain this tendency in unambiguous way. Maybe these rocks, which are more easily to knap but at the same time more easily destruct when working under poor power and coordination control, were rejected because they were taken as dangerous? Anyway, more tight and tough rocks were more preferable. But under the terms of shortage or small choice of raw material such isotropic rocks as obsidians, andesites, or flints were also welcome.

The most ancient sites gravitate toward the mountain areas in the west and the south of the country and known in Transcarpathia, Southern Bug valley, and probably in Crimea. Presence of Lower Paleolithic assemblages in the far east of Ukraine that is nearby the Lugansk city was reported recently (Vetrov Skorikov 2010). Andesite and obsidian were exploited in Transcarpathia, limestone marble, quartzite and quartz in Crimea, quartzite, granite, and flint in the Southern Bug valley, quartzite and sandstones in area of the Severski Donets river in the East of Ukraine. Characteristic feature of the majority of known localities is a location directly on or nearby the areas with easily accessible lithic raw material.

Therefore, the main features of the Lower Paleolithic raw materials strategies should be defined as utilization of wide spectrum of lithic raw material of local provenience and preferably not isotropic.

B – Middle Paleolithic Raw Material Strategies

Middle Paleolithic records of Ukraine allow to recognize two or three very important and interdependent basic changes or tendencies in raw material strategies. These are: a) re-orientation on rocks with perfect isotropic properties, mainly flints; b) sufficient decrease of variability of raw materials used for knapping; c) evidence of multi-staged or multi-aspectual intentional selection of raw materials, including here the so called initial practice of mining.

Should also be emphasized, that the evidence of exploitation of remote and exotic raw materials are also for the first time reported for the Middle Paleolithic period. But, at the same time, such a feature of the previous period as *the local* origins of *the main* portion of used raw materials is still survives.

Whereas andesite and obsidian remain the dominant type of raw materials in Ukrainian Transcarpathia, other territories demonstrate the crucial shift toward the flint working. It does not mean, of course, the complete absence of assemblages which include a certain number of artifacts made on other lithic raw materials. But in virtually all cases these admixtures can be plausibly explained in terms of quantitave or qualitative insufficiency of available flints.

Middle Paleolithic sites of Ukraine demonstrate rather uneven pattern of spatial distribution, with isolated concentrations and blind spots (Fig. 4). It is of great interest, that geographical position of the majority of concentrations of Middle Paleolithic sites practically coincides with localization of the most reliable and stable sources of raw materials (Stepanchuk 2006). This coincidence is hardly coincidental.

So far the only exception is the Dnieper group of the Middle Paleolithic sites which are not directly related to the known primary raw material deposits. These latter are remote southward and northwestward on a distance of 100 to 150 km. Middle Paleolithic sites of the basin of the Middle Dnieper are localized in area which is exceptionally rich in bioresources though remote from the sources of lithic raw materials. Therefore, this instance is a good illustration of quite high flexibility of Neanderthal technologies and subsistence strategies. However, the major portion of sites described to the Middle Paleolithic period is still tightly bound to the sources of raw material, preferably to the primary deposits.

The Middle Paleolithic industries of Ukraine are not monotonous, as elsewhere in Middle Paleolithic, and are far from the uniformity. The reason of this variability is a subject of continuing discussion in the home literature, as elsewhere. Whatever was this reason, either the entirely environment-determined adaptation or basically cultural response on challenges of nature, there is a number of different variations of MP industries, classified in various ways.

One of the variants of classification of the Ukrainian Middle Paleolithic variations is displayed at (Fig. 6). One can regard the presented technological variations - which are also characterized by clear spatial pattern - as consequences of natural variations of environment and landscape. But special examination of possible interrelations allow to conclude that neither climatic circumstances nor factors of behavioral activity did essentially influenced on the habitus of Middle Paleolithic industries (Stepanchuk 2006). There is no meaningful dependence between the type of industry, and landscape types, composition of hunter game, peculiarities of economy, season of habitation, and types of principally available raw materials.

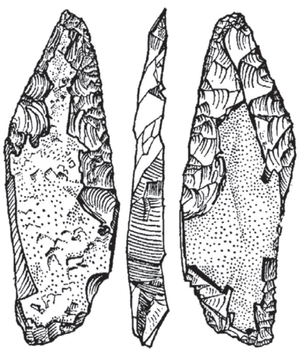
It is worthy to stress - in the context of this paper - that different industrial traditions are characterized by the distinct technological strategies. This distinction is mirrored in applied technologies, final products, and also in specific requirements on lithic raw materials. Few instances would be illustrative in this respect. These are the instance of oriented on utilization of tabular raw materials and used flat knapping Crimean assemblages with bifacial technology (Kolosov 1986), or the instance of oriented on utilization of nodule raw materials and used semi-volumetric knapping Volhynian or Donbass assemblages with blade Levallois technology (Sytnyk 2000; Kolesnik 2003). Worth to stress that *various* shapes of flints are available in the Crimea, Volhynia or Donbass region, as well as *other* kinds of industries are also reported for these areas.

The focusing on a specific form of primary raw materials already represents the stage of intentional selection. As it witnessed by the Middle Paleolithic records, the preliminary selection of raw materials for further knapping and shaping of tools was carried out on a number of parameters, such as dimensions, physical properties, and shape. Physical state of surfaces of pieces of raw materials which were unearthed either intact or knapped in the context of Middle Paleolithic occupations is fairly individual and variable.

I
Middle Palaeolithic
with bifacial & flakey blank technologies

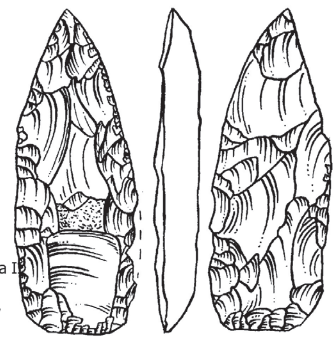
I-1
technocomplex
of bifacial backed tools
(Micoquain industries)

Korolevo II-a industry
Korolevo assemblage II-a
Ezupol' industry
Ezupol' layer II, ?Kolodiev
Zhitomirskaya industry
Zhitomirskaya, early assemblage
? Kanev industry
Kanev locality
? Zaskal'naya IX industry
Zaskal'naya IX, lower layer
? Bodrak industry
Shary I-III
Ak-Kaya group of industries
Zaskal'naya V,
Zaskal'naya VI (Kolosovskaya),
Prolom II, Cary-Kaya, Chokurcha,
Volchij Grot, Krasnaya Balka



I-2
technocomplex
of bifacial leafpoints
(para-Micoquain industries)

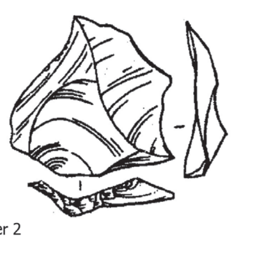
Korolevo V-a group of industries
Korolevo V-a, ?Korolevo V-b, V
Velykyj Glybochok industry
Velykyj Glybochok, layer III
Stinka group of industries
Stinka I, II, Shipot 1, Osypka
Antonovka group of industries
Antonovka I, Antonovka II, Cherkasskoye,
Ozeryanovka 1, 3, Druzhkovka, Krasnyj Yar
Rikhta group of industries
Rikhta, Zhitomirskaya, late assemblage,
Spivak, Bilotyn
Orel group of industries
Orel, Balki, Uzvoz
Starosel'ye group of industries
Starosel'ye, Kabazi II, layer III, Kabazi V,
GABO, layer I, Bakhchisaraiskaya, Chokurcha I
Kiik-Koba group of industries
Kiik-Koba, layer IV, Buran-Kaya III, layer B1,
Prolom I, ?Volchij Grot, middle layer



II
Middle Palaeolithic
with flakey blank technologies

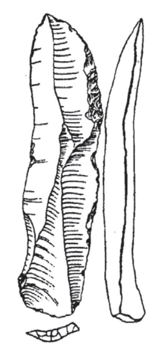
II-1
technocomplex
of flake-oriented Levallois-Mousterian
(flake idustries)

Korolevo III group of industries
Korolevo III, IVa, Malyj Rakovets IV
Korolevo II industry
(Korolevo II)
Buglov V layer group of industries
Buglov V, layer I
Molodovo group of industries
Molodovo I, layers I-IV, Molodovo V, layer 12, 11,
Ketrosy, Proniatyn, Zhornov
Shaitan-Koba group of industries
Shaitan-Koba I, Shaitan-Koba IV, Alioshin Grot, layer 2



II-2
technocomplex
of blade-oriented Levallois-Mousterian
(blade idustries)

Buglov V, layer II industry
Buglov V, layer II
Ezupol' III industry
Ezupol', layer III
Nenasytets industry
Nenasytets, Skubova Balka
Kurdyumovka industry
Kurdyumovka, Udai assemblage
Kabazi II layer II group of industries
Kabazi II, layer II



? III
denticulate Middle Palaeolithic

?Kruglik industry
Kruglik
?Maslovo 5 industry
Maslovo 5
Kiik-Koba lower layer group of industries
Kiik-Koba, layer VI, Krasny Mak, Kabazi II, layer IV

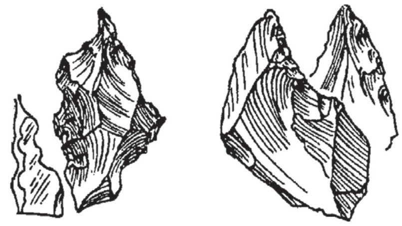


Figure 6 – Industrial variability of the Ukrainian Middle Paleolithic

Among these there are artifacts with practically not weathered fresh carbonate crust. If statistically too frequent, such finds, I believe, suggest the special search for raw materials accumulated in primary deposits. Just intentional activity targeted at collection of pieces of raw materials included in primary deposits might be defined as initial practice of mining.

The main features of the Middle Paleolithic raw materials strategies should be defined as utilization of preferably isotropic lithic raw material of mostly local provenience; there are the first indisputable evidences of exploitation of remote sources of raw materials and isolated pieces of exotic rocks, and also indirect indications of intentional complex activity on selection of lithic raw materials

C – Upper Paleolithic Raw Material Strategies

The tendency of overcoming the dependence on sources of lithic raw materials was started somewhere in the Middle Paleolithic with invention of composite tools and more intensive use of bone and antler in addition to less resistant materials. This tendency becomes more effective and clearly visible during the next phase of cultural development.

Upper Paleolithic period of Ukraine is characterized by the gradual overcoming of dependence on lithic raw materials. Progress in this area was basically ensured by the following innovations, these are: a) intensive involving of bone and antler into tool-making activity; b) invention of far less expendable and more sophisticated knapping techniques; c) invention of insert-technology accompanied by broad applying of composite tools.

Invention of less expendable lithic techniques and technologies contributed greatly to the successful colonization of territories previously inaccessible for stable peopling due to geographical remoteness from zones with predictable lithic resources. Besides, the blade and micro-blade technologies allow to eliminate mostly the restrictions conditioned by the physical properties of raw materials, size restrictions in particular. The allowable distance between sites and raw materials increases up to several tens of kilometers, and, in some exceptional cases, exceeds several hundred kilometers. Nevertheless, the overall trend remains the same as during the previous phase, namely the densely populated areas still coincide with areas of reliably predictable raw material outcrops (Gladkikh & Stanko 1997).

Thus, the main features of the Upper Paleolithic raw materials strategies should be defined as still preponderant utilization of preferably isotropic lithic raw material of local provenience; but the geography of colonized areas become more extended and mobility appeared to be essentially higher due to application of more sophisticated and less expendable technologies. There are the first indisputable evidences of exploitation of very remote sources of raw materials.

6 – Human dispersals at the East European plain

The earliest evidence of human presence in the country is dated to 0,9-1,0 Ma and discovered at Korolevo, west of Carpathian mountains. Korolevo locates in a zone of still actively working quarry and represents conglomeration of numerous sites and localities indirectly on outcrops of andesite raw materials. Of extraordinary importance are assemblages VIII and VII from Korolevo, which, as proved by geostratigraphic, sporo-pollen and geomagnetic data, are associated with sediments occurring below the Brunhes-Matuyama boundary (Gladilin 1985; Levkovskaya *et al.,* 2008). However, geographically Korolevo I is not situated in Eastern, but in Central Europe.

Only a few credible Lower Paleolithic localities have been discovered in the East European part of continental Ukraine and Crimea. Among them, the aged to ~0,4~0,5 Ma Medzhibozh represents the only in Ukraine Lower Paleolithic locality with pebble industry and well preserved fauna demonstrating numerous anthropic modifications.

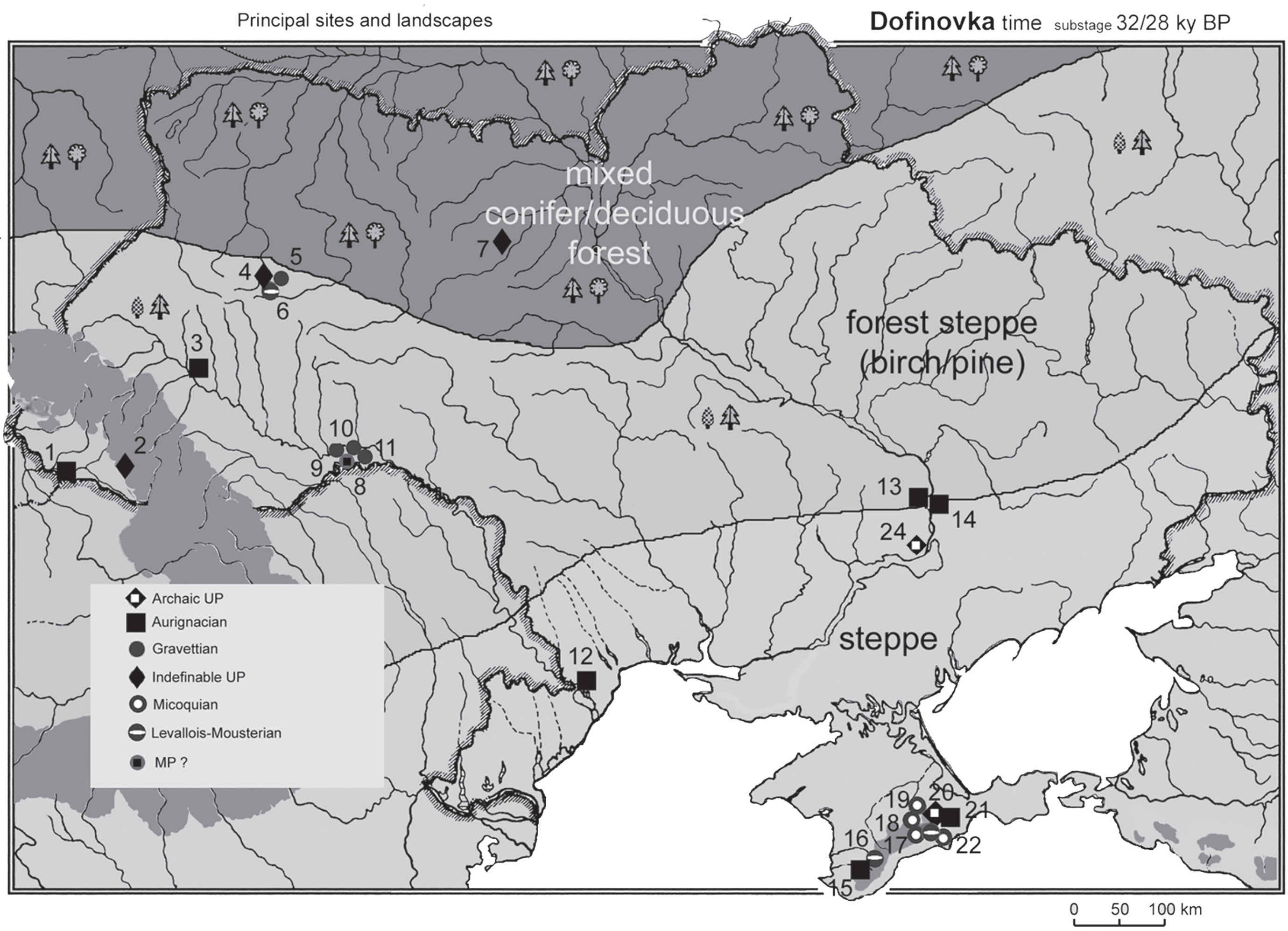


Fig. 7 – Principal sites and landscapes. Dofinovka, early substage, 32/28 uncal ky BP. Environmental reconstruction after Melnichuk 2004.

Key: Archaic UP: 2 – Shayan I: II; 4 - Zhornov: 1; 20 - Buran-Kaya: IIIC; 24 – Mira: I; Aurignacian: 1 – Beregovo I; 3 - Mezhigirtsi: lower; 12 – Zeleny Khutor; 13 – Nenasytets III; 14 - Vorona III: lower; 15 – Siuren' I: FA-1-FB2, GA-GB2; 21 - Buran-Kaya III: 6/5-3; Gravettian: 5 - Zhornov: 2a; 9 – Molodova I: 3; 10 - Molodova V: 10, 9; 11 – Oselivka: 3, 2; Indefinable UP: 7 – Radomyshl'; Micoquian 17 – Prolom I: I; 18 – Zaskal'naya V: II, I; 19 - Zaskal'naya VI (site of Kolosov): II; 22 - Buran-Kaya: B1; Levallois-Mousterian: 6 - Zhornov: 2; 16 – Kabazi II: II/1a; 23 – Alyoshin Grot: I; MP ? 8 – ?Korman' IV: 10, 9.

Therefore, essential is the fact that the process of peopling of territories during the Lower Paleolithic was represented by recurring pioneer colonization of areas with abundant and predictable biological and mineral resources by small groups of migrant population with considerable chronological lacunae between individual episodes of colonization. Thus, prolonged uninterrupted colonization and, therefore, continuity of population and traditions are out of the question.

Probable path of colonization from Near East via Caucasus and the South of Eastern Europe to South-Eastern Europe represents only one of the variants of reconstruction of actual events on the stage of the first wave of colonization of Eurasia, to date more plausible due to the available combination of known facts. Other interpretations are also possible. For instance, the prevalence of sites containing 'core-and-flake' inventory on the territory of Anatolia, Balkan peninsula and the South of Eastern Europe seems to suggest also a 'Balkan' version of migration of the bearers of mode 1 technology from the Near East to Europe. In any case, the available information does not contradict the existing notions about a rather intense process of peopling of Eurasian territories via Near East.

Ecological and tightly associated demographic factors were played as guide agenda in the processes of peopling and colonization of new territories. Availability, predictability and richness of bioresources were the primary cause of population growth and concomitant colonization of new areas. Availability of lithic raw materials resources was additional determinant of colonization processes. Rhythmic climatic fluctuations in Pleistocene were accompanied by repeated landscape-climatic alterations and related changes of resource base. Plurality of environmental changes had affected the rhythmic nature of repeated colonization and consequent depopulation of habitats at the early stages of human presence on the territory of modern Ukraine.

There is no room to suppose permanent population of the territory of Ukraine during the Lower and the major portion of Middle Paleolithic, as well. Instead, a picture of numerous affluxes and refluxes of population seems to be more adequate, as it seen from available archaeological records. Constant presence of population, and, consequently, probable continuity within the frameworks of stable colonized areas, might be suggested only for the late stage of the Middle Paleolithic, beginning from the Eem (or the end of Riss) for the Crimea, and, likely, somewhere from the Ammesrfort-Brörup for the Middle Dniester area and Donbas. Should be stressed once again that all these areas provide abundant, easily accessible, and high quality lithic raw materials of excellent isotropic properties. Stable raw material base seems to be one of the components of prosperity of Middle Paleolithic communities in these areas.

Neanderthal technologies and subsistence strategies were quite effective as it witnessed by a thousands years of coexistence with modern humans under the same environmental conditions (Fig. 7). Coexisted UP and MP population share the same biozones (steppe and mosaic foothills) and the same landscapes (highlands and low mountains) in extreme south and west of the country. Accordingly to the recent radiometric data for some Crimean multilayered MP sites, ultimate Neanderthals on the extreme south of Ukraine might survived beyond as late date as 25 ky BP (Stepanchuk 2006).

As it revealed by the Ukrainian records, Neanderthals built dwellings, buried their dead, engraved bones, used colorants, made something from bird bones, collect and utilize exotic rocks, and were skilled and quite prosperous in many other respects.

Neanderthal skills and knowledge allow them to colonize the most rich and comfort areas of the territory of modern Ukraine with a highest level of predictability and abundance of vital resources. But they remained permanently relied on local rich raw materials sources and demonstrate no purposeful technological shifts towards the more mobile style of behavior.

Anatomically modern humans were obviously more mobile, more innovative and less traditional as Neanderthals. Their behavior features are mirrored in many things, in particular in long distance migrations. The case of Mira layer I, dated to ca. 28 ky BP EUP site in the Dnieper valley, is fairly representative in this respect (see this volume). Evidence collected in Mira layer I witnesses for more than 750 km migration and well illustrate the fact that Upper Paleolithic people already overcome some important limitations of dependence on lithic raw materials.

A – Concluding remarks

Diachronic and spatial aspects of the dynamic of exploitation of raw materials in Paleolithic of Ukraine was examined in the context of specificity of territory, landscape, climate and further environment peculiarities, and also in the context of the process of colonization of the terrain. Such approach allowed to elucidate some meaningful interrelations (Table 2).

In diachronic perspective the main trends in exploitation of lithic raw materials can be formulated in following way. The period of Lower Paleolithic is characterized by the utilization of wide spectrum of lithic raw materials, preferably not isotropic. To the contrary, the Middle Paleolithic is characterized by utilization of preferably siliceous isotropic rocks, and the same regularity is inherent to the Upper Paleolithic, when the gradual overcoming of exclusive dependence on lithic raw materials occurs.

In spatial perspective, the Lower Paleolithic is characterized by relying on exclusively local "underfoot" raw materials that probably mirrors a practice of unplanned situational supply and lack of traditional technologies. The Middle Paleolithic is characterized by utilization of mainly local outcrops, localized mostly in the near vicinity of occupation camps. Special and multi-stage selection of lithic raw materials is specific for this period, as well as widespread occurrence of traditional technologies and standardized

Lithic raw materials exploitation in Ukrainian Paleolithic: The main trends				
	Diachronic Perspective	*Spatial Perspective*	*Cultural Perspective*	*dispersals at the East European plain*
Lower Paleolithic	utilization of wide spectrum of raw materials, preferably not isotropic indefinite dependence on "rocks"	exploitation of strictly local "underfoot" outcrops of LRMs unplanned situational supply by raw materials	lack of traditional technologies lack of standardization	Sporadic colonization of areas bordering with plain during the warmer periods
Middle Paleolithic	utilization of preferably siliceous isotropic rocks exclusive dependence on rich and predictable isotropic LRMs	mainly local outcrops, localized mostly in the near vicinity pre-planned multi-stage selection of LRMs	traditional technologies standardization of products	Permanent presence of population in extreme West and South. Increases and decreases of populated areas depending on climatic changes
Upper Paleolithic	utilization of preferably siliceous isotropic rocks gradual overcoming of exclusive dependence on isotropic LRMs	no obligatory dependence on local LRMs pre-planned multi-stage selection of LRMs	traditional technologies standardization and microlithization of products	At the first stages – the same as during the MP. On the latest stage – total colonization of the territory and permanent presence of population

Table 2 – The main trends of Lithic Raw Materials (LRMs) Exploitation in Paleolithic of Ukraine

products. Upper Paleolithic is characterized by the elimination of dependence on local outcrops in particular, and by the overcoming of dependence on lithic raw materials in general, due to highly innovative insert technologies and further standardization and microlithization of lithic products.

Peculiarities of exploitation of lithic raw materials in Paleolithic of Ukraine well coordinate with regularities of peopling and colonization of the terrain. Thus, the sporadic - during warm periods - colonization of seashore and foothill regions and nearest zones bordering with expanses of the East European plain is peculiar for the Lower Paleolithic. The permanent presence of population in extreme west and south of the country is typical for the Middle Paleolithic, as well as the alternate increases and decreases of number and density of populated areas, which dynamic depends on climatic changes. At its first stages the Upper Paleolithic characterized by the same colonization pattern, as prevailed during the MP. The pattern was crucially changed after 18 ky BP. Since that time and till ca. 13 ky BP the territory of Ukraine was peopled everywhere, and Epi-Gravettian UP occupations are known in low mountains, highlands, lowlands, and valleys of large rivers. Therefore, the obligatory dependence on spatial limitations of predictable and rich mineral resources was decisively overcome.

Acknowledgements

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PART II:
REGIONAL PERSPECTIVES

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Lithic raw material exploitation and circulation in Préhistory. A comparative perspective in diverse palaeoenvironments
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2.1. The raw material variability in the mesolithic site of Ullafelsen (Sellrain, Tyrol, Austria)

Résumé

Dans cet article seront décrites les différentes matières premières exploitées dans le site mésolithique d'Ullafelsen (Alpes Stubai, Tyrol). Le gisement se situe dans un contexte métamorphique de haute montagne (1869m d'altitude), dans lequel les roches appropriées à la taille sont presque totalement absentes. La seule exception est représentée par le quartz local de mauvaise qualité, qui a très rarement été utilisé en raison de sa fracture irrégulière. La plupart des artefacts a été réalisé sur des matières premières qui affleurent loin, voire très loin du site. Les matériaux lithiques ont été regroupés en quatre groupes principaux sur la base de leur provenance régionale. Un groupe d'artefacts a été réalisé sur des silex du Franconian Jura (Bavaria), situés à plus de 200 km vers le Nord. Un autre groupe est compatible avec les silex des Alpes méridionales qui affleurent dans la Val di Non (Trento, Italie), environ 120 km vers le Sud. Le troisième groupe comprend des radiolarites des Alpes Calcaires septentrionales moins appropriés à la taille et plus proches (30-50 km de distance vers l'Est). Le quatrième regroupe les artefacts en quartz, représentés par le cristal de roche métamorphique local de mauvaise qualité, récolté à 40-50 km au Sud-Est (Tauern). En général, on reconnaît une bonne concordance entre la provenance des matières premières et leur attribution culturelle, bien que cet aspect ne puisse être vérifié que sur de rares outils typiques. Parmi les silex du Franconian Jura, quelques éléments suggèrent une tradition beuronienne ; par contre on retrouve des pièces retouchées typiquement sauveterriennes parmi les pièces obtenues sur les silex des Alpes méridionales et le cristal de roche. L'attribution des silex des Alpes Calcaires septentrionaux, plus proches, reste douteuse. Différentes matières premières et différentes traditions sont représentées dans le même site au Mésolithique ancien dans les Alpes Stubai.

Abstract

In this paper the different raw materials exploited at the Mesolithic site of Ullafelsen (Stubai Alps, Tyrol) will be described. The site is situated in a high mountain (1869 m) metamorphic context almost completely free of suitable rocks for knapping. The only exception is represented by the local bad quality metamorphic quartz, which was only seldom used because of its irregular fracture. Most of the artefacts have been made with raw materials cropping far or very far from the site. The lithic materials have been grouped in four main groups on the basis of their regional provenance. A group of artefacts have been realized with Franconian Alb cherts (Bavaria), more than 200 km far to the north. Another group of artefacts is compatible with the Southern Alps cherts cropping in the Val di Non (Trento, Italy), around 120 km straight line to the south. The third group comprehends less suitable and nearer (30-50 km far, to the east) Northern Calcareous Alps radiolarian cherts. The fourth group encloses the quartz artefacts; these are represented by the bad quality and local metamorphic quartz and by the high quality rock crystal that was collected 40-50 km to the south east (Tauern). There is a general concordance between the raw materials provenance and their cultural attribution, even if this is visible only in few typical artefacts. Among the the Franconian cherts some elements suggest a Beuronian tradition whilst among the Southern Alps cherts and the rock crystal there are typical Sauveterrian tools. The attribution of the closest Northern Calcareous cherts is more doubtful. Different raw materials and different cultural traditions are represented in the same site in the lower Mesolithic of the Stubai Alps.

Keywords: Ullafelsen, Mésolithique, matières premières, Sauveterrien, Beuronien

1 – Introduction

The Lower Mesolithic site of Ullafelsen is situated 1869 m high in the Fotscher Valley, Stubai Alps, Tyrol. The site was excavated from 1995 to 2004 by a team of archaeologists from the University of Innsbruck under the direction of Prof. Dieter Schäfer. Its geological setting is characterized by the presence of metamorphic rocks, mainly micaschists and gneiss, without any siliceous raw materials suitable for knapping. On the other hand the petrographic variability of the lithic industry of Ullafelsen is very high. This evidence strongly contrasts with the complete local absence and with the immediate surrounding scarcity of lithic resources that the natural environment offers. Since the beginning of the studies it was clear that most of the raw material were brought to the site from other areas. Understanding the provenance of the lithic materials constituted a basilar work to interpret the dynamics in Early Mesolithic in a wide area comprised between northern Italy, Tyrol and lower Germany.

2 – Description of the assemblage

The Ullafelsen lithic assemblage consists of almost 8.000 artefacts. Most of them are small or very small (few mm) and have not been yet studied. The following data derive from the study of a sample of 2347 artefacts bigger than 1 cm (perimeter). They were collected during the excavations till present day (2012) carried on. We can observe the following proportions:

A. Jurassic cherts from the Frankonian Alb: n = 502 (21,4 %)
B. Cretaceous flints from Southern Alps (northern Italy:): n = 699 (29,8 %)
C. Jurassic radiolarian cherts from Northern Limestones Alps: n = 799 (34,0 %)
D. Quartz artefacts from the Central Eastern Alps: n. 347 (14,8 %)

A – Jurassic cherts from the Frankonian Alb

Two different groups of artefacts have been recognized (Bertola and Schäfer, in press; Bertola and Schäfer, 2011).

Group 1. The artefacts show whitish cortexes locally covered by calcite concretions impregnated with oxides. The chert was probably gathered in secondary deposits. The color and texture of the cherts are inhomogeneous. Dark grey colors alternate with whitish and beige. The texture shows laminations and bands, also discontinuous, providing the chert a marbled texture. Generally the laminas are thin, with a rectilinear or curvy pattern. The degree of silification is variable. Most of the artefacts are made from slightly silicified nodules. Ivory white colors appear mainly in the outer parts. The fossils are generally poorly preserved and hardly visible. Calcispheres, sponge spicules, crinoid articles, few radiolarians and small algal nodules are visible mainly around the cortex and in the more silicified specimens. The morphological characteristics visible on the cortex of the artefacts allow the conclusion that the chert was available in the form of nodules as well as beds.

Group 2. This group is smaller (23.4%) than group 1 (76.6%). It includes litotypes that can be compared with the geological specimen from Abensberg–Arnhofen. They are generally more silicified than group 1. Some of them show the characteristic greyish and whitish horizontally striped texture, others are more homogeneous. The bands are never numerous and always subordinate. They are usually rectilinear, but sometimes show a sinuous pattern. They show, more or less clearly, a micro-laminated aspect; the laminas are often discontinuous and caused by microbial mats. Often the laminated layers alternate with graded bioclastic horizons. One can easily identify crinoid fragments, numerous sponge spicules (mostly monoaxone, some triaxone), calcispheres and poorly preserved radiolarians. Some mainly spherical ooids of few millimetres in size, with whitish and opaque textures, are also present. Benthic foraminifers and pelagic bivalves are less common. The geological referring blocks are assumed to be chert beds. In the Franconian Alb there are many other Jurassic chert outcrops of a similar age. However they are not characterized by the same banded feature typically associated with thin tabular morphology. This kind of chert is described as the most typical variety of the Abensberg-Arnhofen group.

The groups of artefacts described can be attributed with high certainty to the upper Jurassic cherts from the "Plattenkalke" of southern Franconian Alb. A number of indications support this hypothesis: firstly, the macroscopic features of the samples (color, structure, cortex) and secondly, the study of the characteristic microfacies that revealed the fine algal lamination alternated with graded and bioclastic horizons.

B – Cretaceous flints from Southern Alps

A group of artefacts, totally extraneous to the local geological context, is compatible with flint outcrops situated on the southern slope of the Alps (Val di Non, Trentino, Italy). Thanks to the identification of the micropaleontological associations (planktic foraminifera), well preserved for a great part of the samples, it was possible to place the flints from a chronologic / stratigraphic point of view. The chronological interval represented is rather narrow: from Albian to Turonian. Through the study of the petrographic / textural characteristics of the flints, it was possible to ascribe the litotypes to the Scaglia Rossa and the Scaglia Variegata formations (Bertola, 2011a). The distribution concerning these two formations is rather vast and includes a large portion of north–east Italy. The nearest (about 120 km, straight line) outcrops to the site of Ullafelsen are localized in the Non Valley which is the area where the pelagic Mesozoic series of the South Alpine basin reach the further north latitudes. The research and the comparisons have focused around this area immediately from the start. Numerous and aimed field excursions allowed to study and describe different geological outcrops and to collect several flint samples both from the primary and secondary deposits. Thanks to a full-bodied reference lithic collection, well representing the variability of the flints in Non Valley, I carried out a comparison with the artefacts of Ullafelsen. It was not necessary to extend the comparison to other areas. Immediately it was possible to exclude more southern provenance areas (Baldo and Lessini chains) as the Ullafelsen collection lacks some very characteristic flint types from older formations such as Biancone (lower Cretaceous) and Calcari Grigi (Jurassic). The Biancone flints, in particular, are the more abundant ones in the South Alpine outcrops and also the more used in the local prehistoric contexts (Mesolithic as well) given their high quality characteristics. From a geological / structural point of view, the Non Valley has particular characteristics because throughout the Mesozoic it kept a relatively high position compared with other more southern and eastern areas and this greatly conditioned the depth and distribution of the formations. In particular, the Jurassic / lower Cretaceous formations (Calcari Grigi, Rosso Ammonitico, Biancone) are very condensed or absent. The Ullafelsen artefacts association parallels the natural availability of lithic resources of the Non Valley with respect to: a) the narrow chronological interval represented; b) the lack of flint types which are very characteristic of the outcrops situated more towards the south. The analysis of the morphological characteristics of the artefacts preserving natural surfaces demonstrate that the flint was collected from debris at the foot of rocky walls (33.1%), residual soils (54.7%) and torrent pebbles (13.2%). The flint was introduced in little rounded blocks or tabular slabs as big as 8 cm x 6 cm at maximum, often tested or partially flaked. The Adige Valley seems to have been the preferred way for these movements or long distance exchanges.

C – Jurassic radiolarian cherts from Northern Limestones Alps

Here are grouped the artefacts realized with cherts that belong to the sedimentary sequence of the Northern Limestones Alps and can be considered local, even if they are absent in the surrounding of the Ullafelsen site. Even if several sub-categories have been created, we can refer all the artefacts to two geological formations: Ruhpolding (upper Jurassic: the red litothypes) and Chiemgau / upper Allgäu (middle Jurassic: the gray and green litothypes) (Bertola, 2011b). In some areas (Jurassic basinal sequences) these two formations stay directly in contact and it is easily possible to collect all the cherts previously described. In Tyrol (but extended also out of the region) the main important basinal area was represented by the Eiberg basin, elongated W to E for about 200 km. During 2010 and 2011 several field excursions in the Northern Limestone Alps were finalized to sample cherts comparable to the Ullafelsen artefacts. The investigated area was comprised between the Lechtal Alps to the west and Kufstein to the est. The better and widest chert outcrops have been sampled in the area between the eastern Karwendel and the western Rofan (Achensee valley and surroundings). The following comparisons of the samples with the artefacts confirmed the strong analogies. We have clear evidences that the provisioning area of the "local cherts" was placed near the lake Achensee, around 40-50 km est / north east of Ullafelsen. This area, easily accessible along the Inn valley, till now represent an important way to the Bavaria. Maybe the groups bearing the Bavarian cherts provisioned also in this area. Other chert types (there are several types cropping in the Northern limestone Alps, from Triassic to Cretaceous) have been totally ignored also because of their bad quality. Their total absence however suggest that people provisioned in some defined areas and with some defined chert types.

D – Quartz artefacts from Central Eastern Alps

The quartz artefacts can be divided in two categories.

1. Rough quartz lenses forming into the gneiss sequences. This kind of quartz is quite common in the metamorphic environment of the central Alps, as well as in the surroundings of the Ullafelsen site. It is a very bad material for knapping which was seldom used. 25 artefacts were realized with this material.

2. Rock crystal. This kind of quartz is absent in the surroundings of the Ullafelsen site. It was a material particularly researched for its flaking suitability, even if difficult to find. It grew inside fissures mainly in the inner parts of the whole Alps, along the central axis. Nearby the Ullafelsen site the area with the richest and bigger minerals is the Zillertal Alps, belonging to the Tauern Window, situated 40-50 kilometers est of the site, near the border with Italy. A study confirmed the compatibility of the Ullafelsen artefacts with the minerals of this region even if other provenance areas cannot be excluded (Niedermayr, 2011). 322 artefacts were realized with this material.

Discussion

In early Holocene times probably different Mesolithic groups frequented the site of Ullafelsen. We have the evidences of the passage of people bearing and flaking southern Franconian cherts, distant 200 km or more to the north. The Lower Mesolithic of the Altmühl and Danube river valleys belongs to the South German *Beuronian* lithic tradition. We also have a group of flints coming from northern Italy, around 120 km to the south, where in the lower Mesolithic a different tradition, the *Sauveterrian,* developed. Significant intercultural contacts between the two areas should be taken into consideration.

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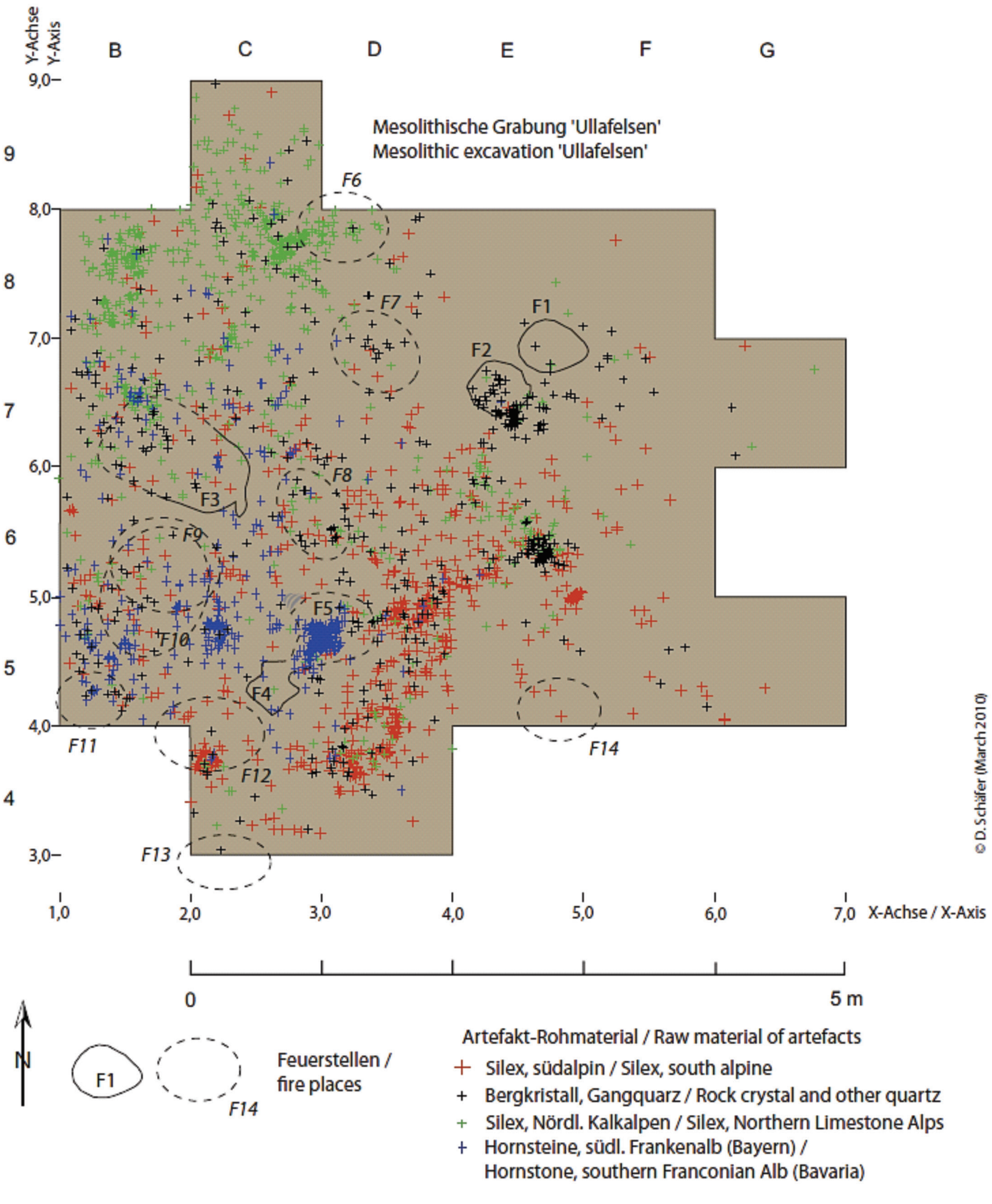


Figure 1 – Spatial distribution of the Ullafelsen different raw materials categories of artefacts. Cretaceous Southern Alps flints: red; Nothern Calcareous Alps cherts: green; Franconian Alb cherts: blue; Central Alps quartz: black (from Schäfer, 2011).

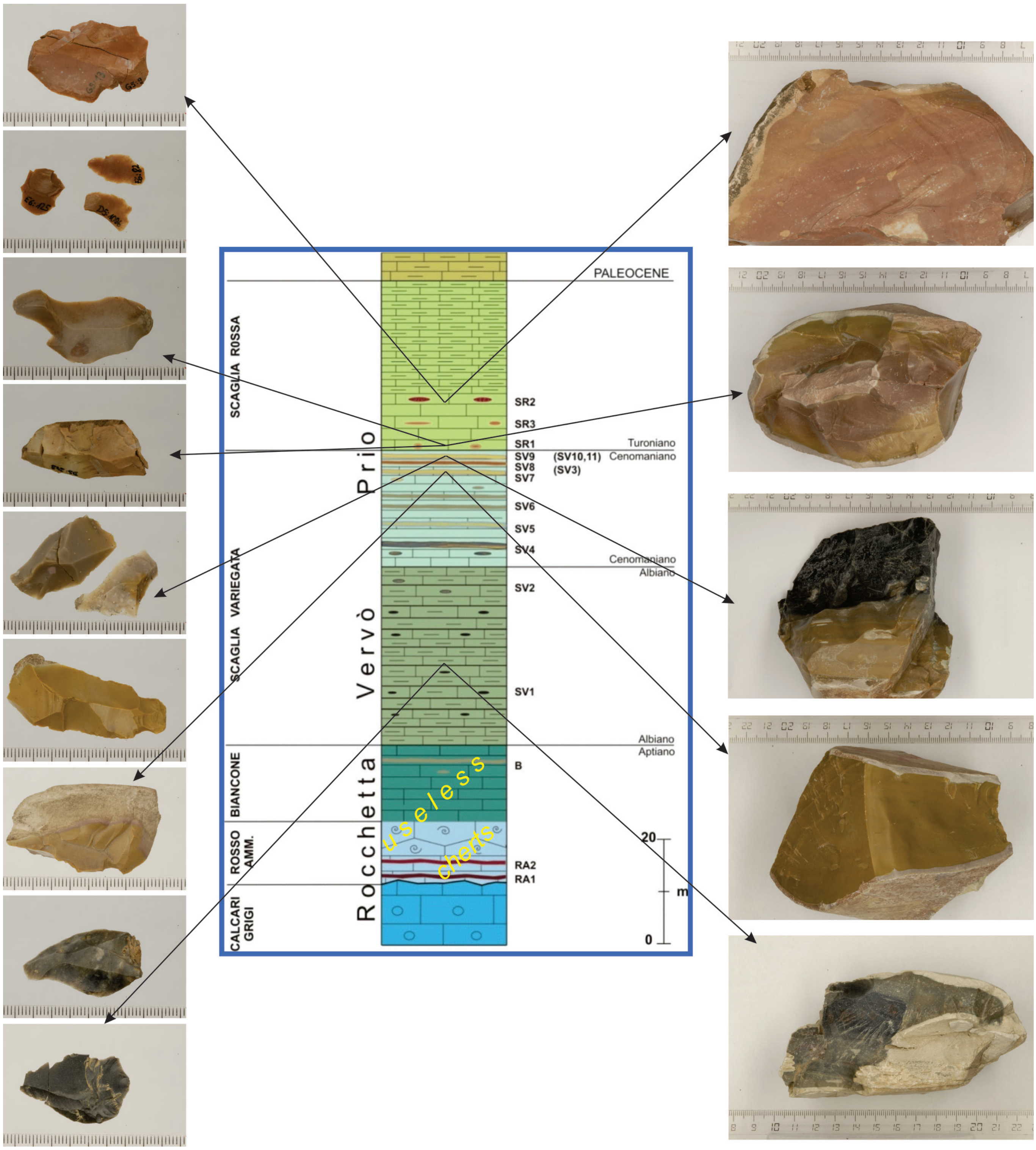


Figure 2 – The Southern Alps (Val di Non) cherts: comparison between geological (right) and archaeological (left) samples.

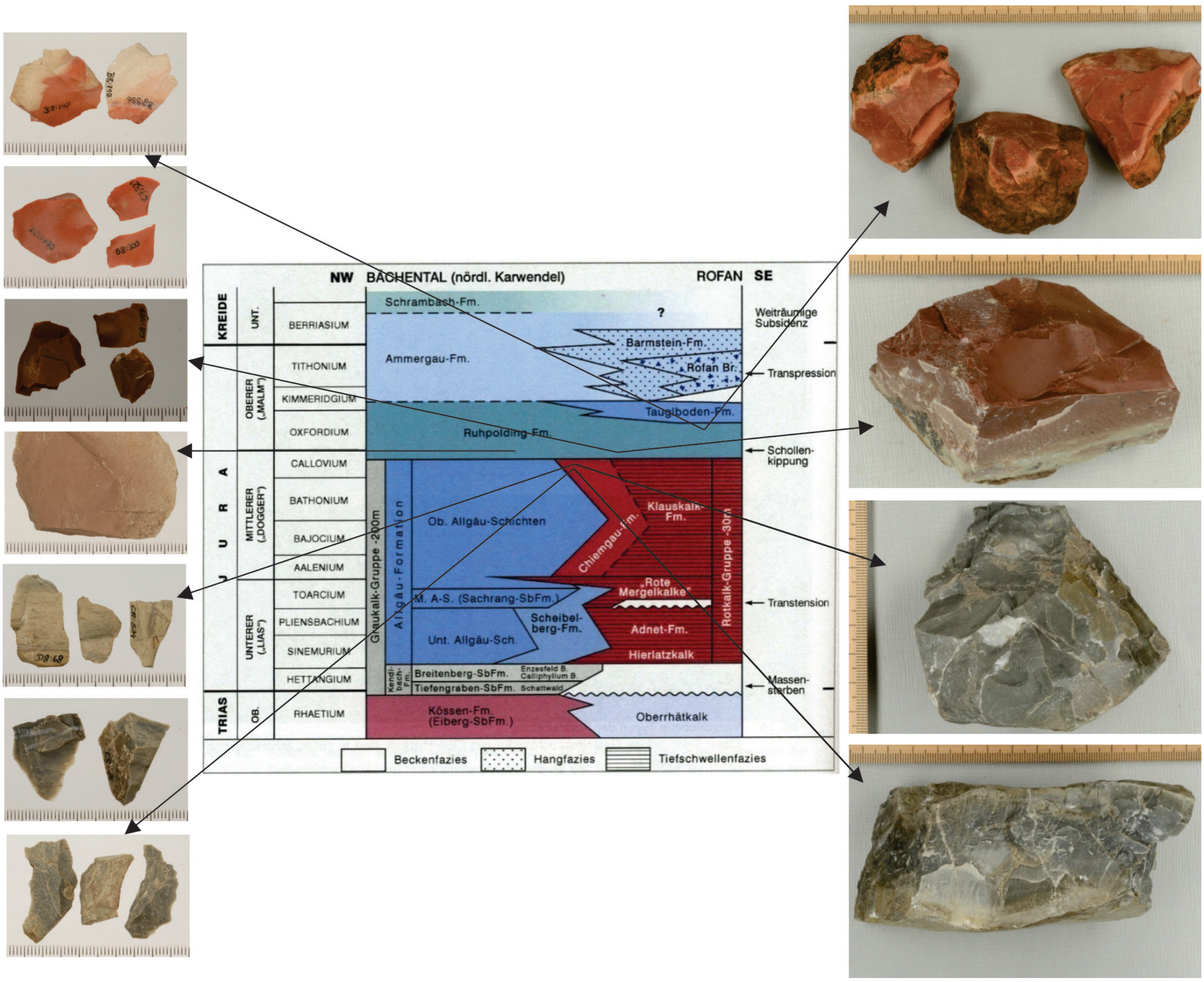


Figure 3 – The Northern Calcareous Alps cherts: comparison between geological (right) and archaeological (left) samples (map from Brandner & Gruber, 2011).

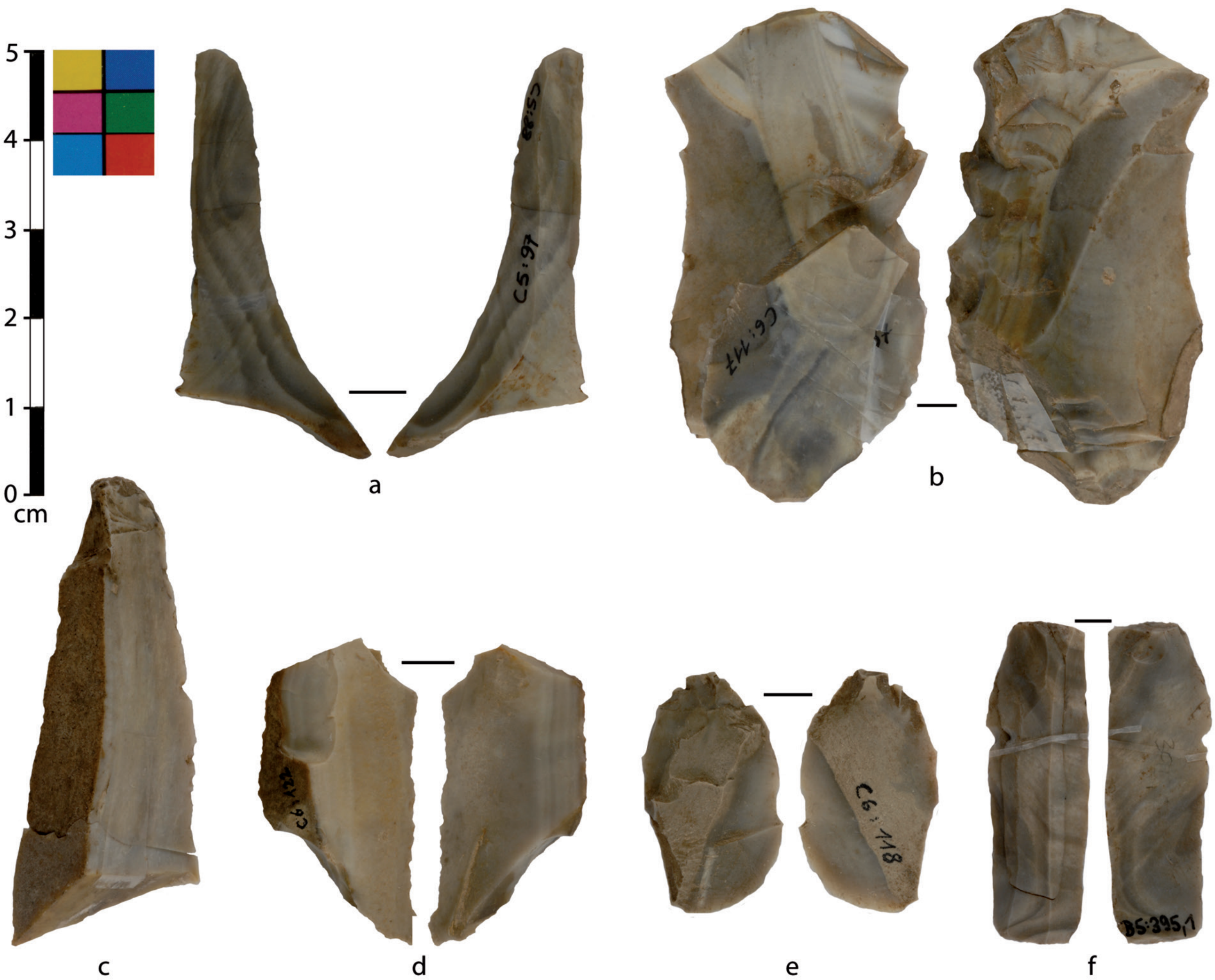
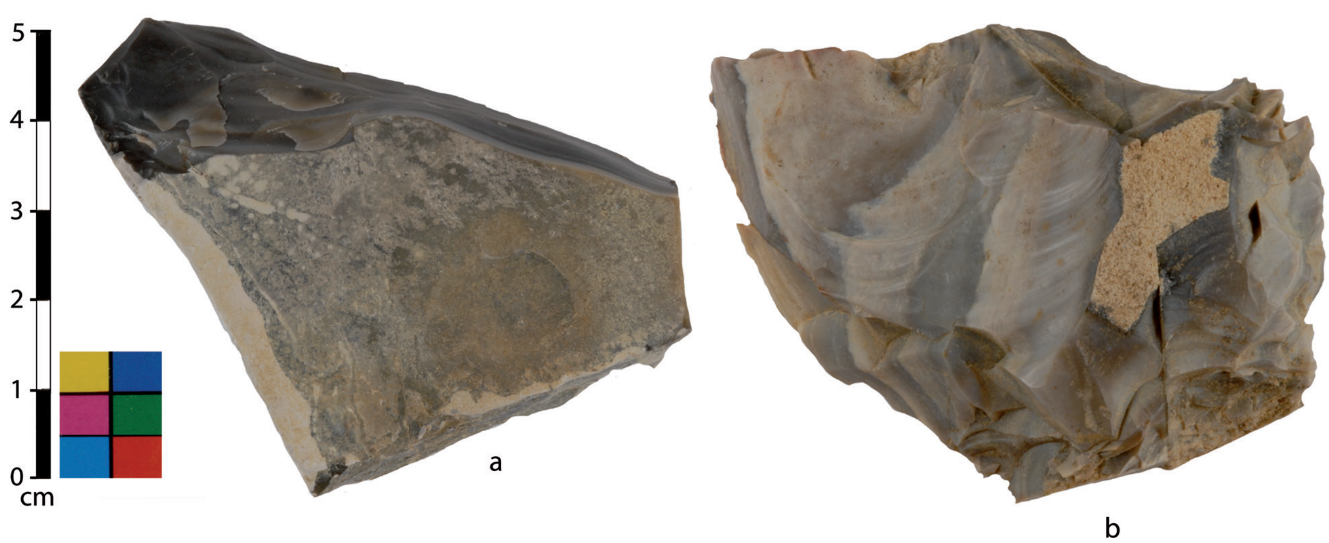


Figure 4 – The Franconian Alb cherts: comparison between geological (bottom) and archaeological group 2 (up) samples (from Bertola & Schäfer, 2011).



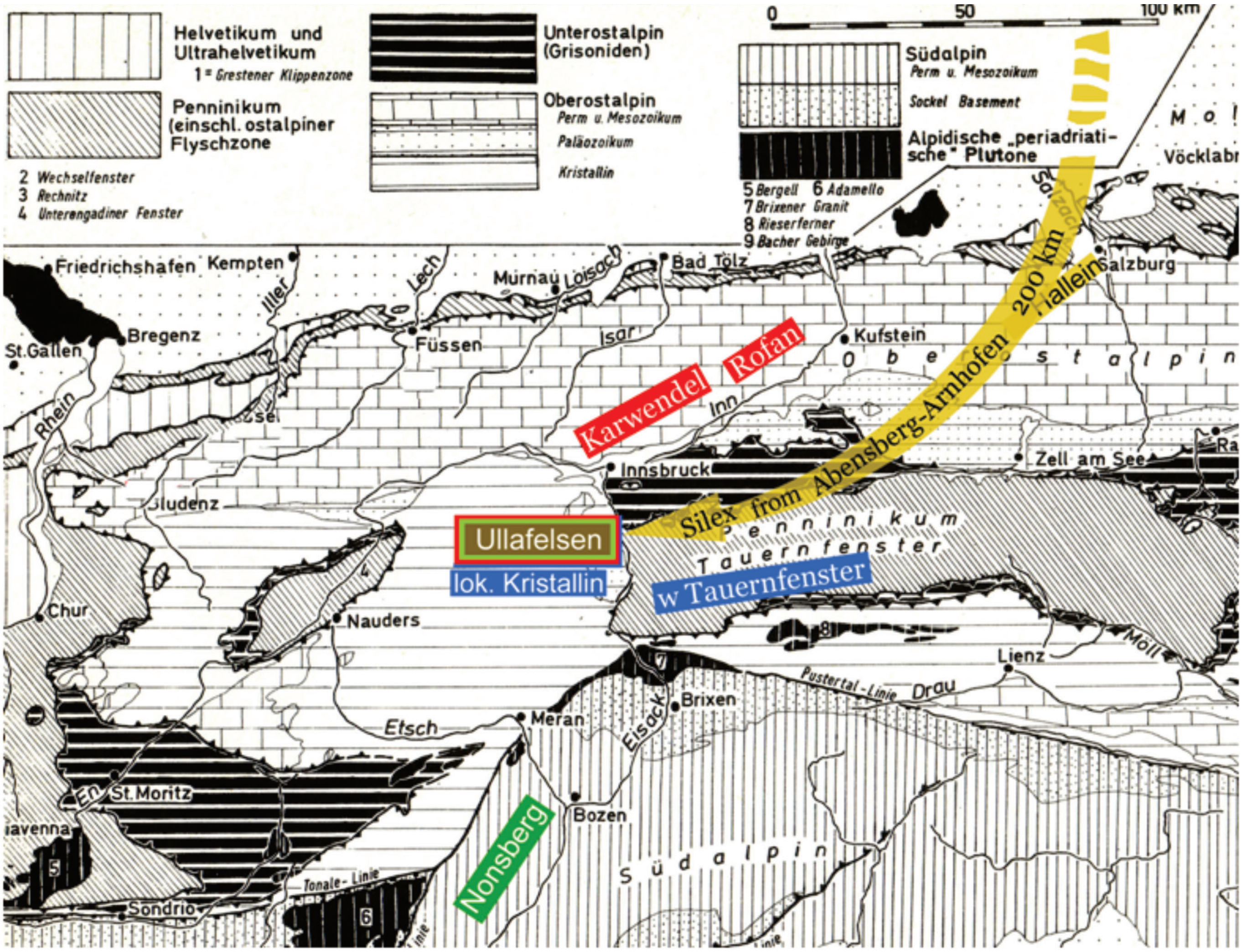


Figure 5 – The Eastern Alps geological context and the localization of the raw material sources of the Ullafelsen artefacts assemblage (map from Gwinner, 1978).

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Lithic raw material exploitation and circulation in Préhistory. A comparative perspective in diverse palaeoenvironments
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2.2. Petroarchaeological research in the Carpathian Basin: methods, results, challenges

Résumé

Cet article passe brièvement en revue les études pétroarchéologiques dans un contexte géologique très spécifique dans le bassin Carpatique (également connu sous le nom de Bassin Pannonien), une région de plaine entourée par de hautes montagnes, les Alpes (côté occidental), les Carpates (au Nord et à l'Est) et les Dinarides (au Sud). Le fleuve Danube traverse cette région grosso modo du Nord-Ouest au Sud Est, reliant par sa voie navigable les Balkans au Nord de l'Europe centrale. Bien que cette région soit formée d'une unité géographique relativement fermée et qu'elle ait été politiquement unie sous le régime des Habsbourg et du royaume de Hongrie, elle est actuellement partagée entre neuf pays. La Hongrie représente la partie centrale du Bassin. Cette situation a également des conséquences sur la recherche pétroarchéologique dans la région. Pour une appréciation adéquate de la provenance et du cheminement de la matière première préhistorique, il ne suffit pas de connaître les sources de matières premières de l'actuelle Hongrie, mais nous devons également connaître le stock de matières premières de l'ensemble du bassin des Carpates, les matériaux de l'ELD, et même au-delà. Cette connaissance a conduit à la base de la méthode pétroarchéologique hongroise, base de données des collections (Biró 2005) adoptée pour les investigations concernant les ressources lithiques depuis le milieu des années '80 (Biró 1986, 1987). Une collection de comparaison de matières premières (Lithotheca, Biró & Dobosi, 1991 ; Biró et al., 2000a) a été développée et maintenue au sein du Département archéologique de l'HNM (Musée National Hongrois), dans un premier temps consacrée aux matières premières principales, puis graduellement étendue aux autres ressources utilisées en Préhistoire. Les échantillons de matières premières collectés à la source sont examinés à l'aide d'analyses variées, principalement des techniques minéralogiques, pétrographiques et géochimiques afin de distinguer les caractéristiques potentielles des sources. Parallèlement à ces études, les matériaux lithiques récoltés dans un contexte archéologique ont d'abord fait l'objet d'études macroscopiques basiques, puis d'études comparatives avec des échantillons de matériaux de la « Lithotheca ». Certains échantillons sélectionnés des matériaux archéologiques sont analysés par des méthodes plus poussées, occasionnant des destructions minimes à l'objet en utilisant des techniques testées sur des échantillons de matières premières de références et pétrographiquement caractéristiques. C'est un long processus, nous pourrions même dire, une étude sans fin. Cet article a pour but de présenter un rapport faisant le point des résultats et des travaux actuels à ce sujet.

Abstract

This paper gives a short review on petroarchaeological studies in a very specific geographical setting, the Carpathian Basin (also known as Pannonian Basin), a mainly lowland area surrounded by high mountains, the Alps (on the Western side), the Carpathians (on the North and East) and the Dinarides (on the South). The river Danube transects the area roughly, from NW to SE, connecting by its huge waterway the Balkans to North-Central Europe. Though this area forms a relatively closed geographical unit and had been politically united under, e.g., Hapsburg reign and the Hungarian Crown, it is currently divided between, for the time being, nine countries. Hungary is spreading over the central part of the basin. This situation has its consequences also on the petroarchaeological research of the area; it is not enough to know sources and raw materials within present-day Hungary but, for an adequate assessment of prehistoric raw material procurement systems and trade connections, we also have to know the raw material stock of the complete Carpathian Basin and in case of ELD materials, even beyond that. This recognition has lead to the basic method of Hungarian petroarchaeology, the collection and database approach (Biró 2005) adopted for the investigation of lithic resources since the mid-eighties (Biró ed. 1986, 1987).A comparative raw material collection (Lithotheca; Biró & Dobosi 1991, Biró et al. 2000a) was founded and maintained within the Archaeological Department of the HNM, first on chipped stone raw materials mainly; then, gradually extended over other lithic resources used in prehistory. The source-collected raw material samples are examined by various analytical, mainly mineralogical/petrographical and geochemical techniques to investigate potentials of source characterisation among them. Parallel to this, the lithic finds recovered from archaeological context are also studied, macroscopically as a basic approach and compared to the samples in the Lithotheca. On selected samples from archaeological context, further analytical studies are performed, taking into consideration minimal destruction to the object and using techniques tested on potential raw material samples that may contribute to effective petroarchaeological characterisation. This is a long, we may say, never ending process. The current paper is intended to give a state-of-art report on the results and actual tasks on the subject.

Keywords: Petroarchaeology, Lithotheca, Chipped stone artefacts, Polished stone artefacts, Quernstones

1 – Introduction

Our prehistoric ancestors had an excellent practical knowledge on their physical environment and the specific qualities of the raw materials they utilised in their everyday life. The knowledge on the source areas and basic techniques for extracting, processing and using the optimal materials was one of the basic elements of the community lore. Investigating the material heritage of prehistoric people therefore should also deal with these mineral resources, whether they are used in modern industries or not. Apart from basic problems of early technologies they may also highlight movements and contacts of prehistoric people and have important indications on the structure and operation of prehistoric societies.

2 – Research history

The need for investigating and analysing lithic raw materials as a source of historical information was raised first in Hungary by Flóris Rómer, "father of Hungarian archaeology" (Rómer 1866). He himself worked together with prominent geologists of his age, in the first place, József Szabó, also pioneering excellent figure of his discipline. Geologists, geoscientists had an important role in establishing Palaeolithic studies in Hungary and provided the natural scientific background for the finds, among them, the stone artefacts proper. Starting from the first monographs on Hungarian Palaeolithic (Kormos 1912 (Tata), Kadić 1915 (Miskolc-Szeleta cave)) the analysis of the raw material of the stone tools was an essential component in the scientific description of the lithic inventory. Especially noteworthy in this respect was the contribution of A. Vendl, especially for sites and lithic assemblages of the Bükk Mts. (Vendl 1930, 1933, 1935) (Fig. 1) .Vendl also contributed to the study of the Subalyuk monograph (Vendl 1939).

This positive tradition was kept in more recent works on Palaeolithic sites, e.g. the site monograph of Tata (Vértes ed. 1964, petroarchaeological chapter by Végh & Viczián 1964); Érd (Gábori-Csánk ed. 1968, petroarchaeological chapter by Dienes 1968) and

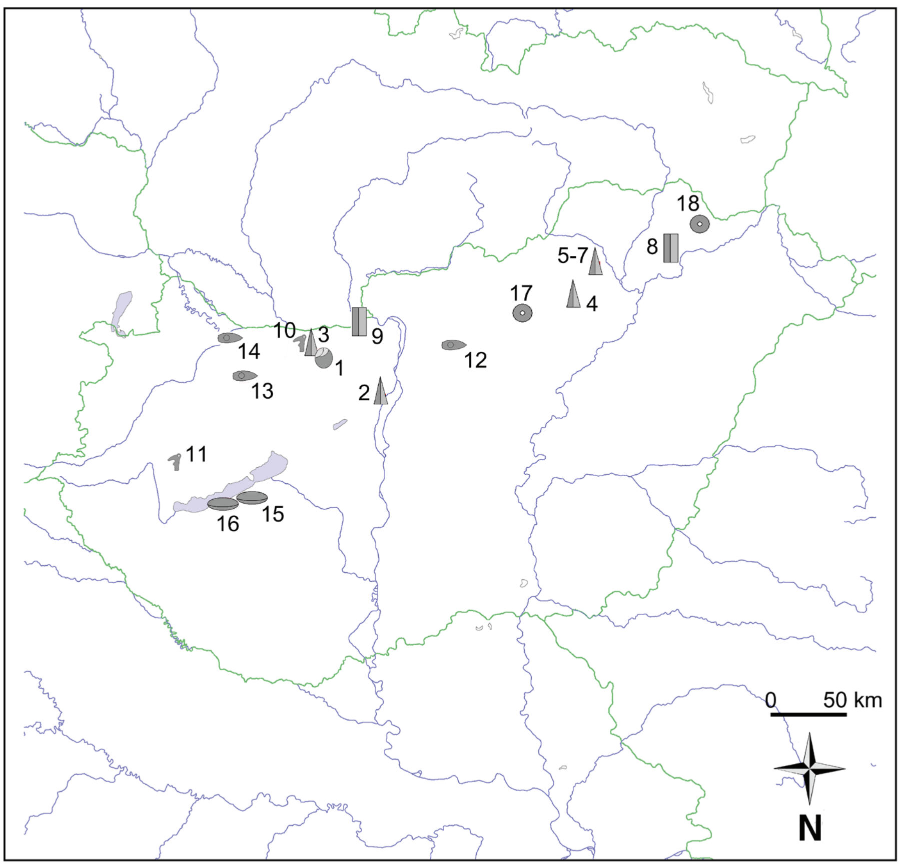


Figure 1
Map of sites mentioned in the text.

Key:
Palaeolithic sites: 1, Vértesszőlős-Limestone quarry LP; 2, Érd-Parkváros MP; 3,Tata-Porhanyó quarry MP; 4, Cserépfalu-Subalyuk cave MP; 5, Miskolc-Sólyomkút cave MP; 6, Miskolc-Büdöspest cave MP; 7, Miskolc-Szeleta cave EUP; 8, Bodrogkeresztúr-Henye UP; 9, Esztergom-Gyurgyalag UP;
Flint mines: 10, Tata-Kálváriadomb FQ, 11, Sümeg-Mogyorósdomb FQ;
Neolithic and more recent sites: 12, Aszód-Papi földek N; 13, Bakonypéterd N, 14, Gyirmót-Sugárkő N; 15, Balatonszemes N; 16, Balatonlelle CA, 17, Domoszló-Pipis MQ; 18, Sárospatak-Megyer hegy MQ

Vértesszőlős (Kretzoi & Dobosi eds. 1990, petroarchaeological chapter by V. Máthé 1990). In the meantime, an initiative to properly identify and characterise raw material types was published (Dobosi 1978, in collaboration with L. Ravasz-Baranyai).

These sites and monographs concentrated mainly on Middle Palaeolithic (in the case of Vértesszőlős, Lower Palaeolithic) assemblages and the petroarchaeological study could demonstrate basically local raw material basis and supply.

The most recent Palaeolithic monograph (on the Upper Palaeolithic site Bodrogkeresztúr-Henye, Dobosi ed. 2000) comprised, apart from the archaeologists' raw material classifications, two petroarchaeological chapters on instrumental analytical basis, one by FTD and NAA of obsidians and one on geochemical study (PIXE-PIGE) of some siliceous raw materials from the site. (Biró *et al.,* 2000b, 2000c).

Unfortunately, the interest apparent in Palaeolithic petroarchaeology did not extend to the vestiges of more recent archaeological periods, including the "pottery" phases of prehistory. With the exception of a few prominent raw materials, esp. obsidian the general knowledge on lithic resources was very poor (Patay 1976, Lech 1981).

In the 1980-ies, raw material research efforts of the Hungarian Geological Institute under the auspices of J. Fülöp essentially promoted petroarchaeological studies.

The immediate results were (1) a diachronical survey of raw material use and processing from prehistory till modern times (Fülöp 1984); (2) a summary of existing petroarchaeological efforts (Biró 1984a); mapping and collecting Hungarian sources of chipped stone raw materials (Biró 1984b, 1986) international conference on the subject (Biró ed. 1986, 1987) (3) and finally, the establishment of the comparative collection of lithic resources in the Hungarian National Museum (Lithotheca; Biró & Dobosi 1991, Biró *et al.,* 2000a).

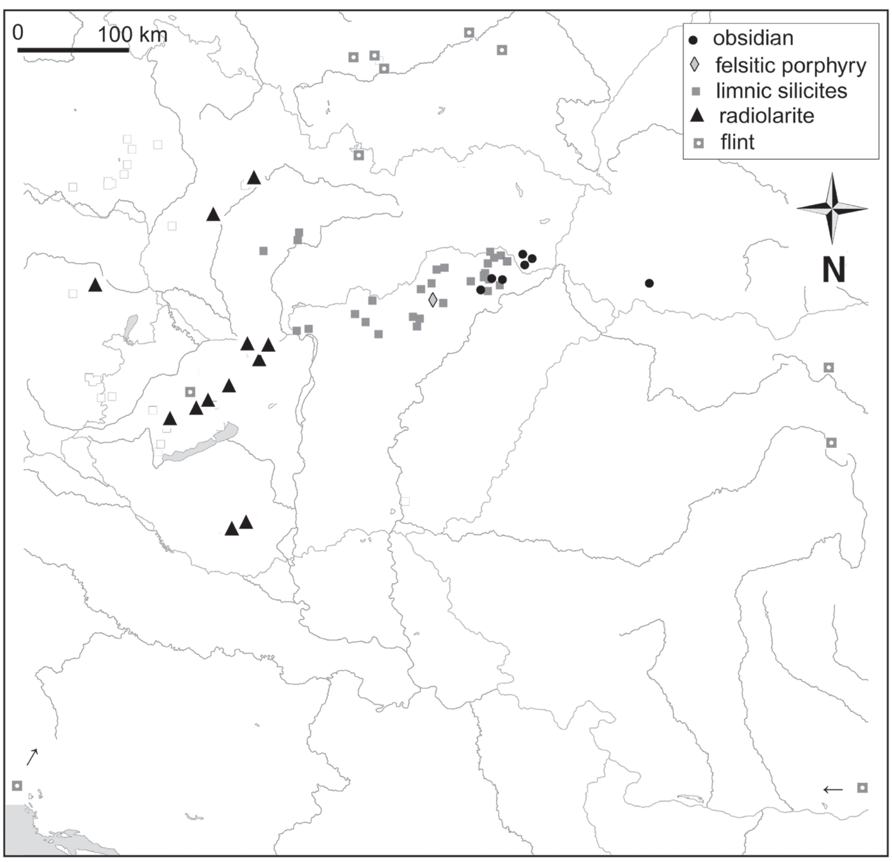


Figure 2
Map of raw material sources mentioned in the text

Key: included on the graph

After the establishment of this basic tool for research, we had several important projects, step-by-step increasing our knowledge on sources and sites (Fig. 2).

3 – Chipped stone tool raw materials

In the first run, chipped stone raw materials were investigated mainly. This is partly due to chronological and practical issues (the most important and numerous fraction of lithics is undoubtedly chipped stone tools) but also reflected on 'flint mining' research evolving with great pace from the 1960-ies (Vértes 1964, Fülöp 1973, Weisgerber 1980). Some elements of the chipped stone raw material stock served as basis of classical petroarchaeological and archaeometrical studies like obsidian (Roska 1934), Polish flint from the Holy Cross Mts. (at the Sólyomkút cave near Miskolc; Vértes 1960), "Quartzporphyr" (in modern terminology, felsitic meta-rhyolite; Vértes-Tóth 1963, Dobosi 1978). Developing techniques of fingerprinting and characterisation was systematically applied with an emphasis of non-destructive techniques (Biró & Pálosi 1986, Biró 1988a, Biró *et al.,* 1986, Biró *et al.,* 2000b, 2000c, Markó *et al.,* 2003, Kasztovszky *et al.,* 2008 etc.)

Distribution studies on characteristic raw materials were published: on obsidian (Biró 1981, 1984c; Dobosi 2011, also current paper by Biró in this volume) supported by various analytical studies like EDS-XRF (Biró *et al.,* 1986, Biró *et al.,* 1988), FTD (Biró *et al.,* 2000b) PIXE-PIGE Biró *et al.,* 2000c) or PGAA (Kasztovszky & Biró 2004, 2006, Kasztovszky *et al.,* 2008 etc.); rock crystal (Dobosi & Gatter 1996) and Szeletian felsitic porphyry (Markó *et al.,* 2003). These raw materials are fairly unique and can be efficiently characterised on the level of individual source or source region (Fig. 2.)

Considerable effort was made to characterise flint (Kasztovszky *et al.,* 2005, 2008, Biró *et al.,* 2009a), radiolarite (Biró *et al.,* 2002) and hydrothermal-limnic silicites (Szekszárdi 2005, Szekszárdi *et al.,* 2010). Flint varieties coming from outside the Carpathian Basin (mainly from the areas to the North and East of the Carpathian Mts.) are important element of the Hungarian ELD materials since the Palaeolithic times (e.g., Esztergom-Gyurgyalag, Dobosi & Kövecses-Varga 1991) and became abundant by the Late Neolithic and the Copper Age in the Eastern parts of the country (Biró 1998a, b). Radiolarite is the basic supply for the areas to the West of the Danube and we have to consider interaction zones between various mountain ranges which are historically very important. The most recent analytical considerations on the subjects were published in the framework of a Hungarian – Croatian collaboration project (Biró *et al.,* 2009, Halamić & Šošić-Klindžić 2009). Limnic silicites offer a different problematic, both analytical and terminological ones (Szekszárdi *et al.,* 2010, Biró 2010). They are the "home" raw materials for the Eastern part of Hungary, occurring in many outcrops along the foothill regions of the North-Hungarian Mid-Mountain range. The can be very varied, even at the same source, from mineralogical and physical aspects and their procurement required special skills on behalf of the knapper.

Petrographical thin sections were made on source collected as well as archaeological materials to characterise the main raw material types. (Fig. 3).

These latter raw materials, however, are more difficult to characterise and especially to separate by analytical methods, therefore we still use macroscopic "phenotypes" in distribution studies (Biró 1988b, 1998a, 1998b). On the basis of these macroscopic type groups, basic petroarchaeological characterisation of cca. 600 sites has been accomplished, from Palaeolithic to Late Prehistoric times. Currently the following "phenotypes" are separated on macroscopic level, with more or less relevance to distinguishing the sources proper:

A – Obsidian

- *Carpathian 1* (Slovakian) type
- *Carpathian 2* (Hungarian) type
- *Carpathian 3* (Ukrainian) type from Transcarpathian Ukraine

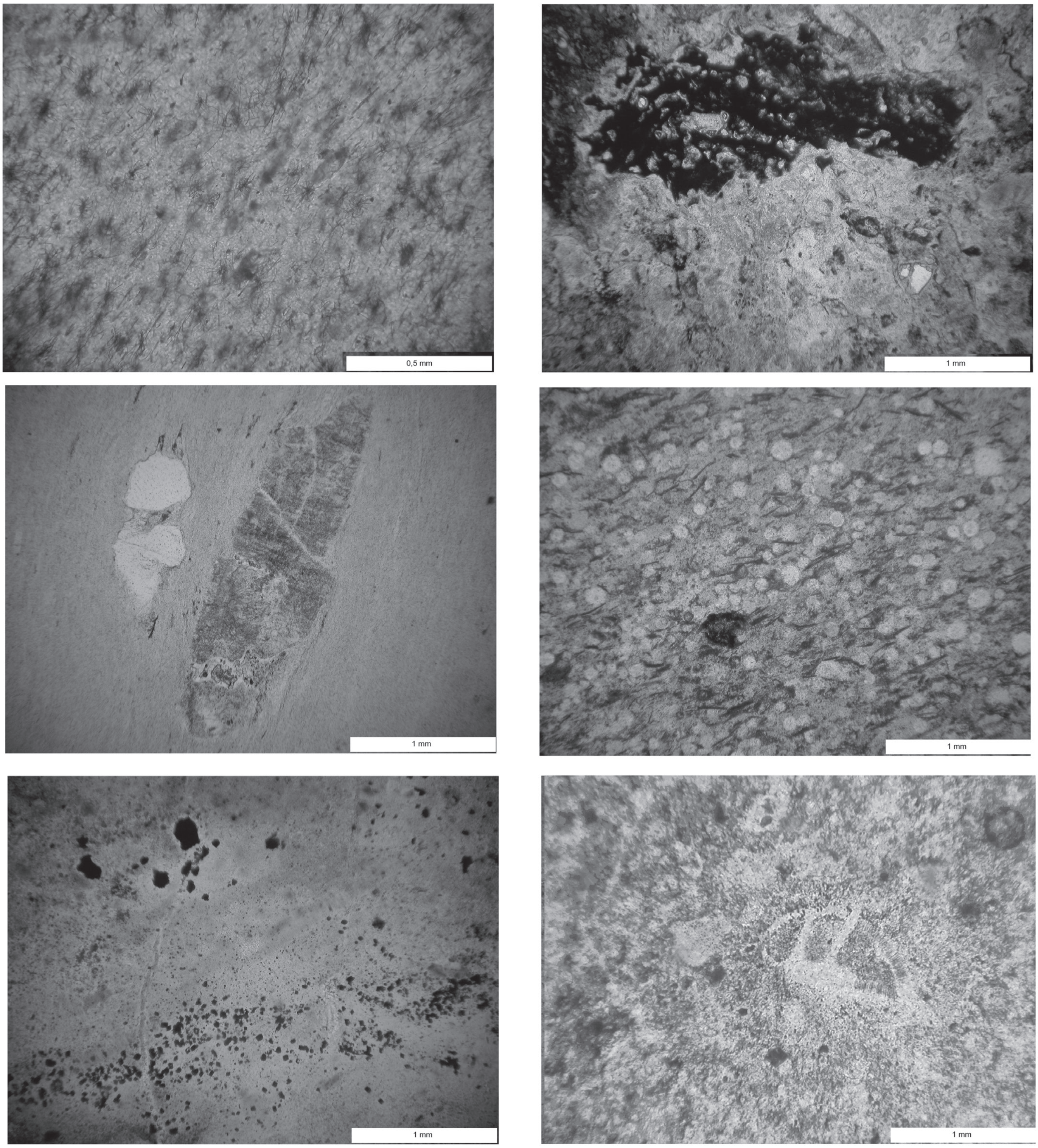


Figure 3 – Main types of chipped stone raw materials in petrographical thin section

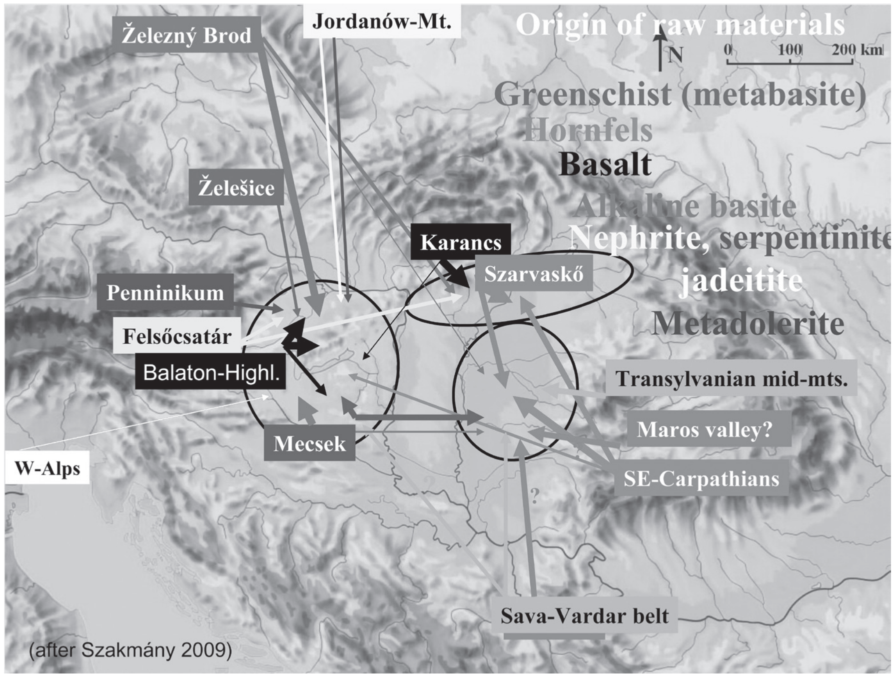
1, obsidian (Bodrogzsadány, AS); 2, limnic opal (Mátraháza, GS); 3, Szeletian felsitic porphyry (Bükkszentlászló, GS); 4, radiolarite (Lábatlan, GS); 5, limnic quartzite (Miskolc-Avas, GS+AS); 6, flint (Aszód, AS). All photos taken with 1Nikol, with 5x or 10x objectives. Scale provided on the images.

All types seem to have sub-types on the basis of macroscopic features and geochemical data. More is explained on the research of Carpathian obsidians in a separate paper in the same volume.

B – Radiolarite

Phenotypes can be separated geographically by mountains (e.g., *Mecsek radiolarite*, *Bakony radiolarite*, *Gerecse radiolarite*), find spot (*Vienna-Mauer radiolarite*) or wider region (*Carpathian radiolarite*) and colour varieties (e.g., *Szentgál radiolarite* – red Bakony radiolarites, *Úrkút-Eplény radiolarite* – mustard-yellow variant, also from the Bakony sources, *Hárskút radiolarite* – dark brown radiolarite with orange tint. Without exactly knowing the sources, on the border regions we can come across "foreign" radiolarites,

Figure 4
Raw material provinces and inflow of polished stone tool raw materials, after Szakmány 2009



probably coming from Transylvania (Maros valley), Croatia and Bosnia. These siliceous raw materials are often described as "jasper". Unification of terminology and a better knowledge of the actual sources is very important for future research.

C – Limnic and hydrothermal silicites

Limnic and hydrothermal silicites is for another large and significant group. They are extremely varied even on one source and can be very similar over large distances. Special types which can be separated with some hope of provenancing relevance include *light colour variegated Mátra limnic quartzite*, *Mátraháza-Sombokor type limnic opal* with quartz grains – fairly common along the southern fringes of the Mátra and Bükk Mountains. Tokaj limnic quartzites are especially abundant and can be more or less identified as coming from the Southern or the Northern sources of the Tokaj Mts. A point-like special variety is "*stone marrow*" (=kővelő), a hydroquartzite with high kaolinite content, basic raw material of the Bodrogkeresztúr UP site. Close to the "stone marrow" outcrops, another very characteristic hydrothermal silex can be observed with light grey stripes, often coloured with light yellow stripes as well. This source is located in the confines of Mád towards Mezőzombor, and was periodically very popular, especially in the Late Neolithic and the first half of the Copper Age.

D – Szeletian felsitic porphyry

This is a prominent raw material of the Hungarian Palaeolithic, especially the leaf-point producing industries of the Bükk Mts. and further on in the North-Hungarian Mid-Mountain range. Its popularity ended with the Palaeolithic and in more recent times we can mainly find occasional reworked pieces on some Neolithic sites.

E – Hornstone

Hornstone is a special term used mainly by Central European (German tradition) research. Anglo-Saxon terminology would call it chert. It is of sedimentary origin, typically of grey, "horn-like" appearance (hence the name, Hornstein (=szarukő). It was mainly popular as local raw material in the Palaeolithic, several regional varieties can be separated mainly on geographical arguments (*Buda hornstone*, *Bükk hornstone* and hornstone from the Balaton highlands and the Keszthely Mts.) Buda hornstone has seemingly two peaks of utilisation, in the Middle Palaeolithic (Dienes 1968) and later in the metal ages, most probably upgraded by heat treatment (Biró 2002).

Figure 5
Jadeite and nephrite artefacts from the Ebenhöch collection of the Hungarian National Museum

Top row: jadeite chisel-blade,
HNM 300/876.264. Locality: Bakonypéterd
Bottom row: nephrite chisel,
HNM 300/876.248. Locality: Gyirmót-Sugárkő

F – Flint

Flint in geological context means a young marine shallow water sedimentary rock. In this strict sense, in Hungary we have only one source at Nagytevel, West-Central Transdanubia, named *Tevel flint*. This raw material was preferentially used in the Neolithic period mainly.

Even more important, a lot of ELD flint types appeared in the central parts of the Carpathian Basin, starting from the Palaeolithic times. Among them we can find well-known Polish flint varieties like Jurassic Cracow flint, Chocolate flint, Volhynian flint and from Eastern Romania, Prut flint. From the south-east, two macroscopic phenotypes have been identified, the so-called Balkan and the Banat flint. Recent petroarchaeological studies (Biagi & Starnini 2013) suggested that the source region for both types can be the same on the lower reaches of the river Danube. Also fairly recently, high quality siliceous raw material from South-Western origin, so-called Lessini flint was found at SW Hungarian archaeological sites (Biró 2006).

G – Rock crystal

Among the special high-prestige materials occurring rarely in the lithic inventories, we can mention (Alpine) rock crystal. So far, stone tools made of this material were located on Palaeolithic sites only.

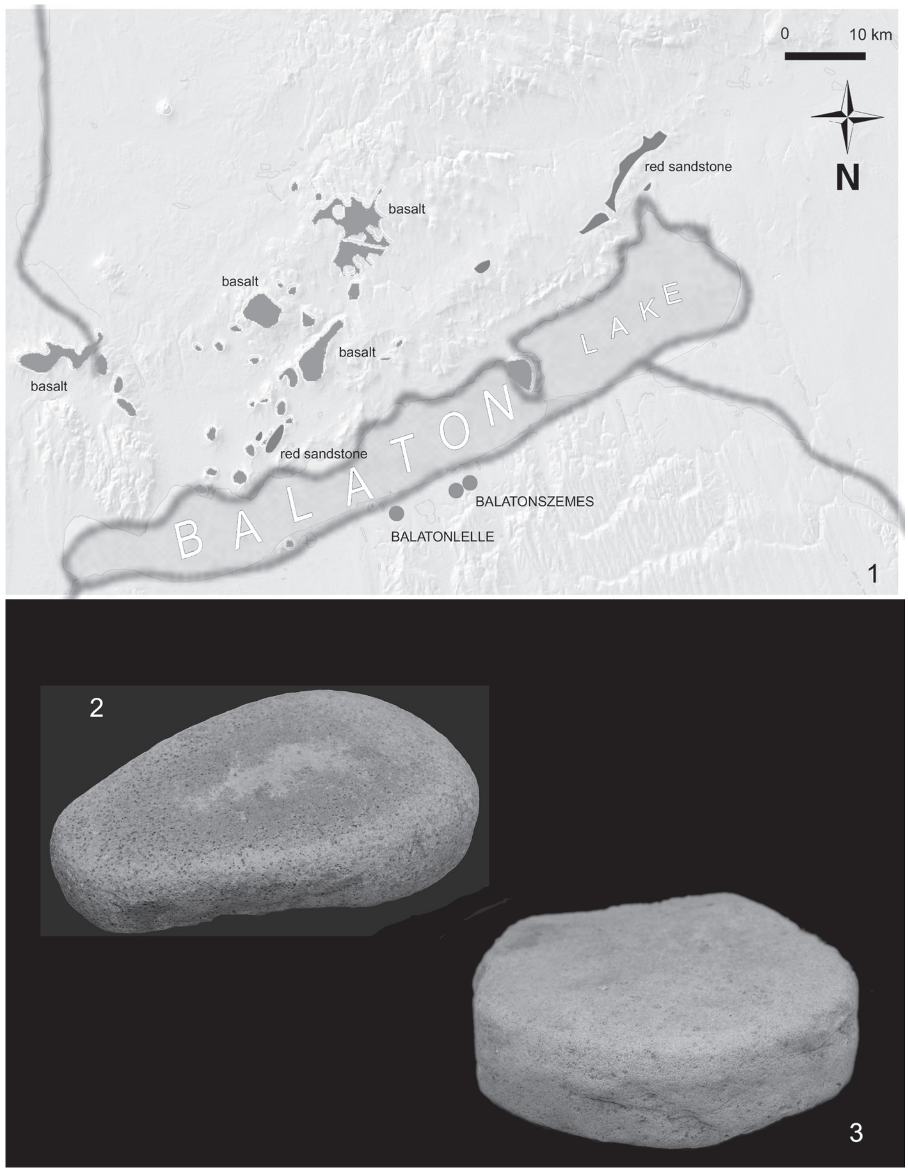


Figure 6
Large quernstones made of red sandstone and basalt tuff from Balatonszemes, transported across Lake Balaton in Early Neolithic context

1. Outline map of the area with sources of red sandstone and basalt on the Northern side of the lake Balaton; sites with giant quernstones on the Southern shore;
2. Quernstone made of basalt tuff from Balatonszemes, approx. 60 kg;
3. Quernstone made of red sandstone from Balatonszemes, approx. 80 kg.

This list is naturally incomplete, especially local resources were not listed completely.

4 – Polished stone tool raw materials

The investigation of polished stone tools and their raw material started considerably later. This group of tools has an essentially shorter time span and much less overall quantities are involved; nevertheless, polished stone artefacts (axes, chisel-blades etc.) had a high prestige in the ancient societies due to their often distant and specific, rare raw materials and the considerable amount of labour invested in them, therefore their potentials in tracing movements of peoples can be even more important (e.g., Western Alpine jadeite; Petrequin *et al.,* 2008).

Although the necessity of petrographically investigating polished stone artefacts was raised already by Rómer (1866); we made the first steps in this direction only by the second half of the 1990-ies (Szakmány & Starnini 1996, Biró 1998c, Biró & Szakmány 2000). An essential impetus was supplied by the UNESCO project IGCP-442 (http://www.ace.hu/igcp442/), resulting in the identification of the most important local and imported polished stone raw materials and their characteristics in Hungary (Szakmány 2009, Szakmány *et al.,* 2011). In this process, large collections of stray finds obtained by museums, e.g., the Miháldy-collection (Horváth 2001, Szakmány *et al.,* 2001, Füri

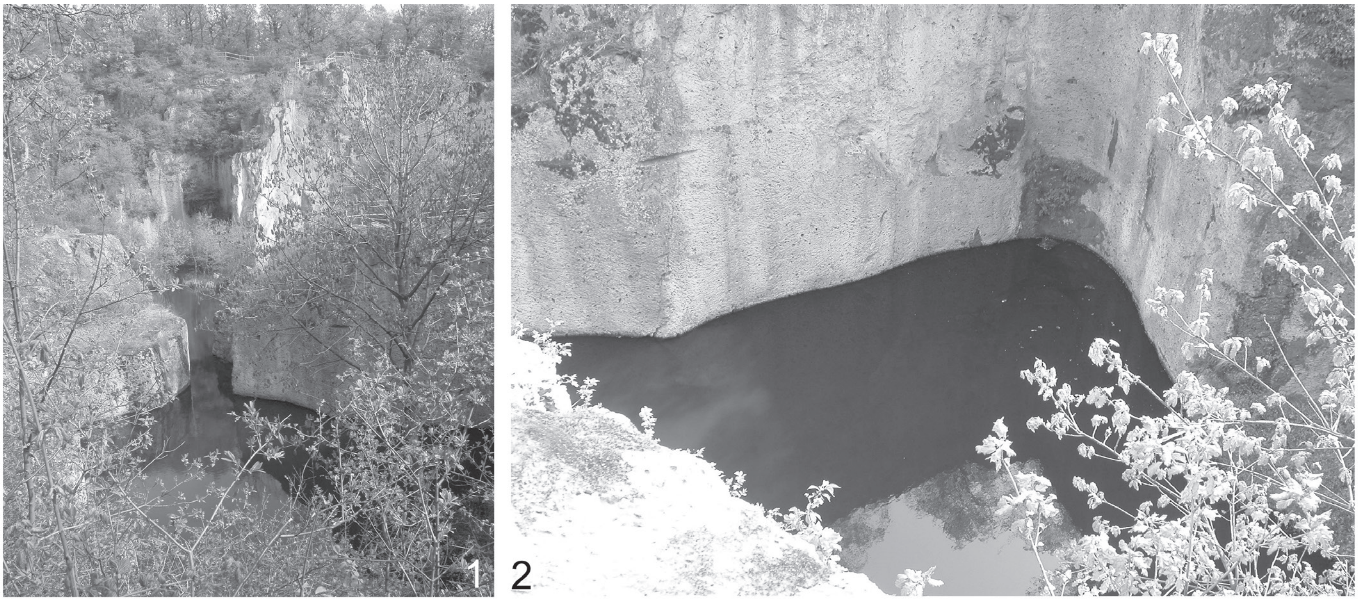


Figure 7
Mediaeval millstone quarry (hydroquartzite) on Sárospatak-Megyer hill;

1. overview of the quarry; 2. traces of extraction of millstones on the quarry walls

& Szakmány 2004) and the Ebenhöch-collection (Friedel *et al.,* 2008, 2011) and more recently, a major private collection from Diósviszló (Oláh *et al.,* 2013) helped us to identify basic raw materials used for polished stone axes in Hungary. Specific study was dedicated to polished stone axes with context from the HNM; as a result, provinces of similar supply patterns were identified. (Oravecz & Józsa 2004, 2005). The most important raw materials for polished stone axes involve local/regional basalt and basaltic andesite, greenschist from Western Hungary, blueshist from eastern Slovakia, gabbroidal rocks from various origin and long distance elements: greenschist/ metabasite, hornfels and serpentinite (Fig.4). Currently we are involved in fingerprinting and analysing special long distance raw materials (ELD) in Hungary like jadeite, nephrite and hornfels (analyses in progress; Szakmány *et al.,* 2013, Péterdi in press (Fig.5). We are currently connected to the large EU project Jade2 as well (JADE 1, 2).

5 – Other lithic utensils

The most recent branch of petroarchaeological investigation is directed towards a group of artefacts that was formerly neglected in any respect. We summarise them under the loose category "other stone utensils" covering grinding stones, polishers, hammerstones etc. and also a number of 'manuport' lithics on the archaeological site where we cannot find a direct and evident use or purpose for the item. These artefacts are typically of local origin and represent a large mass to carry and to collect. The first site where 'other stone utensils' were investigated in integrated system with the chipped and polished stone tools is the Late Neolithic site Aszód-Papi földek (approx. 7500 BP), (Biró 1992, 1998a; currently in preparation for the Aszód site monograph). Recently, more and more sites, especially those of large surface preventive excavations produce tons of 'stone utensils'. Their investigation offers a lot of interesting details on the life and choices of prehistoric people (Péterdi *et al.,* 2011, Biró & Péterdi 2011, Szakmány & Nagy-Szabó 2011 etc.). The most spectacular items among this category are quernstones and millstones. They are often multi-functional tools in the sense that apart from grinding cereals they could be used for other purposes like powdering pigments and polishing other artefacts made of stone, bone/antler and even metal. Large and heavy items were transported from the sources across the water, e.g., in the case of the southern shore of Lake Balaton where grinding stones over 50 kg each, made of a specific sandstone (so-called Permian red sandstone) and basalt tuff, both from the Balaton Highland (Biró & Markó 2007) (Fig.6). Intensive research of historical stone quarries resulted in the location of quernstone and millstone quarries in the Tokaj and Mátra Mts., respectively (Fig. 7; Fig. 8.).

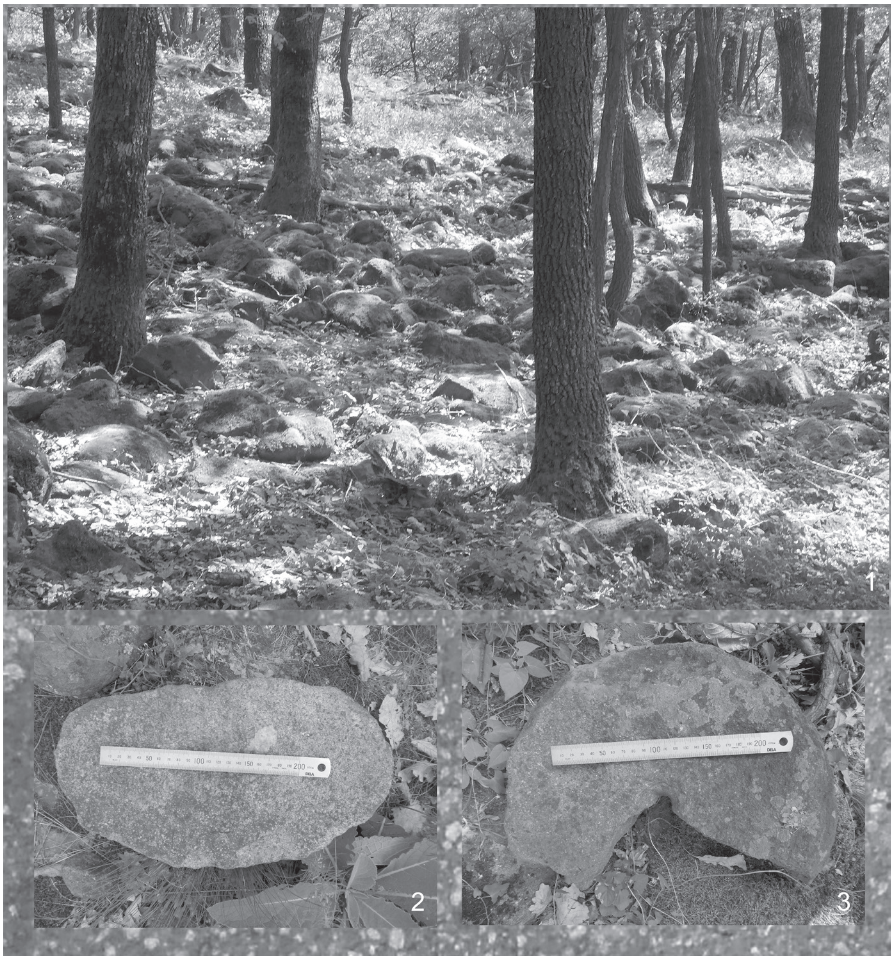


Figure 8
Quernstone/millstone quarry and workshop in the Mátra Mts.)

1. Boulders of andesite of suitable size spread over the Domoszló-Pipis hillside
2. Prehistoric „style" quernstone at the Domoszló-Pipis exploitation site
3. Millstone at the Domoszló-Pipis exploitation site

6 – Conclusions

Petroarchaeological research evolved throughout the past decades into a strong and disciplinarily well established branch of interdisciplinary sciences offering essential help for archaeological and historical studies. The basic methodology involves an extended and representative comparative collection, systematical field surveys on potential source regions, parallel survey of archaeological lithic assemblages and thematical analyses of specific groups of reference materials with archaeological sample sets.

Abbreviations used in the text

AS	Archaeological site (on Fig. 3.)
EDS	Energy Dispersive Spectrometry
ELD	Extra-Long-Distance
GS	Geological source (on Fig. 3.)
HNM	Hungarian National Museum
LD	Long-Distance
PGAA	Prompt Gamma Activation Analysis
PIXE-PIGE	Proton Induced X-Ray Spectrometry
PIXE-PIGE	Proton Induced Gamma Spectrometry
XRD	X-Ray Diffraction Analysis
XRF	X-Ray Fluorescence Spectrometry

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2.3. Obsidian outcrops in ukrainian transcarpathians and their use during the Paleolithic time

Résumé

Nous connaissons encore mal les artefacts d'obsidienne trouvés à l'Age de la pierre en Ukraine et leur origine est mal comprise. Les principales sources d'obsidiennes se trouvent dans les montagnes volcaniques des Carpates, en Crimée et dans le Caucase. En l'état actuel de nos connaissances, il n'existe d'affleurements d'obsidiennes que dans la région volcanique de Transcarpathie, en Ukraine.

Les affleurements d'obsidiennes de la région de Transcarpathie sont uniquement connus à proximité de Velykyi Sholes (à côté des villages de Rokosovo et Mariyj Rakovets). Les recherches, en collaboration récente, ont mis en évidence la présence d'obsidienne locale. Les données obtenues par les méthodes XRF et NAA indiquent que l'obsidienne ukrainienne peut être chimiquement distinguée d'obsidiennes provenant d'autres régions des Carpates et suggèrent que le matériau ukrainien est caractérisé par une homogénéité dans la composition chimique et appartient à la catégorie 3 du type des sources d'obsidienne des Carpates (Rosania et al., 2008). Le site de Mariyj Rakovets IV est situé dans une région de volcans éteints de l'ère Néogène. Les habitants paléolithiques de ce site avaient intensivement employé des roches en obsidienne formées à la surface lors de l'éruption. Les couches archéologiques peuvent être séparées en 3 ensembles dans le contexte stratigraphique : le Paléolithique ancien (VII, VI, V), moyen (IV, III, II), et supérieur (I). Il n'existe pratiquement pas d'obsidienne d'origine locale à proximité du site de Mariyj Rakovets IV. Les affleurements les plus proches sont situés à une distance de 2 kilomètres et peuvent aujourd'hui même être localisés sur les pentes érodées. Les hommes paléolithiques de cette région, à différentes périodes et en particulier au Paléolithique supérieur, n'ont pas employé d'obsidienne, mais d'autres matières premières disponibles. Il n'est pas encore possible de trouver des preuves du transport de l'obsidienne d'un site à un autre site (excepté l'exemple du site de Korolevo).

Abstract

In Ukraine, obsidian artifacts found in the Stone Age, and their origin is poorly understood. Soon as possible sources of supply of obsidian artifacts are volcanic mountain in the Carpathians, the Crimea and the Caucasus.

At the current stage of research only volcanic region of Transcarpathia is the source outputs obsidian in Ukraine. Obsidian outcrops in the territory of Transcarpathia are known only in the vicinity of the ridge of Velykyj Sholes (next to villages Rokosovo and Malyj Rakovets). Recent collaborative studies have confirmed the presence of local obsidian. XRF and NAA data indicate that Ukrainian obsidian is chemically different from other Carpathian obsidians, and suggest that the Ukrainian material is internally homogenous and belongs to so called Carpathian 3 source (Rosania *et al.*, 2008). The site of Malyj Rakovets IV is located in area of the extinct volcanoes of the Neogene period. Paleolithic inhabitants intensively used the obsidian rocks that were formed on the surface during eruptions. Artifacts of the Lower (VII, VI, V), Middle (IV, III, II), and Upper Paleolithic (I) cultural horizons of the site were discovered in stratigraphical context. On the site Malyj Rakovets IV natural obsidian blocks are virtually absent. The nearest outcrops are known at the distance of two kilometers of where and still can be found on eroded slopes. The local Paleolithic inhabitants in different times used other available raw materials. This is particularly clearly visible in the Upper Palaeolithic time.

Keywords: Ukraine, Transcarpathia, Velykiy Sholes Ridge, obsidian, outcrops, Malyj Rakovets IV, Paleolithic site, raw materials

1 – Introduction

Obsidian artifacts were reported as collected in different contexts from the very beginning of studies on the Paleolithic of Transcarpathia (Lehoczky 1910; Janšák 1935; Skutil 1935). In the second half of the XX century, the discovery of new Paleolithic sites which presented obsidian artifacts essentially add to these data (Sova 1964; Petrougne 1960, 1972; Kulakovskaja 1989; Gladilin and Sitlivyj 1990; Sitlivyj 1989; Sitlivyj and Ryzov 1992; Ryzhov 1998, 2003, 2009; Tkachenko 2003).

In 1970-80s of XX century during the works of the archaeological expedition led by V. Gladilin the Paleolithic site in the vicinity of villages Rokosovo and Malyj Rakovets were discovered (Irshava and Khust district). Obsidian was the main raw material used at these Paleolithic sites. Unfortunately, most of the items were collected on the surface and only the site of Malyj Rakovets IV provides artifacts recovered in stratigraphic position (Sitlivyj 1989).

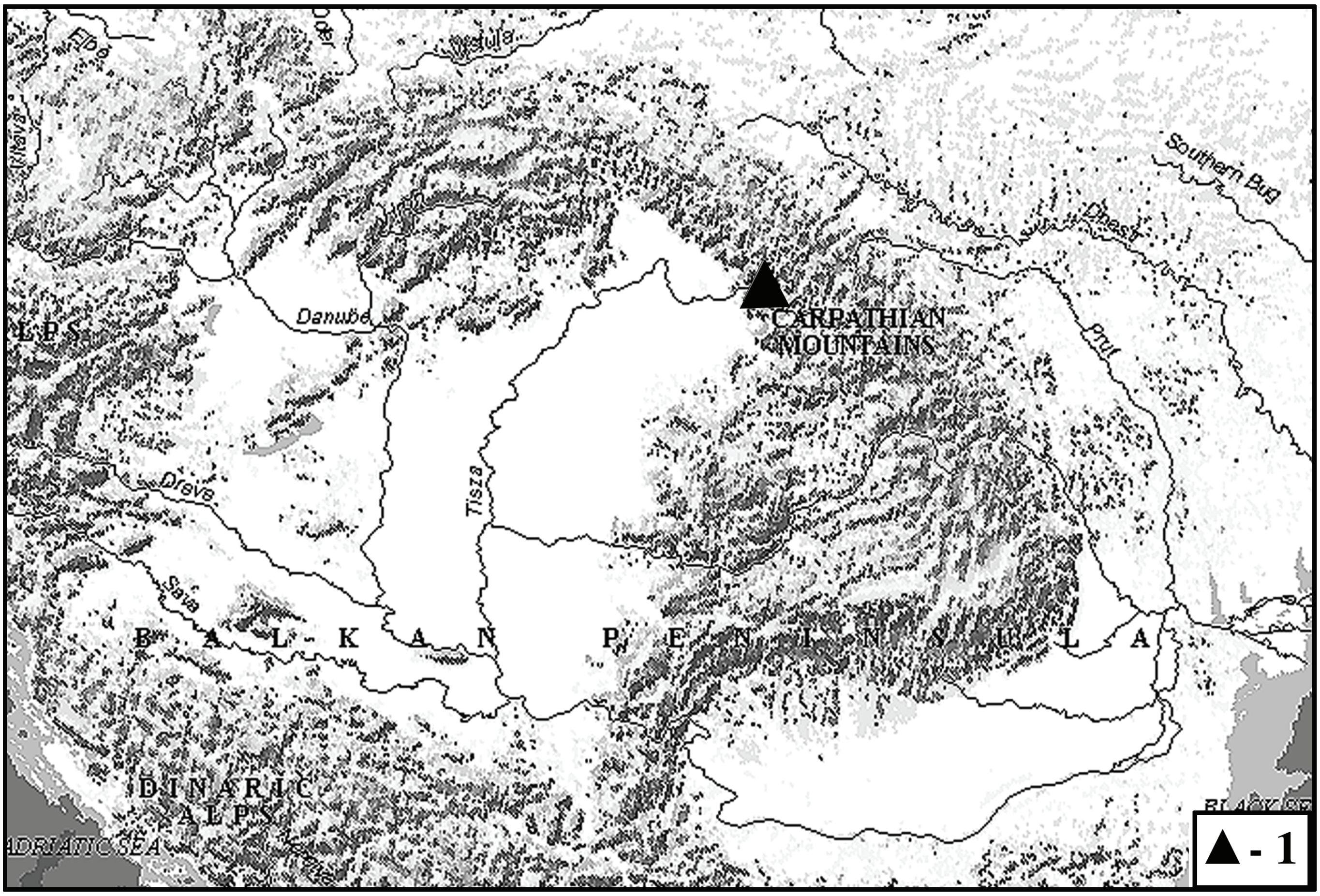


Figure 1 – Map Carpathians: 1 - Obsidian outcrops in the Ukrainian Carpathians

The result of the investigation was the discovery of several cultural stratigrafic horizons in the Malyj Rakovets IV, yielding Lower (VII, VI, V), and Middle (IV, III, II) and Upper Paleolithic (I) artifacts (Gladilin, Sitlivyj 1990; Sitlivyj, Ryzov 1992; Ryzhov 1998, 1999, 2003, 2009).

2 – Geological background of obsidian studies in Transcarpathia

Obsidian occurs in the southeast area of the volcanic Vihorlat-Gutinian mountain range in Ukrainian Transcarpathia (Zakarpattya). This volcanic mountain range starts on the territory of Slovakia and passes in the southeast direction across the territory of Ukrainian Transcarpathia to Romania (Fig. 1 & 2).

During 1948 and 1967-1968 geologist V.F. Petrougne (Petrougne 1960, 1972) collect obsidian of the Velykyj Sholes Ridge on the eastern slopes of Vihorlat-Hutyn volcanic mountain range, localized in the Ukrainian Carpathians.

Volcanic bombs ejected from explosive eruptions during the last (IVth) orogenetic phase of regional volcanic activity roughly 8 to 15 Ma (Fig.3) (Nasedkin 1963; Maleev 1964; Shevkopljas *et al.,* 1986; Pécskay *et al.,* 2000).

In central part of Velykyj Sholes Ridge geologists found six sites liparites outcrops (upper lava flows). In the western part of the spine occur liparites tuffs with a small spread. On the north hillside thick top closer to the center of the region are liparites outcrops, which are confined to hydrothermal rocks that cover an area about 0.5 km^2 (Fig.4, 5).

Accordingly to geological data, the Velykyj Sholes Ridge represents the destroyed polygenic stratovolcano of Strombolian and Plinian type. Volcanic material delayed in an aqueous medium in the lower parts of the relief, after which the material was transported by temporary water and mud flows.

The diameter of the main part of the volcano was about 10 km and its height reaches approximately 2 km. Eruption of lava flows liparites held on the last stages of life of the volcano, when the building it was already largely destroyed (Fig. 5) (Maleev 1964).

Geologist Nasedkin V.V. has investigated obsidian outcrops nearby Rokosovo in Bykchachiy Jar (Fig.6) (Nasedkin 1963: 44).

3 – Petrographic study of obsidians from the Ridge of Velykyj Sholes

The first petrographic studies of obsidian in the area showed that obsidian occurs in two forms: 1 – clear translucent, banded obsidian, 2 - dark, almost opacus, banded (Petrougne 1972: 86).

Obsidian has a black color and frosted glass glitter. Obsidian surface deprived shine, rough and "hole". Crystalline phase (40-50% by weight of the rock) and represented phenocrysts kristallito-microlitic formations. Phenocryst content is typically less than 5-10% of the total weight of the rock.

Phenocrysts are represented by the following minerals: andezin-labrador, rhombic pirokosen, glandular basaltic hornblende, hypersthene and plagioclase. Microliths are needles of amphibole and plagioclase tablets.

In the crystallization of glass around phenocrysts occur spherulites potassium-sodium consisting of feldspar and cristobalite or tridymite. The initial stage of the devitrification leads to the formation of voids around phenocrysts and brown with a faint halo polarization. Spherulites not violate primary fluidal rocks, as it were riddled with fluidal flows microliths.

Obsidian has a low water content, amount of it varies from 0.01 to 0.05%. Refraction coefficient: 1,482 ± 0,001; 1,487 ± 0,002; 1,498 ± 0,001. Ultimate uniaxial compression this obsidian equal 2500-4450 kg/cm^2. The chemical composition of obsidian following: SiO_2 - 70,00%; TiO_2 - 0.20% $A1_2O_3$ - 15.49% Fe_2O_3 - 1.10% FeO - 0.24% CaO - 2.33% MgO - traces , MnO - traces, K_2O - 3,37%; N_2O - 3,82%; SO_3 - tracks; R_2O_5 - traces, loss on ignition - 0.24% total - 100.79% (Nasedkin 1963, Petrougne 1972).

In 2006, we selected 4 samples of obsidian from different topographical points south-western slope of the Velykyj Sholes Ridge. In 2011, Dr. Manichev V.Y. (Institute of Geochemistry, Mineralogy and Ore named Semenenko Academy of science Ukraine) were held petrographic study of samples of obsidian (Fig.7).

Sample № 1(Fig.7: 1) *Malyj Rakovets III (48°14'17.99"N; 23°10'56.78"E)*. On the surface (200 m to south from Malyj Rakovets IV).

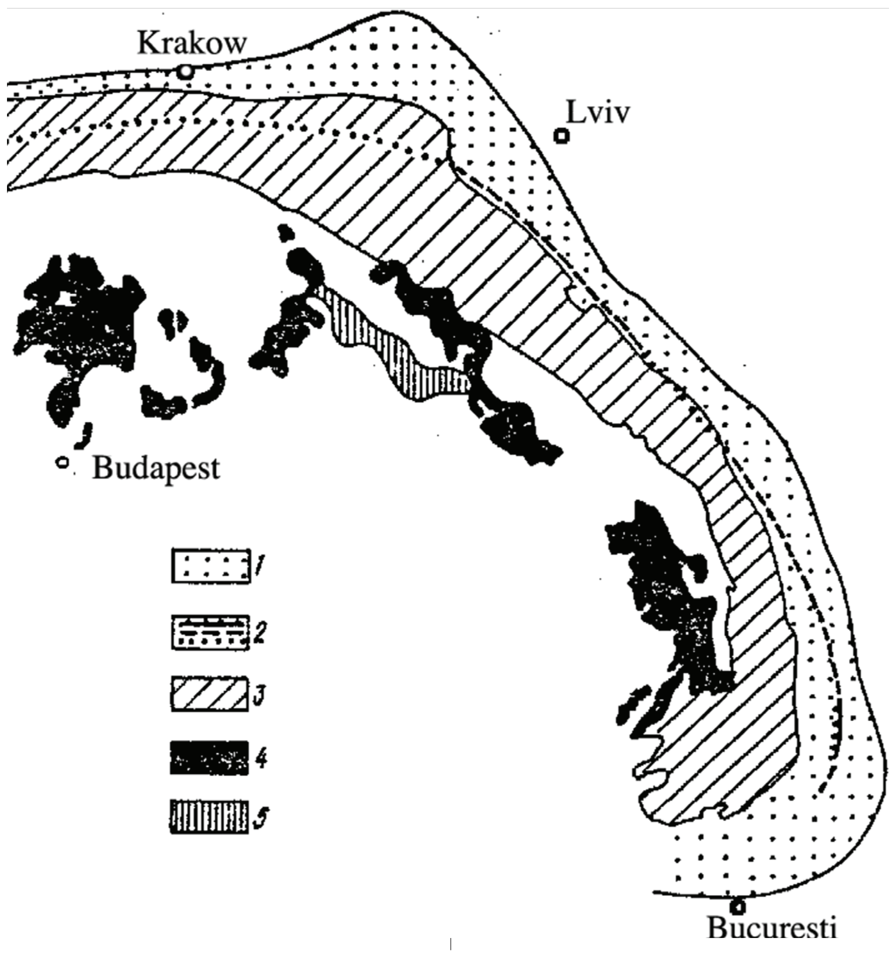


Figure 2 – Carpathian arc in the Neogene: 1 - piedmont depressions; 2 - seismic zone; 3 - system flysch Carpathians; 4 - volcanic mountains; 5 - buried volcanoes ridge. 6 - Transcarpathian obsidian outcrops (after Gofshteyn 1995)

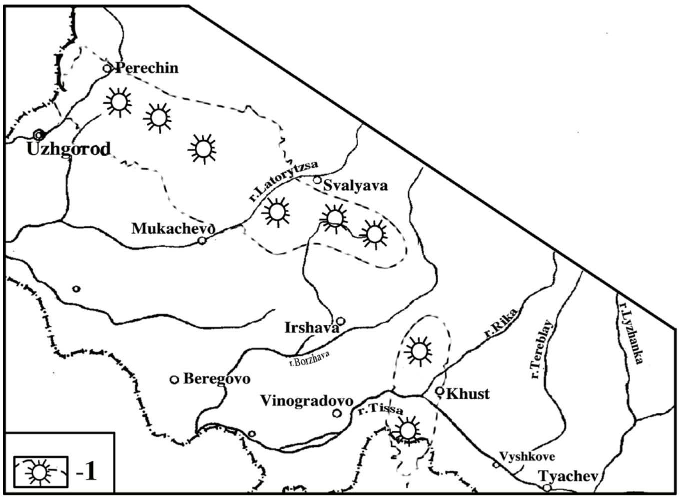
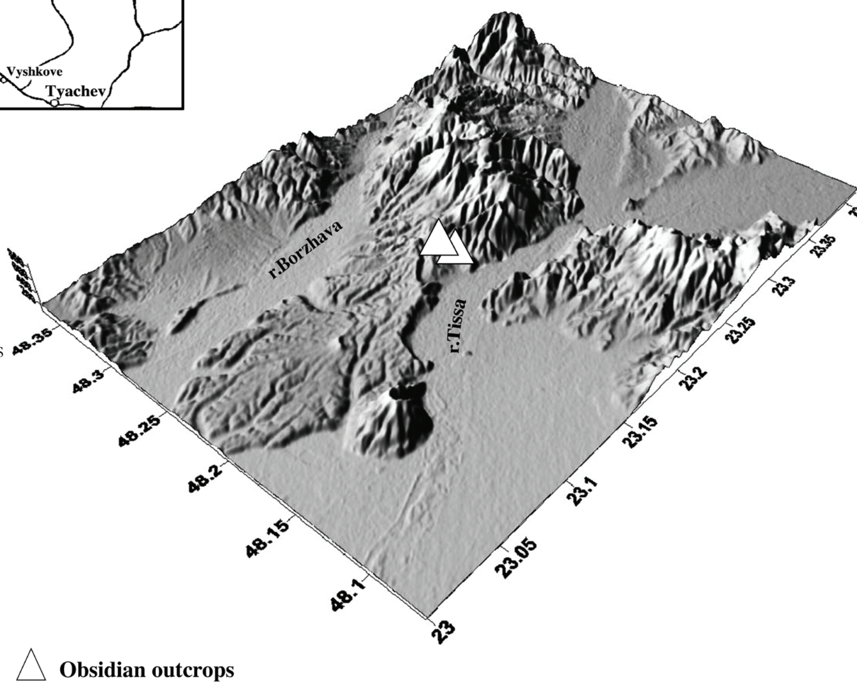


Figure 3 (Above) – Volcanic activity in the late Neogene in Transcarpathia: volcanoes and scope of products of the volcanic activity (after Maleev

Figure 4 (Right) – Computer model of the Velykiy Sholles Ridge: 1 – obsidian outcrops between villages Malyj Rakovets and Rokosovo

Figure 5 (Below) – Location scheme the volcanoes eruption center in Velykiy Scholes Ridge: 1 - stratovolcanoes; 2 - monovolcanoes; 3 - deposits of dacitic; 4 - deposits of andesite-dacite composition; 5 - domes, stocks, dikes, eruption center I, III, IV phases; 6 - district acidic magma intrusions; 7 - tuffaceous sedimentary deposits; 8 - deposits of liparite composition; 9 - palaeolithic sites with obsidian artefacts (after Maleev 1964)



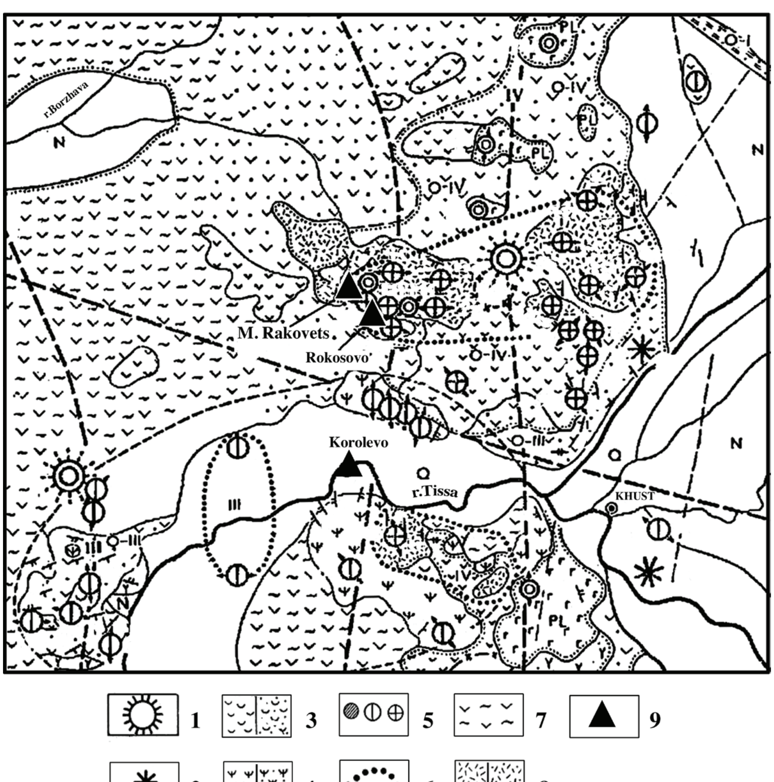
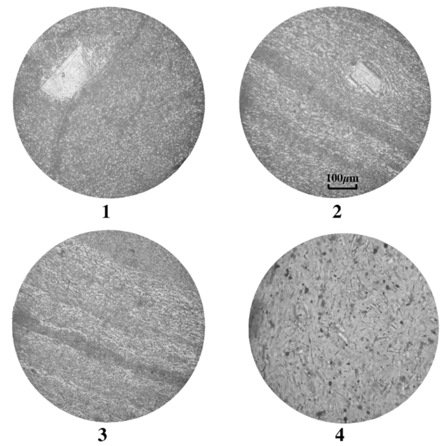
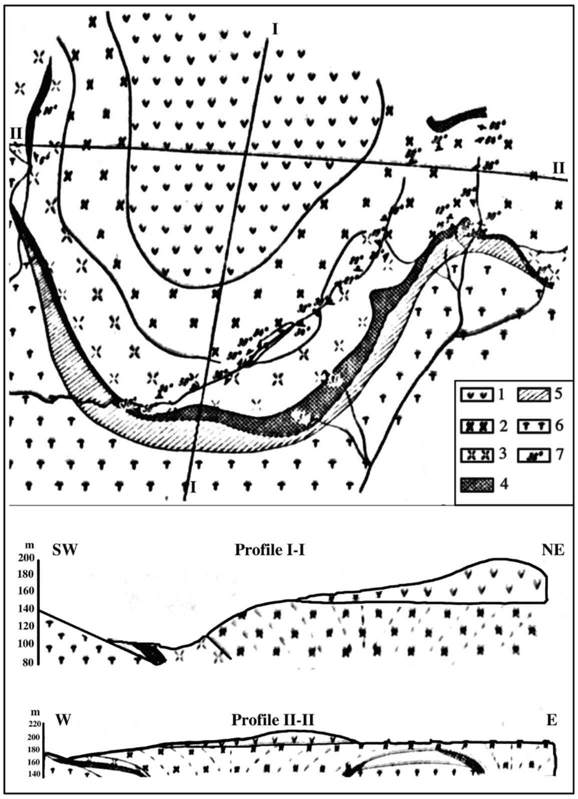


Figure 7 (Below) – Petrographic thin sections of obsidian of the Velykiy Scholes Ridge area: 1 - obsidian from surface Rokosovo IV; 2 - from cultural layer II of Malyj Rakovets IV; 3 - Malyj Rakovets III, on the surface (200 m to south from Malyj Rakovets IV); 4 - Malyj Rakovets IV, from cultural layer I





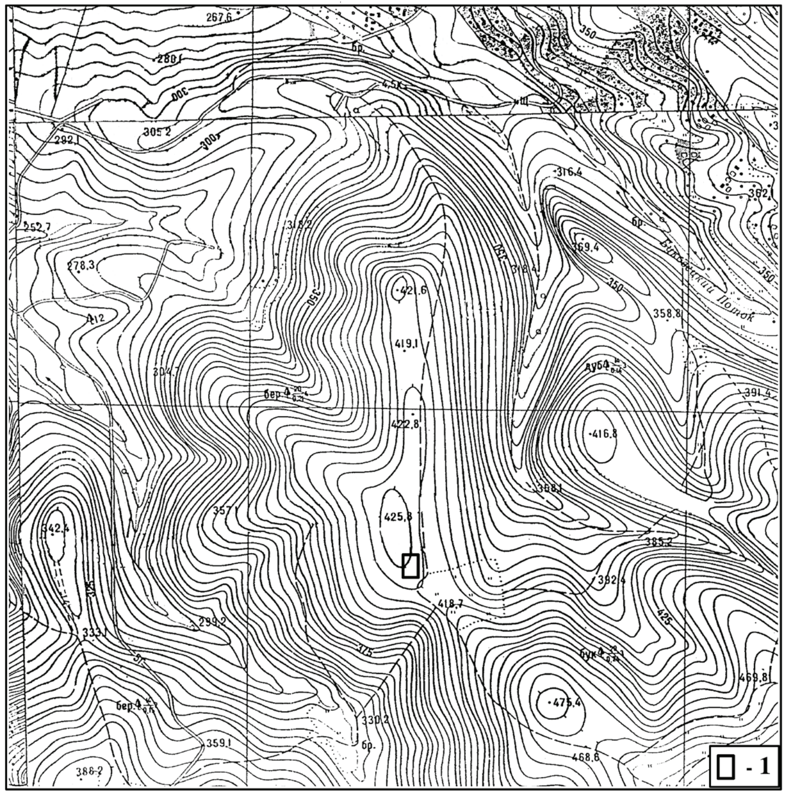
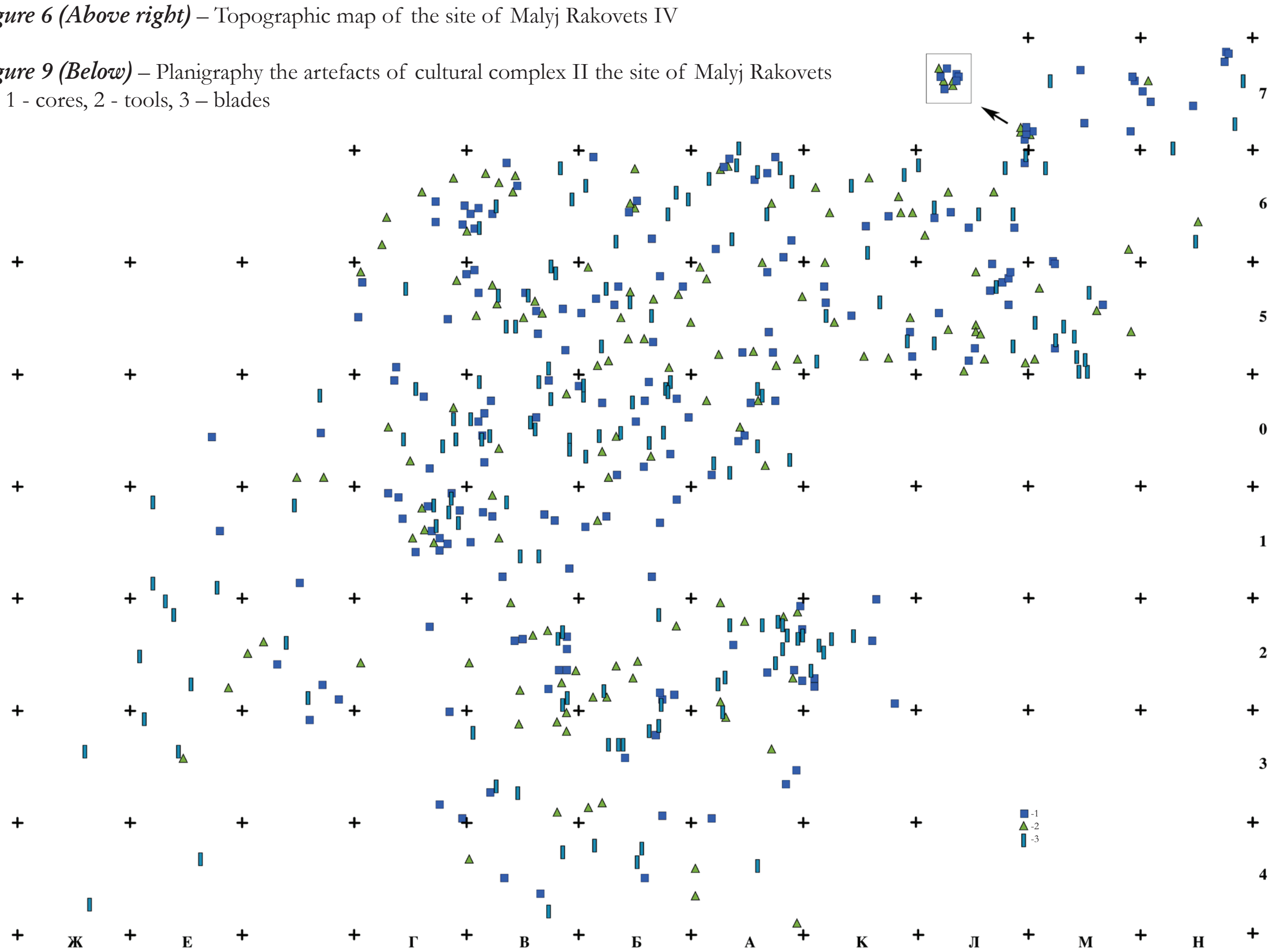


Figure 6 (Above left) – Schematic geological map of the extrusive dome Bykchachy Yar (Rokosovo): 1 - andesite; 2 - liparite with tridymite; 3 - kristabolito-liparite; 4 - obsidian-perlite glass; 5 - dome agglomerate; 6 - tuff of liparites composition; 7 - elements abundance and orientation of lines in the current range (after Nasedkin 1963)

Figure 6 (Above right) – Topographic map of the site of Malyj Rakovets IV

Figure 9 (Below) – Planigraphy the artefacts of cultural complex II the site of Malyj Rakovets IV: 1 - cores, 2 - tools, 3 – blades



Volcanic glass. Obsidian. The color black, shiny, conchoidal fracture. Microscopically breed is a glass with a characteristic striped texture, defined brownish and gray color. In the bulk glass isolated microliths of feldspar, hornblende and ore minerals are black, correct and tablet form.

Sample № 2 (Fig.7: 2). *Rokosovo IV (48°13'50.04"N; 23°11'7.43"E).* On the surface (2 km south from *Malyj Rakovets IV).*

Volcanic glass. Obsidian. The color-striped black. Breaking mostly poorly conchoidal fracture, brilliant. Microscopically striped texture (fluidal) for which there is a horizontal whith brownish and light gray areas. Evenly throughout the volume of volcanic glasses indicated the presence of a small amount tablet feldspar, rarely hornblende (0.02 mm).

Sample № 3 (Fig.7: 3). *Malyj Rakovets IV (48°14'18.71"N; 23°10'45.65"E).* From cultural layer II (Middle Palaelithic).

Volcanic glass. Obsidian. The color-striped black. Analog sample№2.

Sample № 4 (Fig.7: 4). *Malyj Rakovets IV.* From cultural layer I (Upper Palaelithic).

Volcanic glass. Obsidian. Rock black. Tekstura of black uniform, chaotic. In the bulk, glass high content of microcrystals. In a small number indicated the presence of different sized light spheroid.

In the preliminary results of the petrographic analysis of samples number 2 and number 3 are identical. As a result, we find confirmation of transportation or distribution of obsidian in a radius of 1,5-2,5 km in the south-western part of the Velykiy Scholes range.

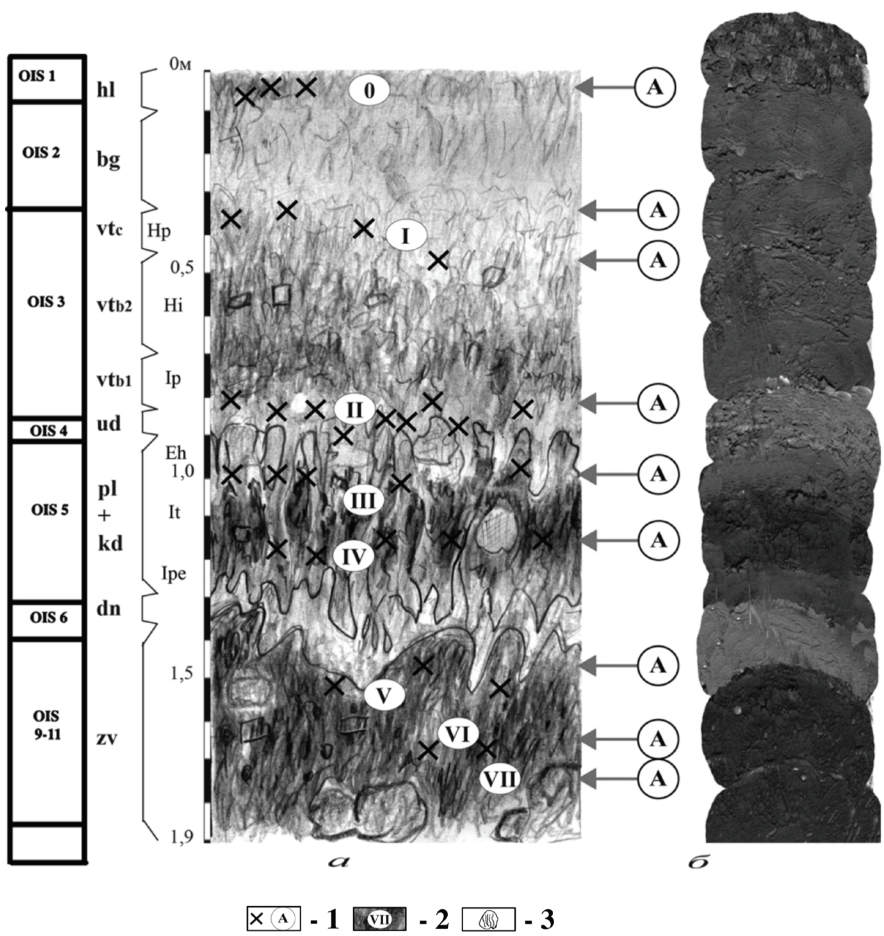


Figure 10 – Malyj Rakovets IV. Stratigraphical sequence of SE wall of square H-5. 1, artefacts; 2, culture-chronological assemblage; 3, tufa concretion

Sample № 1, was selected at 200 m south of the site Malyj Rakovets IV is somewhat different from the two foresaid. Sample № 4 was selected from cultural-chronological complex I (Upper Paleolithic) completely different from all other samples this series. It is quite possible we have result of transportation from other obsidian sources of the Carpathian Basin.

4 – Archaeological research

Local obsidian is the most common raw material for Malyj Rakovets IV, the rest consists of quartzite, flint, slate, sandstone, quartz and andesite. Non-volcanic material is represented by pebbles.

The raw material is not found naturally on the site and was transported (0,5-3 км) by numerous streams in the vicinity of the settlement. It is important that the artifacts made of volcanic materials and coming from different chronological complexes at this site and have differently preserved surfaces due to various degrees of patination and cellular leaching (corrosion) (Fig.11).

The most ancient artefacts have the most destroyed surface and vice versa the youngest implements have a better state of preservation.

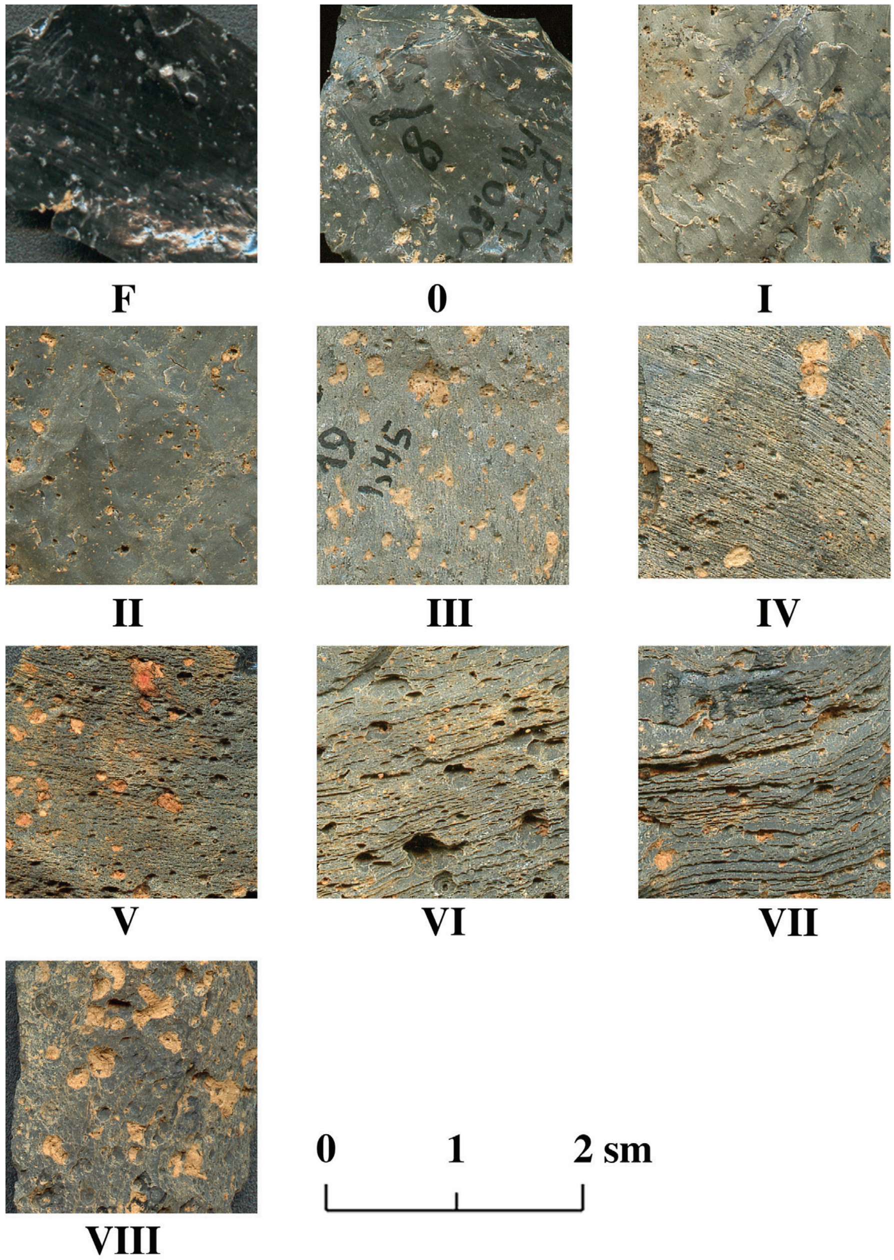


Figure 11 – Obsidian chronological systems of the site of Malyj Rakovets IV on the degree of leaching: 0-VII - cultural-chronological complex; F - fresh chip

5 – The palaeolithic site of Malyj Rakovets IV

(48°14'18.71"N; 23°10'45.65"E)

The palaeolithic site of Malyj Rakovets IV is located on the volcanic Vihorlat-Gutinian Ridge (Velykyj Scholes Ridge), southeast of the Malyj Rakovets village between the towns Khust and lrsava in Transcarpathia, West Ukraine (Fig.3, 5). Malyj Rakovets IV is the highest of the Lower and Middle Palaeolithic sites in this region (Fig.8).

The first stone artifacts were collected between the villages Malyj Rakovets and Rokosovo (another area with numerous sites) by V. Petrougne and then by V.Gladilin at the end of 1960's. In 1978, in course of a survey along the trench for the gas pipeline "Sojuz" V. Sitlivyj and Y. Kucharchuk discovered a number of stone artifacts of Lower and Middle Palaeolithic types at the site MR IV and, following the planed direction of the pipeline towards the town of Vinogradovo, in a few additional places: MR V, VI, VII (Sitlivyj 1989).

Archaeological researches were conducted by the archaeological museum of the Institute of Zoology of Ukraine at this location in 1990-1991 (Sitlivyj and Ryzov 1992). These works were followed by 1995-2006 excavations conducted by the archaeological expeditions of the Department of Archaeology and Museology of Kyiv National Taras Shevchenko University (Ryzhov 1998, 2003, 2009).

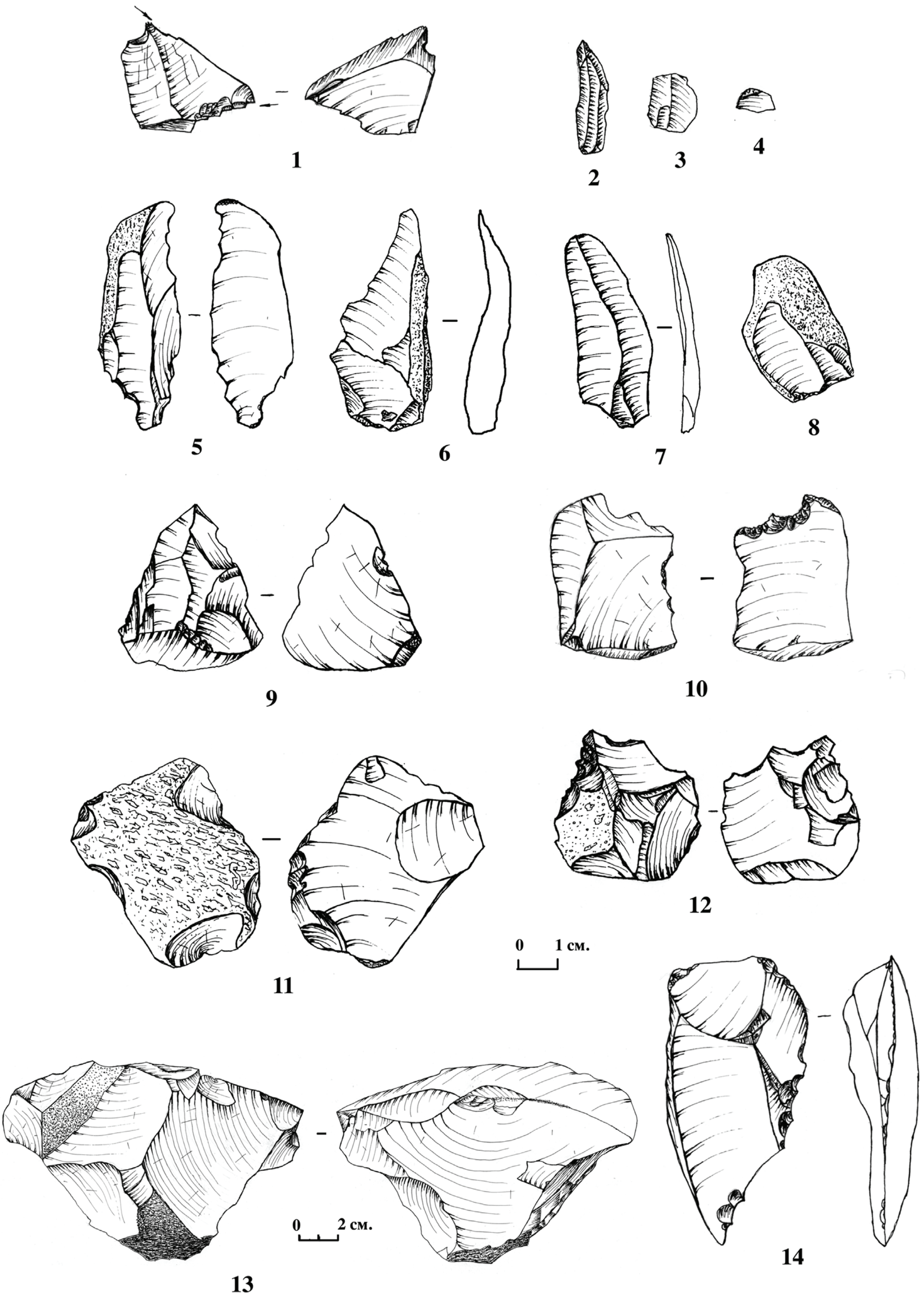
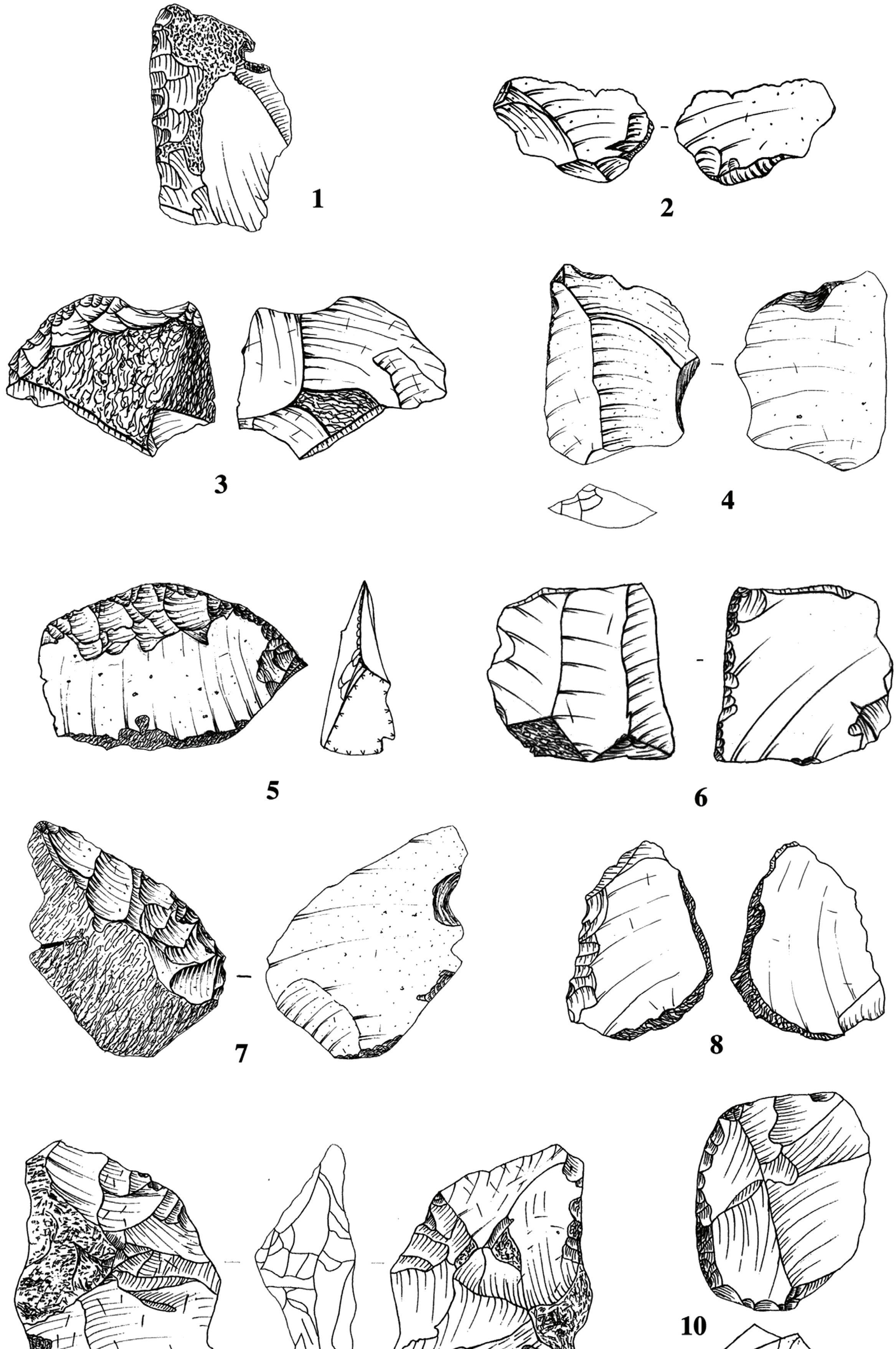


Figure 12 (Above) – The site of Malyj Rakovets IV. Lithic artefacts of culture–chronological complex I. 2, 6, 7 – from not local obsidian; 3, 4, 8 – flint; 1, 5, 9, 10 – 14 - local obsidian (Carpathian III)

Figure 13 (Right) – The site of Malyj Rakovets IV, Lithic artefacts of culture–chronological complex II. Stone tools from local obsidian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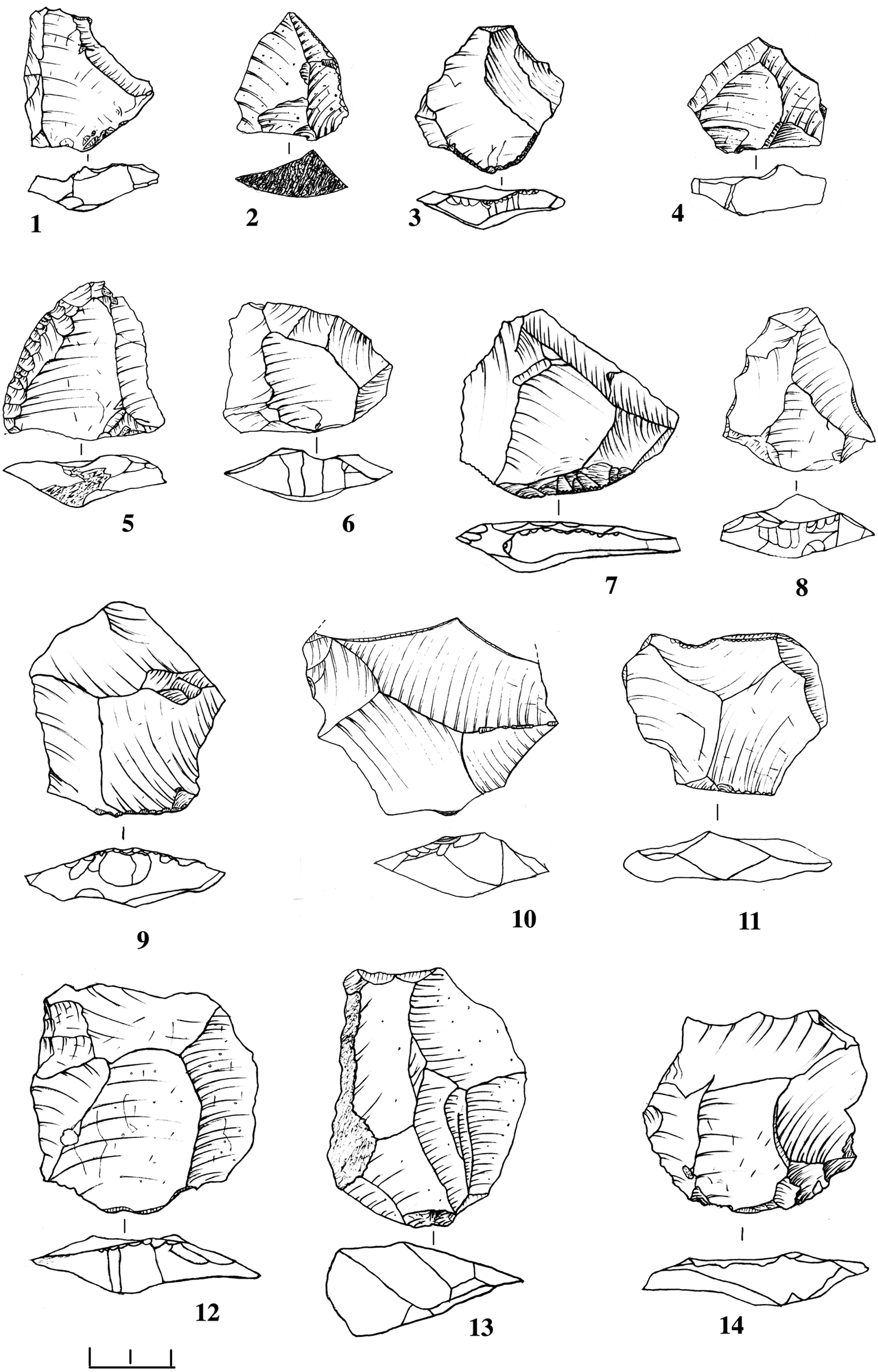
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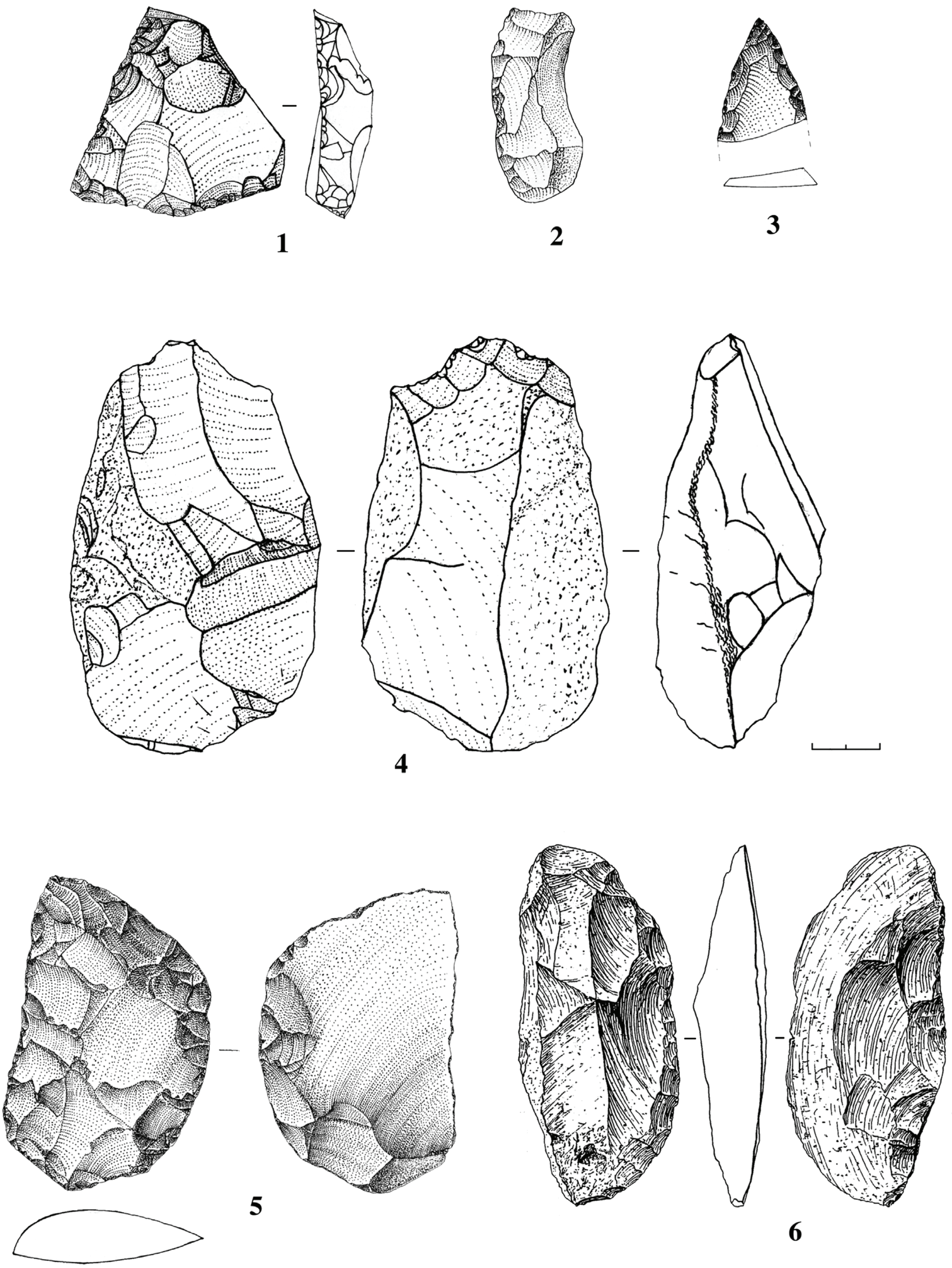


Figure 14 (Left) – The site of Malyj Rakovets IV. Lithic artefacts of culture–chronological complex II. Levallois flakes from local obsidian

Figure 15 (Above) – The site of Malyj Rakovets IV. Lithic artefacts of culture–chronological complex II: core from quarzite – 4; quarzite tools – 1, 2, 3, 5; andezite side-screper – 6

In the process of dating the geostratigrafical and technic-typological study were used and dissection technique finds the degree of preservation (leaching) products from volcanic materials (Fig.11, planche 23) (Gladilin, Sitlivy 1991). Thus, over the years of research in the site was allocated eight cultural horizon: 0 – Neolithic and Bronze age; I - Upper Paleolithic; II, III, IV - Middle Paleolithic; V, VI, VII - Lower Paleolithic (Ryzhov 2009).

The total area of the excavation was 208 m^2 (Fig. 9). There was found about 6 thousand artifacts. The bulk (75%) of these findings belong to the II-th cultural horizon (Middle Paleolithic). Faunal and paleoanthropological findings were not found.

In 2006 studies were conducted stratigraphic research (paleopedological, macro and micromorphological) by the Institute of Geography of the Academy of Sciences of Ukraine. The result was a more detailed stratigraphic column (Fig. 10). Here were tracked for the following deposits: hl, bg, vt, ud, pl, kd, dn, zv (Ryzhov et all 2008).

Eight cultural complexes were recognized at the site on the base of geostratigraphical data and technical-typological studies, these are: Neolithic-Bronze age (0), Upper Paleolithic (I), Midlle Paleolithic (II-IV), Lower Paleolithic (V-VII).

A – Cultural-chronological complex of Malyj Rakovets IV (Upper Paleolithic)

Most of the remains occur at depths of 0,30-0,50 m at the top of Vitachev horizont (vt). Obsidian findings (83%) differ from the previous by the presence of complex (0 complex) and opaque crust leaching with a blue tint patina. There are in total 177 found: debitage – 150, tools - 27.

By its technical and typological characteristics, this complex is different from all the other complexes *Malyj Rakovets IV*. Complex I comprise blades (17%) and burin (1.7%). Assemblage includes backed bladelet made on not local obsidian raw material (2).

Variety of raw materials used at the site increases during the Upper Paleolithic period. Tools from non-local obsidian, radiolarites, hydroquartzites, and various flints are represented. Retouched obsidian blades and end-scrapers are dominating, but burin made on non-obsidian material (Fig. 12) is also represented in the assemblage.

B – Cultural-chronological complex of Malyj Rakovets IV (Middle Paleolithic)

Findings of this complex occur at depths of 1,40-1,20 m in the south-eastern part of the excavation while in the north-western part of the excavation area the majority of artifacts were recovered at a depth of 1,00-1,20 m. The major portion of artifacts was reported for the lower section of forest soil of vitachev age (vt_{b1}).

Assemblage of complex II comprises 4210 finds: debitage products - 3765/89, 4%, tools - 236/5, 6%, undefinable - 209/4, 9% (Fig. 13, 15). Following groups of tools are recognized among artifacts, namely: side-scrapers and knives - 67/28, 3%, notches - 17/7, 2%, retouched flakes - 34/14, 4%, and denticulates - 16/6, 8%, Levallois points - 4/1, 7%, blades retouched - 2/0, 8%, end-scrapers - 8/3, 9%, burin - 1/0, 4%, blank of tools - 4/1, 7%, hammerstones - 28 / 11.8% and anvil - 2/0, 8%.

Tools were made of obsidian (85,5%), quartzite (6%), slate (3%), flint (1,5%). Hammerstones are made of sandstone, quartzite and quartz pebbles. Usually, the tools were prepared on flakes and blades. Their length varies between 3-10,8cm, the width is between 2,7-7,8 cm, thickness 0,7-4 cm. The average proportions are 6 x 4,4 xl, 8 cm. Generally retouch on tools is unifacial scalariform, occurs pearllike, step, sub-parallel. The tools with retouch on dorsal side dominate (79,3%), ventral retouching occurs (18,9%)

From the typological point of view, available side-scrapers, knives and denticulates are simple: convex, concave, straight, sinuous (Fig. 13, 15). The tools with more then one retouched edge (double, convergent) are rare. Points are not numerous but typical. They are represented by retouched Levallois points and points on blades. Upper Palaeolithic tools are rare and atypical.

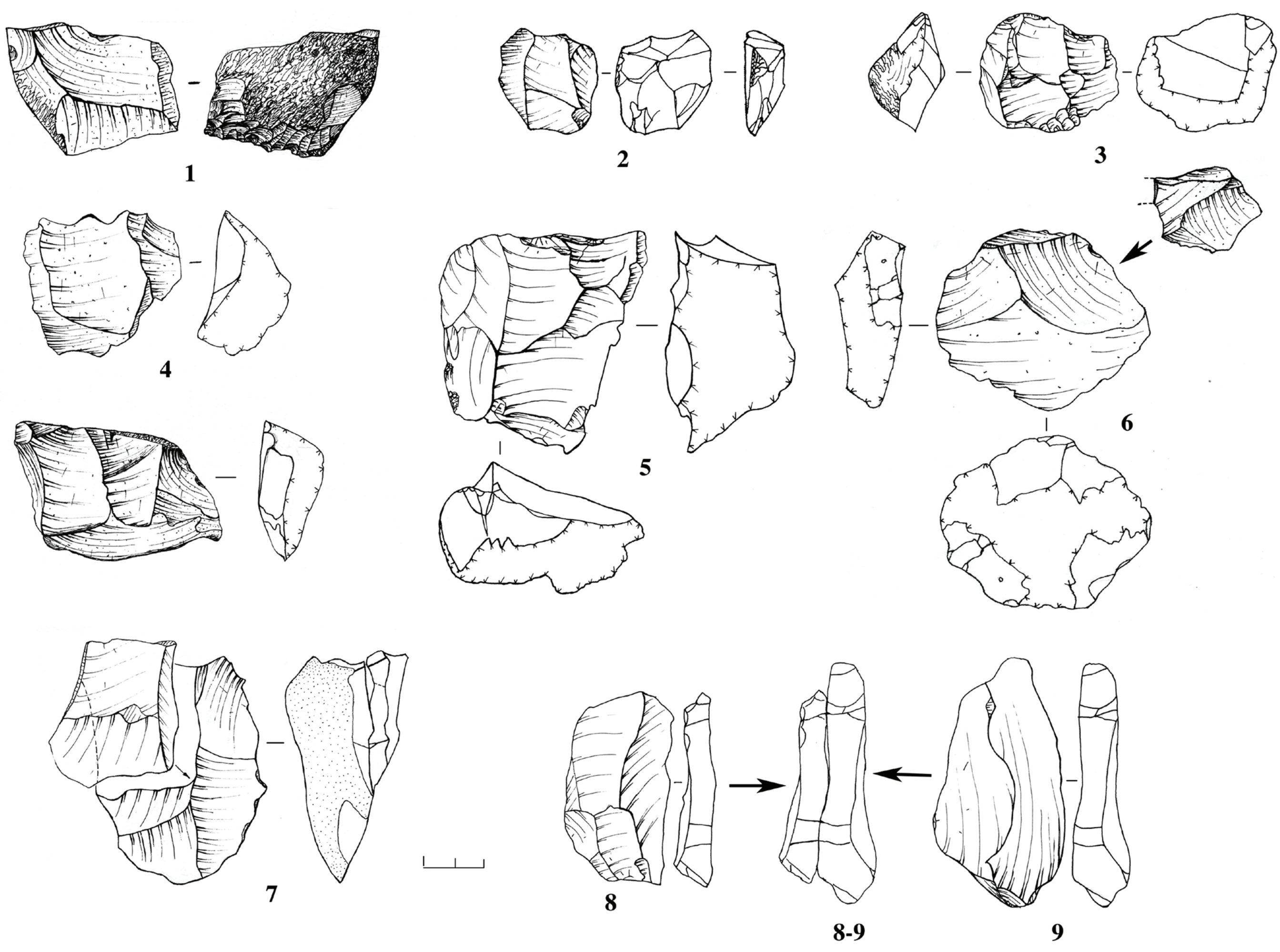
Malyj Rakovets IV, complex II is characterized by Mousterian forms with prevailing simple side-scrapers and knives, modest level of denticulate and notches. The specific character of the complex is given by Levallois points with broad base, some partly bifacial and stepped retouched knives and side-scrapers. This assemblage was attributed to the typical Mousterian characterized by domination of simple scrapers and backed knives made on flakes.

C – Cultural-chronological complex of Malyj Rakovets IV (Middle Paleolithic)

Artefacts of this complex were unearthed directly in the upper part of Priluky soil (pl). Obsidian artifacts are characterized by more intensive weathering and rough patina. One of the surfaces of artifacts usually demonstrates cells leach residues Priluky soil hydroxides of iron and manganese.

The assemblage of this complex includes debitage products - 115, tools - 15. Debitage is typical for the Middle Palaeollithic time in this region (including Levallois forms) and comprises flakes – 62, cores – 15, pieces – 25, small flakes or chips up to 2 cm - 13. The tools included: denticulates - 3, side-scrapers – 2, retouched flakes - 4, retouched flakes - 1, broken tools - 4, retoucher – 1 (Fig. 17).

Figure 16 – The site of Malyj Rakovets IV. Lithic artefacts of culture–chronological complex II: cores from local obsidian (1, 3, 4. 5, 6, 7), cores from radiolarite (2), conjoining flakes. (8-9)



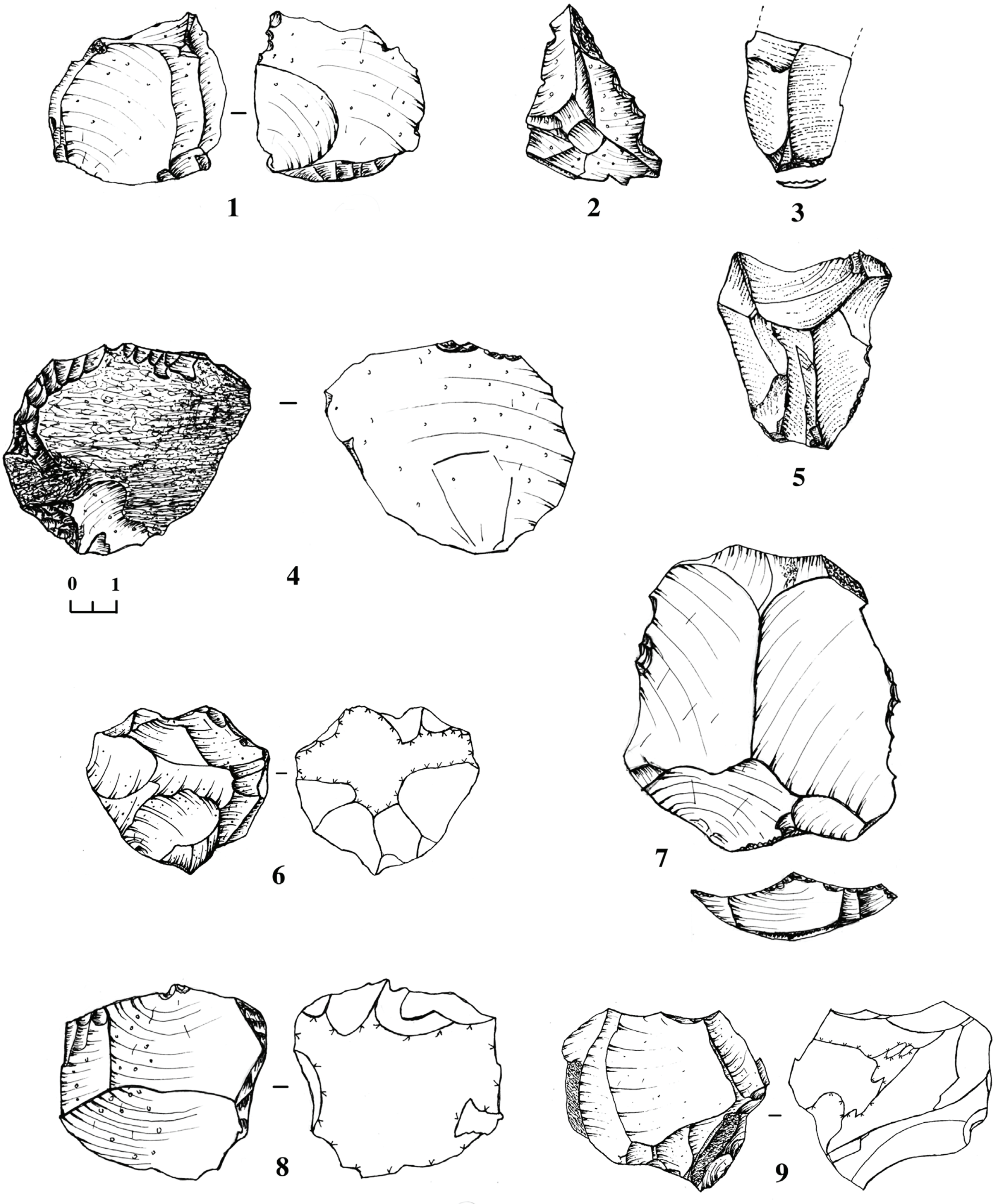
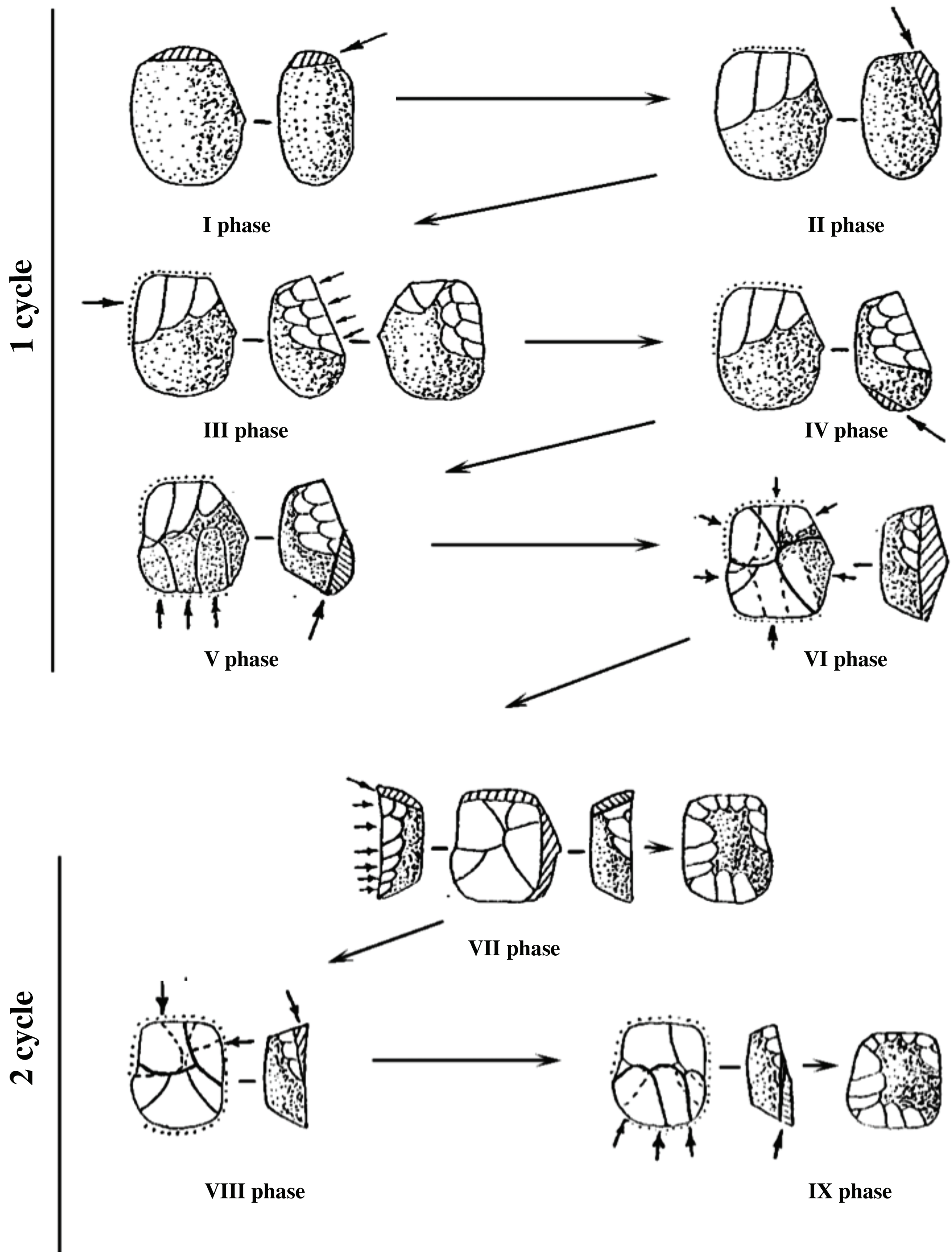


Figure 17 (Above) – The site of Malyj Rakovets IV. Lithic artefacts of culture–chronological complex III: obsidian tools (1, 2, 4), Levallois flakes with retoch (5 – quarzite, 7 – obsidian), discoide core (6), rokosovo cores (8, 9)

Figure 18 (Right) – Strategic model of obsidian knapping cores. Cultural-chronological complex II


1 cycle
I phase
II phase
III phase
IV phase
V phase
VI phase
2 cycle
VII phase
VIII phase
IX phase

A relatively small collection of this complex was attributed to the Middle Palaeolithic assemblages with Levallois technique.

D – Cultural-chronological complex of Malyj Rakovets IV (Middle Palaeolithic)

Findings occur in the middle part of the Priluky soil and have stronger leaching than the cultural complex III. Collection includes 72 finds: debitage – 67, tools - 5. Among the tools allocated andesity back knife and quartzite Levallois flake with retouch.

E – Cultural-chronological complex of Malyj Rakovets IV (Acheulian period)

Artifacts were recorded in Zavdovka soil at different levels. Obsidian artefacts differ by the degree of preservation of surfaces. These assemblages are not numerous (V - 16 pcs, VI - 6 pcs., VII - 9 pcs.) and do not represent a homogeneous typological groups.

Lower Palaeolithic assemblages are characterized by presence of tools on massive natural flakes with irregular retouch. This time mostly black obsidian bombs of larger dimensions were used. Some obsidian finds with intensively corroded surfaces at the same time represents the morphologically more primitive artifact types, like proto-Levallois and cubic cores were discovered. These are assigned to the Acheulian time.

Natural obsidian blocks are virtually absent at the site of Malyj Rakovets IV. The nearest surface outcrop is localized at a distance of two kilometers and obsidians till now can be found in this area on eroded slopes. Local Paleolithic occupants used another available raw material, as well. This feature becomes especially clearly visible during the Upper Paleolithic. Evidence of local transportation of obsidian to other sites of the area (save for the Korolevo site) is not traced yet.

6 – Conclusion

Obsidian outcrops in the Ukrainian Transcarpathians were localized as a result of special geological and archaeological research

XRF data, NAA and petro-geologic data indicate that Ukrainian obsidian is chemically different from other Carpathian obsidians, and suggest that the Ukrainian material is internally homogenous and belongs to so called Carpathian 3 source (Rosania *et al.,* 2008)

The study of Paleolithic sites in Velykiy Scholes Ridge witnesses for rather long period of exploitation of obsidian by Prehistoric man, as there are obsidian artifacts dates to the Lower, Middle and Upper Paleolithic. Unfortunately the major part of Paleolithic sites was destroyed by erosion processes very intensive in this area of Carpathians.

Due to its stratigraphic context, the multilayered site of Malyj Rakovets IV is of great importance for the study of Prehistory of Carpathian Basin. The same obsidian raw material outcrop was exploited by the inhabitants of the site at different stages of its occupation. At the same time, non-volcanic rocks and imported obsidian were also used at the site

However, at the moment, there are no facts of transportation of obsidian finished tools or blocks of raw material for long distances (over 10 km).

Technological and typological indications of obsidian products do not show sharp differences to the general principles of knapped isotropic rocks in the Paleolithic time.

The study was developed by obsidian artifacts chronological scale for degree of preservation surface that matches the stratigraphic bedding artifacts. Further research in this area can improve the dating obsidian material which is found on the surface or present as an import in other sites.

Acknowledgements

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Lithic raw material exploitation and circulation in Préhistory. A comparative perspective in diverse palaeoenvironments
Liège, ERAUL 138, 2014, p. 135-158

2.4. Small opportunities and big needs: Mira Early Upper Paleolithic case of raw materials exploitation (Dnieper basin, Ukraine)

Résumé

La transition du Paléolithique moyen au Paléolithique supérieur en Europe de l'Est se caractérise par la coexistence d'industries du Paléolithique moyen, du Paléolithique supérieur authentique et du Paléolithique supérieur de transition (ou archaïque ou symbiotique). Ce dernier type d'industrie montre quelques rudiments typologiques et technologiques du Paléolithique moyen d'une part et quelques éléments du Paléolithique supérieur d'autre part. Le site de Mira représente un exemple plutôt rare de Paléolithique supérieur ancien archaïque en Ukraine, recouvert par le Paléolithique supérieur authentique et il est donc à ce titre un exemple intéressant. Le site de Mira se situe dans la vallée de la rivière Dniepr, près de la ville de Zaporozhiye, en Ukraine, en Europe de l'Est. Ce site présente deux occupations paléolithiques distinctes ; deux couches (II/2 et I) séparées par une couche II/I qui est caractérisée par un aspect brûlé naturel. D'après les aspects géologiques essentiels et la taphonomie archéologique nous pouvons considérer les couches I et II/2 de ce site comme de bons exemples de sols d'habitat bien conservés, ces couches nettes et homogènes témoignent de séjours très courts de l'homme préhistorique. Les analyses lithologiques, géomorphologiques, palynologiques, antracologiques, micro et macrofauniques, ainsi que les analyses radiométriques (AMS et C14 conventionnels) permettent d'attribuer les sédiments avec vestiges culturels à l'interstade de Denekamp/Vitachiv tardif/Bryansk de l'avant-dernier pléniglaciaire et de dater les deux occupations paléolithiques entre 28-27 milles ans B.P., C14 non calibré. Il n'y avait pas beaucoup d'artefacts en silex dans la couche II/2. Le site de Mira fournit beaucoup d'informations importantes. En particulier nous trouvons des matières premières d'origine lointaine dans la couche I de ce site. Dans cette couche il y a un certain nombre de types de matières premières utilisées, siliceuses et non siliceuses. Ces collections montrent des modifications importantes par rapport à la forme initiale des pièces dues à des reprises multiples de taille en raison de la pénurie de matière première. Il est probable que le manque de matière première a favorisé la microlithisation des échantillons, la transformation de la forme morphotypologique et même l'invention de nouveaux objets en silex. Cet article fait le point sur les caractéristiques de l'assemblage des objets de la couche I du site de Mira faisant particulièrement référence à sa variabilité et à l'utilisation de la matière première en relation avec sa pénurie.

Abstract

Middle to Upper Paleolithic transition on the territory of Eastern Europe is characterized by coexistence of Middle Paleolithic, true (or full-fledged, or authentic) Upper Paleolithic and transitional (archaic or symbiotic) UP industries. These latter industries exhibit some typological and technological rudiments of Middle Paleolithic, at the same time being quite Upper Paleolithic in other aspects. The site of Mira represents rather rare in the Ukraine instance of archaic EUP industry overlaid – that makes the case even more interesting – with full-fledged or authentic UP. Mira is located in the valley of the river Dnieper, Eastern Europe, Ukraine, next to Zaporozhiye city. The site yields two distinct Palaeolithic occupations, i.e. II/2 and I separated with likely natural burning event II/1. Essential aspects of geological and archaeological taphonomy allows to define Mira layers I and II/2 as representing good example of well-preserved living floors being remains of separate and homogeneous short term occupations. Lithologic, geomorphologic, palynologic, antrocologic, micro- and megafaunistic analyses and radiometric (AMS and conventional 14C) data unanimously correlate culture-bearing sediments with Denekamp /late Vitachiv /Bryansk interstadial of Middle Pleniglacial and put both Palaeolithic occupations between 28-27 uncal C14 ky BP. Layer II/2 yields only not numerous flint artefacts. Mira records provide wide spectrum of evidence. In particular, specific case of remote raw materials exploitation might be described for the Mira layer I assemblage. Lithic series of Mira layer I is highly variable in respect of used raw materials, both siliceous and not siliceous. This assemblage demonstrates signs of serious deformation of its initial habitus by multiple re-workings of limited number of initially available lithics. Raw materials shortage clearly impacted on intensive microlithisation of the inventory, stimulated the transformation of typo-morphological pattern, and likely promoted the independent invention of original flint implements. Proposed paper is mainly focused on characteristic of Mira layer I assemblage with special reference to the aspects of variability, exploitation and use of lithic raw materials under the terms of their shortage.

Keywords: Eastern Europe, Ukraine, Mira, Early Upper Paleolithic, raw materials, technology, morphology, innovations

1 – Introduction

A lot of new data concerning one of the most debated issues of home Paleolithic studies, namely the beginning of anatomically modern human dispersals at Eastern Europe, were accumulated in course of last few years (Anikovich, *et al.,* 2007; Vishnyatsky, 2008; Derevyanko, 2005; 2010). Certain important new evidence on above topic were obtained recently in Ukraine, as well. In particular, one can say about the new multilayered site of Mira in Sub-Ridge area of Dnieper basin.

The results of geological and paleontological studies, and absolute chronology data unanimously put both Paleolithic occupations of Mira into the interstadial of the Middle Pleniglacial. Paleolithic occupations associate with Denekamp (Late Vitachev-Bryansk episode) and are dated back to ca. 28 ky BP (conventional ^{14}C date).

Mira provides clear pattern of overlapping of typologically and technologically more advanced UP industry of layer II/2 by the more archaic industry of the uppermost UP layer I, exhibiting some kind of mixture of Upper and Middle Paleolithic features and accompanied by remains of AMH.

The lack of any other "Aurignacian signs" in the lithic assemblage of Mira layer I except for rather atypical micro-tools (and, probably, large blades and isolated high scrapers), and presence of unique non-geometric microliths provide good perspectives for the study of terms of probable independent invention of microlithic inventory.

Anthropological finds of Mira layer I once again reaffirm the affiliation of Szeletoide (or Post-Micoquian) industries of Eastern Europe with Anatomically Modern Humans.

Despite the rather well recognizable archaic component, Mira layer I represents completely Upper Paleolithic pattern of behavior, including personal ornaments, developed bone technology, dwelling construction, and also the evidence of remote migration. Economic profile Mira layer I might be defined as a seasonal (fall-winter) base camp near the place of successful horse hunt.

Though statistically insufficient, typically UP assemblage of Mira: II/2 provides an example of sharply different technology and typology. Broad analogy of this material might be seen in the Early Gravettian of Central and Eastern Europe. There is a surprisingly close morphological and technological resemblance of blunted bladelets from Mira: II/2 with artifacts recovered in horizon 24A1 of Paglicci in Southern Italy. Worthy to note, that this, though basically Aurignacian, Italian assemblage demonstrates – as its investigators emphasizes – the features of evolutionary shift towards the Gravettian. High mobility of layer II/2 inhabitants is confirmed by the fact of remote location of sources of lithics for their tools, at least 300-350 km away from the site.

2 – The site of Mira: localisation, environment, specific features

Open-air site of Mira locates in the valley of the river Dnieper, Eastern Europe, Ukraine, actually about 15 km South from the city of Zaporozhiye, 47°40' of N latitude and 34°50' of E longitude (Fig. 1). Should be specially stressed, that the area of localisation of the site includes no primary outcrops of knapable lithic raw materials, and only flints redeposited by river flow might be collected in the vicinity of the site. The nearest available outcrops of flints and cherts are reported no closer than 100 km from the site. The nearest outcrops of petrified wood, sometimes used for knapping, are separated by several tens km. This environmental feature is specific for the whole Quaternary period of this area in general. Nevertheless the area was highly attractive for prehistoric hunter-gatherers. Raw materials shortages were compensated by very dense and rich bioresources typical for landscapes of valleys of large rivers. In the case of the Mira layer I even afore weak opportunities to renew the stocks of raw materials by the searching flints in river deposits were denied by cold season of occupation.

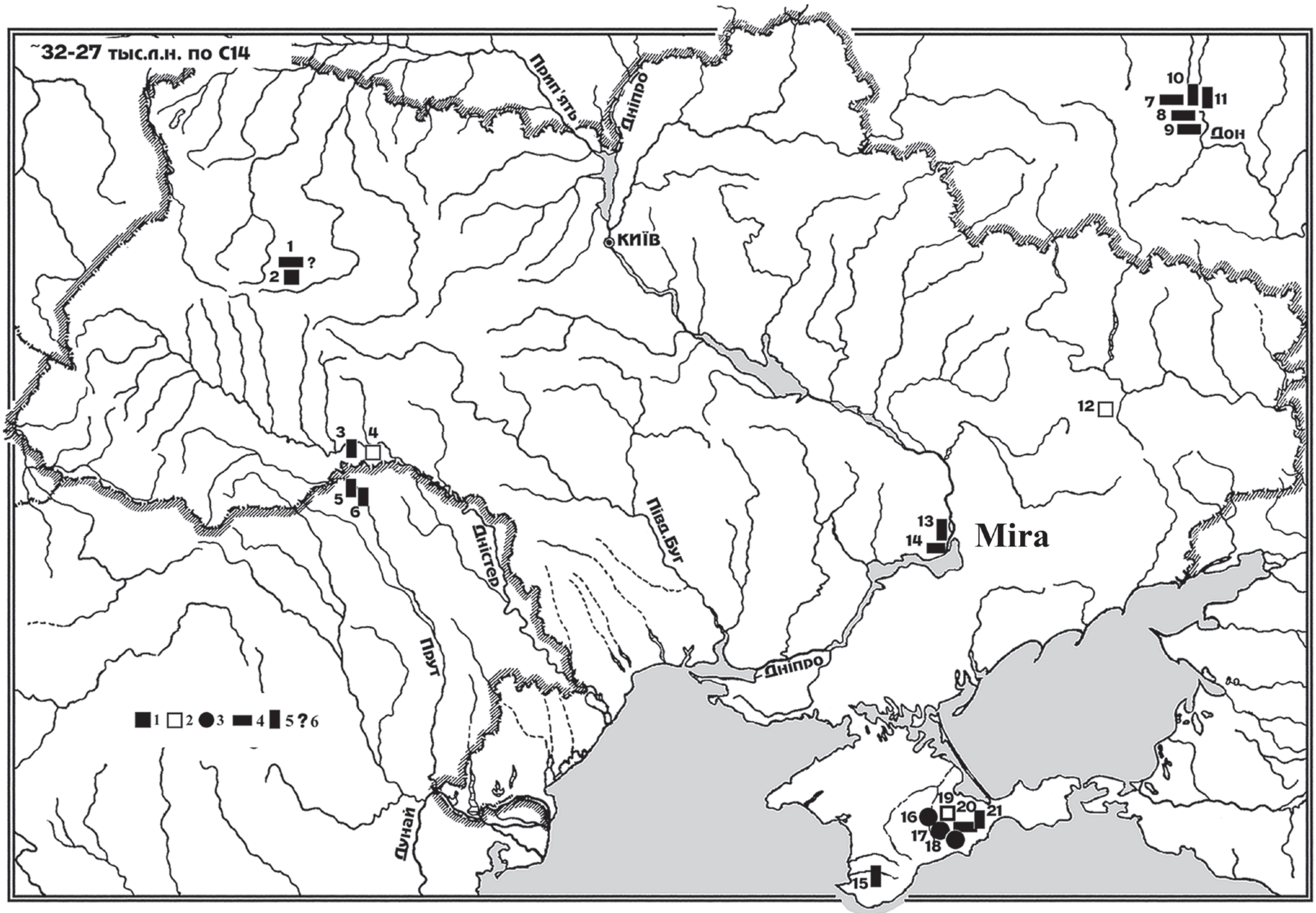

Figure 1 – The site of Mira (No. 13,14) in the context of the main Eastern European Middle and Upper Palaeolithic sites aged between 32-27 uncal ^{14}C ky BP

1 - Kulychivka; 2 - Zhornov; 3 - Molodova I, layer IX; 4 - Korman', layer 9, 8; 5 - Mitoc Malul Galben, layer 12b-8b (Aurignacian); 6 - Mitoc Malul Galben, layer 7b (Gravettian); 7 - Kostenki 6; - Kostenki 12, layer 1a (Stretskaya Archaeological Culture); 8 - Kostenki 14, layer II, IV (Gorodtsovskaya Archaeological Culture); 9 - Kostenki 16 (Gorodtsovskaya Archaeological Culture); 10 - Kostenki 1, layer 3 (Aurignacian); 11 - Kostenki 8, layer II (Gravettian); 12 - Belokuz'minovka; 13 - Mira, layer II/2 (Gravettian ?); 14 - Mira, layer I; 15 - Siuren' I, layer Fb1, Ga, H; 16 - Zaskal'naya I, layer II and I; 17 - Prolom I, layer I; 18 - Buran-Kaya III, layer B1; 19 - Alioshin Grot, layer I; 20 - Buran-Kaya III, layer C; 21 - Buran-Kaya III, layer 6-2 (Gravettian).

Key: 1 - MP flake industries; 2 – indefinite MP (?) industries without bifacial forms; 3 - MP bifacial industries; 4 - archaic UP industries; 5 - UP industries; 6 - uncertain chronological position.

Three layers including archaeological and natural objects were recognized here. Two of them yield obvious evidence of human activity; these are cultural layers II/2 and I. The lowermost II/2 is separated from the uppermost layer I with remains of burned pines of layer II/1. The nature of remains in layer II/1 is still unclear; as they may present results of either human or natural activity, or probably combined effect of both.

Both Mira I and II/2 associate with the soil-sedimentary processes. Lithological, geomorphological, palynological, antrocological, micro- and megafaunistic analyses and radiometric (AMS and conventional ^{14}C) data allow precisely correlation of layers II/2, II/1 and I with Denekamp /late Vitachiv /Bryansk interstadial of Middle Pleniglacial and put both Paleolithic occupations between 27-28 uncalibrated ^{14}C ky BP (Stepanchuk *et al.,* 2004). As it supposed, human activity remains were likely quickly buried after the occupation, ensuring good surviving of artifacts and site structures. Actually they represents good example of well-preserved archaeological living floors.

Petrographic study of rock composition of lithic series coming from 2000 excavations of the site of Mira was conducted by Dr. V.F. Petrougne by means of studying of immersion samples under polarising microscope. Series of ca. 300 samples of flint and stone artefacts was subjected to analysing.

In archaeological sense assemblage of layer I might be defined as archaic EUP, while underlying Mira: II/2 appears to be authentic UP possessing Aurignacian and Gravettian features.

Lithic series of layers II/2 and I statistically are sharply different. While assemblage of layer II/2 enumerates only about 200 knapped flints, recovered on the same area (ca. 70 square meter) assemblage of layer I enumerates almost 60.000 lithic artifacts. This difference, probably, might be explained in terms of different durability of occupations, more ephemeral in the case of layer II/2. Another likely explanation is that only fringe zones of occupied area II/2 were unearthed till recently. Anyway, only general features of assemblage II/2 might be restored, while lithic series of layer I allow more comprehensive studies and detailed characteristic.

The following aspects are important in respect of better comprehension of situation with raw materials, namely: economic status of occupations, seasonality, and availability of raw materials in the vicinity of the site. Occupation of layer I was comparatively long-term, and was in function for several months. There are different indications pointing to the Autumn-Winter season of this habitation. Coming from the whole corpus of data in hands, it is possible to describe economic specificity of layer I occupation as seasonal settlement raised next to the place of successful single episode of hunting on harem group of wild horses. Evidence is far less representative in the case of layer II/2. It only possible to state now, that this occupation was likely ephemeral, and that accompanied faunal remains belong mainly to bison and horse. No data concerning seasonality of II/2 are in hands. Both assemblages were based upon flints, though not siliceous rocks are widely represented in assemblage of Mira I, as well. Interesting that Mira layer I assemblage includes few small-dimensioned pieces of flint which likely were found in alluvial context nearby the site. Additional difficulties in raw materials supply in the case of Mira I were added by natural constrains of season of habitation. These evidence obviously witness for objectively very strict conditions of raw materials supply at the site.

3 – Mira layer I industry: Variability of lithic raw materials

Nevertheless more than 20 varieties of used lithic rocks were recognized in materials of layer I (Petrougne 2002-2003; Stepanchuk & Petrougne 2008), of which 13 are different varieties of flints. Composition of industry of the lowermost layer is obviously more poor, besides the fact the non-siliceous rocks products are completely absent among lithic artifacts. Petrographic study of lithic artifacts recovered in 2000 was conducted by V.F. Petrougne (Petrougne, 2002-2003; Stepanchuk, *et al.,* 2004; Stepanchuk & Petrougne, 2005) by the mean of studying of immersion preparations under a polarizing microscope. The total number of petrographically examined flint and stone artifacts enumerates about 300 specimens (Tabl. 1).

Should be empasized that the total number of finds of the upper layer constitutes ca. 54,000 artifacts, while the layer II/2 yields only 200. The major portion of both series is represented by micro-flakes and tiny chips, enumerating up to 97% of assemblage. Larger artifacts were mostly subjected to the petrographic analysing, of course (Tabl.

Name of rock	Conditional code	Presence in layer I	Presence in layer II/2
Flint	Ia^1, Ia^2, Ia^3, Ia^4, Ia^5, Ia-b(A), Ia-b(B), Ia-b(V), Ia-b(G-1), Ia-b(G-2)	all except for Ia^5	Ia^5
Fossilized wood	Ib	+	-
Local sandstone	IIa	+	-
Quartzite sandstone	IIb	+	-
Zeolitised tuff	III	+	-
Effusive rock	V	+	-
Quartz-diabase	V	+	-
Quartz milonite-ultramilonite	VIa	+	-
Quartzite	VIb	+	-
Actinolitite	VIIa	+	-
Amphibolite	VIIb	+	-
Migmatite or gneiss	VIII	+	-
Tektite-Moldavite (?)	IX	+	-

Table 1 – Mira. The list of rocks, represented in materials of layer I and II/2

2). Each fifth large-sized flint artifact was analyzed, as well as each seven of ten non-siliceous lithic find. Below proposed brief description and definition of raw materials composition is belonging to late prof. V.F. Petrougne. These data are available in more detail in several special papers (Petrougne, 2002-2003; Stepanchuk, Petrougne 2005; and at http://www.ace.hu/ametry/meghive_2005_3.html).

UNIT Ia: Siliceous, mainly diagenetic and partially infiltratic rocks of basically chalcedoneous content

Subunit Ia¹

Mainly tabular laminated light grey to almost black flint with thin grey grainy mono-mineral chalcedony coarse cortex.
After V.F. Petrougne conclusion, flints of this subunit should be considered as delivered from the territory of modern Romania.

Subunit Ia²

Subunit of flints that are similar by structure and microfauna to previous type, but in various extent red-coloured. There is no data on primary outcrops of such kind of raw materials on the territory of Ukraine. To judge by series of signs, firstly by the content of microfauna, flints of this subunit are also originated from currently not precisely localised Romanian geo-locale.

Subunit Ia³

This subunit includes mainly grey with slight greenish tincture and grey-smoky spots, little transparent flints of alternately clayey-chalcedony content.

Table 2 – Mira. Provenience of raw materials used for production of flint artefacts from the uppermost layer I

Provenance of raw materials		Eastern Carpathians				Eastern Carpathians?	Prut	Dniester	Southern Bug		Dnieper (Krivoj Rog)	Dnieper (Cherkassy)	Volhyno-Podolian ?
Code of raw materials		Ia¹	Ia²	Ia³	Ia⁴	IIb	Ia-b (A)	Ia-b (B)	Ia-b (V)	Ia-b (V) ?	Ia-b (G-1)	Ia-b (G-2)	Ia⁵ ?
Category of artefact	flakes	1						1					
	blades	1											
	biface waste-flakes	10	1										
	waste-flakes of flake tool rejuvenation	5											
	tools on flake	49	5	3	1	1	4	1	1	1	1	1	1
	tools on bladey-flake	17		1									
	tools on blade	36	2	4	3	2	1	1	1				
	tools on bladelets	5											
	tools on biface waste-flakes	25			1								
	tools on waste-flakes of rejuvenation of edges of flake tool	14											
	tools on waste-flake of thinning of flake tool	8											
	core on flake tool	2											
	bifacial tool	3		3									2
	partially bifacial tool	2											
Total for varieties of raw materials		178	8	11	5	3	5	3	2	1	1	1	3
Total areas of origins of raw materials		Eastern Carpathians: 205					Prut: 5	Dniester:3	Southern Bug: 3		Dnieper: 2		Volhynia ?:3
Total areas of origins of raw materials, % (221=100%)		92.7					2.3	1.4	1.4		0.9		1.4

Localisation of primary outcrops of this kind of flints is still unknown, and this kind of rock is definitely absent on the territory of Right Bank Ukraine, Sub- and Transcarpathia, and in Carpathians itself.

Subunit Ia[4]
Subunit consists of hlauconised and partly patined flint raw materials. It might be paragenetically connected with area of primary outcrops of tabular smoky flints of subunit Ia[1].

Subunit Ia[5]
Transparent smoky chalcedony thin grain raw materials. Flints are similar to those of so called Volhynian (Podolian) type in its smoky variety.

Subunit Ia-b
This subunit is rather provisional and includes quantitatively subordinate series of samples of unusual mineral raw materials.
Ia-b (A)
These lithics with an apospiculae structure are analogous to flints associated with Lower Cenomanian deposits known in middle flow of Dniester and Prut rivers.
Ia-b (B)
A black smoky flint with white softy cortex. The raw material is originated from primary deposits of an Upper Cenomanian age exposed along the Dniester valley between mouth of River Kalus and Resina town.
Ia-b (V)
Almost not transparent, bold lustred, multicoloured, with blue-black, red-brown, smoky grey-whitish, secondary greenish-gray tints. Nodular cortex is white and soft. This rock is analogous to Sarmatian clayey-chalcedony flints of Bakshala type, e.g. known on the cortex of erosion of Ukrainian crystal shield in the mouth of River Bakshala in the basin of Lower Bug.
Ia-b (G-1)
Light grey not transparent almost dim fine-grained flints. Similar flints are known in the cortex of erosion of Proterozoic rocks of upper suite of Krivoj Rog series on the territory of Krivoj Rog town.
Ia-b (G-2)
Three-coloured, well transparent, mainly muddy-smoky, bold lustred and fine-grained flints. This kind of raw materials is known in the cortex of erosion of Ukrainian crystal shield in Middle Dnieper are and elsewhere in Right Bank Ukraine, e.g. in Cherkassy region (Petrougne, 2000).

UNIT Ib: **Siliceous rock of infiltratic-metasomatic origin**

This unit is represented by two varieties. The first – more frequent – is identical to chalcedonised petrified wood known in Paleogene deposits nearby town of Marganets, and might be provisionally identified as swamp cypress.
The second variety is represented by the isolated large size sample, the origin of which is not defined.

UNIT II: **Clastic(detrital) sedimentary rocks**

Subunit IIa
Predominantly grey sandstone with massive texture, basically analogous to Tertiary sandstones (from Buchak to Upper Pliocene) which were formed due to the destruction of crystalline formations of Ukrainian shield. This sandstone has most likely a regionally local genesis.

Subunit IIb
It is light grey, with glass lustre, quartzite-like sandstone. Romanian origin of this rock is cannot be excluded though outcrops of likely sandstone are known in Southern Bug valley, on the right bank of Mertvovod River, eastward of Voznesensk town.

UNIT III: **Sedimentary-volcanogenic, pyroclastic rocks**

Subunit IIIa

By the sum of signs, rock represents a practically completely zeolitised originally vitroclastic cemented (welded?) ashen tuff of silt structure and dacite (?) content. Most reasonably this rock is cognate with ante-Sarmatian formations of East-Carpathian region. Zeolitised tuffs and below characterized amphibolites – products of different stages of the process of zeolitisation - are represented in Mira layer I assemblage jointly. It is good ground to consider their origin from the area in which both formations are known. Therefore, we should say about the exterior zone of Carpathian arc, ranging between Ukrainian Transcarpathia and Northern part of Romanian Eastern Carpathians, up to latitude of Tirgu-Mures town (Onchescu 1960).

UNIT IV: **Effusive (volcanic, lava) rocks**

It is a greenish-grey in colour rock of microoligofire structure with an extra fine-grained basis. By the association with zeolitised pyroclastes has most likely regional-Carpathian origin.

UNIT V: **Intrusive (Plutonic) and dike and sill formations**

Dark grey quartz-diabase. The local origin seems to be most likely. The nearest outcrops of quartz-diabase are known, for instance, in the mouth of Samara River.

UNIT VI: **Rocks of dynamometamorphic genesis**

Subunit VIa

Quartz milonite-ultramilonite of most likely local origin, somewhere from the local crust decay of Ukrainian crystal shield localized not far from the site.

Subunit VIb

This, formed by quartz rock, is either of local (and moraine of Dnieper glacial), or more western (basin of Southern Bug, north to Pervomaisk town), and even Carpathian (alluvium of local rivers) might equally be supposed.

Unit VII: **Rocks of middle stages of regional metamorphism**

Subunit VII:

Almost mono-mineral aggregate composed of sub-prismatic crystals of actinolitite, isolated flakes of chlorite, silt dimensioned grains of quartz and magnetite.
To judge by pebble appearance, crystal-optic constants and paragenetic associations differing from actinolitite rocks known in area of Krivoj Rog (Petrougne 1967a), Dnieper area, and in Eastern Asov sea region (Danilevich 1970), actinolitites from Mira - as well as genetically close hornblende amphibolites - might originate from Carpathians, even maybe from the Rakhov massive in Transcarpathian Ukraine.

Subunit VIIb

This rock, black or dark grey on surface, with massive texture and heteronematoblastic structure, is determined as amphibolite.
Amphibolites are widely known among crystalline formations of southern edge of Ukrainian shield. But territorially the closest rocks known in various localities in Dnieper basin are different by row of macro- and micro-signs.
Till the definition of absolute age of the Mira samples by Ka/Ar, it is possible to consider them as belonging to the Carpathian area (Matkovskij, 1967) and area of crystalline shales (Onchescu, 1960).

Unit VIII: **Rocks of high stages of regional metamorphism**

These rocks are represented by isolated samples and have local origin. Among these are likely specimens of migmatite or gneiss from neighbouring areas of Ukrainian shield.

UNIT IX: **Rocks of uncertain genesis**

Water (?) eroded fragment of light green glass of gravel dimension, with dim surface but well translucent. Fraction with glass lustre, without admixture of clastic grains or inclusions. It might be either tektite-moldavite or rolled in water modern industrial glass. Sample is more similar to tektites by structural-texture features but index of refraction is more typical for modern glass. Chemical analysis of sample and its gas inclusions would be decisive for final solution.

Therefore, the examination of petrographic content of lithic artifacts of the site of Mira allows – to prof. V.F. Petrougne notion – to conclude the following.

1. Quantitatively predominate flints (subunits Ia^{1-3}) of the uppermost archaic UP layer of the site (Mira: I) are represented by mostly tabular smoky, grey-smoky and grey chalcedonolites which, due to their specific composition of inclusions, have no analogies among the silicilites of Ukrainian Right-Bank area, Ukrainian Carpathians, and Transcarpathia (Petrougne 1995). This flint raw materials (subunits Ia^{1-3} and, probably, Ia^{4}) have an Eastern Carpathian origins and, as well as a part of the non-siliceous stone rocks discovered at the site, were seemingly collected somewhere on the territory of modern Romania. The state of the physical preservation of chalcedonolitic artefacts allows to suppose the exploitation of either fresh primary outcrops or eluvially disintegrated flint-bearing rocks, most likely dated to Upper Cretaceous period. The lithics of subunits Ia-b and Ib quantitatively are less significant. Nevertheless, their peculiarities allow to define their exact origins. The assemblage of the upper layer of Mira includes the following varieties of lithics, i.e.: apospiculae chalcedonolites of Lower Cenomanian age (subunit Ia-b(A)) which were picked up in the area of modern Kosteshti town in the Prut valley; spiculae-inoceramic flints of Upper Cenomanian age (subunit Ia-b(B)) originated from the area of modern Soroki town in the Dniester valley; residual-infiltrated Sarmatian flints and opoka-like rocks (subunit Ia-b(V)) from the area of the mouth of river Bakshala in the Southern Bug valley; local cherts of Krivoy Rog type (subunit Ia-b(G-1)) in River Ingulets valley; fossilised wood (unit Ib) from the area of modern towns of Nikopol and Marganets in Lower Dnieper valley.

   There are both local and remote non-siliceous rocks in the Mira layer I assemblage, as well. The paragenetic association of zeolitised tuffs (subunit IIIa), actinolitites (subunit VIIa), amphibolites (subunit VIIb), and effusives (unit IV) points to Carpathian origins of certain exotic varieties of non-siliceous rocks. Sandstone of subunit IIa, quartz milonite-ultramilonite of subunit VIa, migmatite or gneiss (unit VIII), and probably quartz-diabase (unit V) have local origins.

2. The high quality homogeneous, fine-grained chalcedony flint raw material of the lower occupation Mira: II/2 (subunit Ia^{5}), though also smoky, but including only rare elementary microfauna, provides good macro- and microscopic affinities to chalcedonolites of western, at least Volhynian type. A further study is desirable with the aim of discovery of silicificated remains of fish whitebait. If the results would be positive, preliminary assumption about a Turonian age and Volhynian-Podolian origin of this raw materials should be regarded as proven.

3. In the case of the lowermost Mira: II/2 occupation, the outcrops of the lithic raw materials were remote from the site for at least 300 to 350 km, and might be localised somewhere in Western Ukraine. The typomorphic peculiarities of flints and non-siliceous rocks allow a comparatively precise tracing of the supposed route of a West-to-East movement of the people who left the uppermost Palaeolithic layer of Mira. There are grounds to believe that they started somewhere on the territory of modern Romania and passed almost in longitudinal direction across the valleys of Rivers Prut, Dniester, Southern Bug, Ingulets, and, finally, stopped at the right bank of Dnieper. The initial set of presumably East Carpathian flint and non-siliceous artefacts was added by testing of flint raw materials on the route to the Dnieper and by collecting seemingly local non-siliceous rocks of a Dnieper

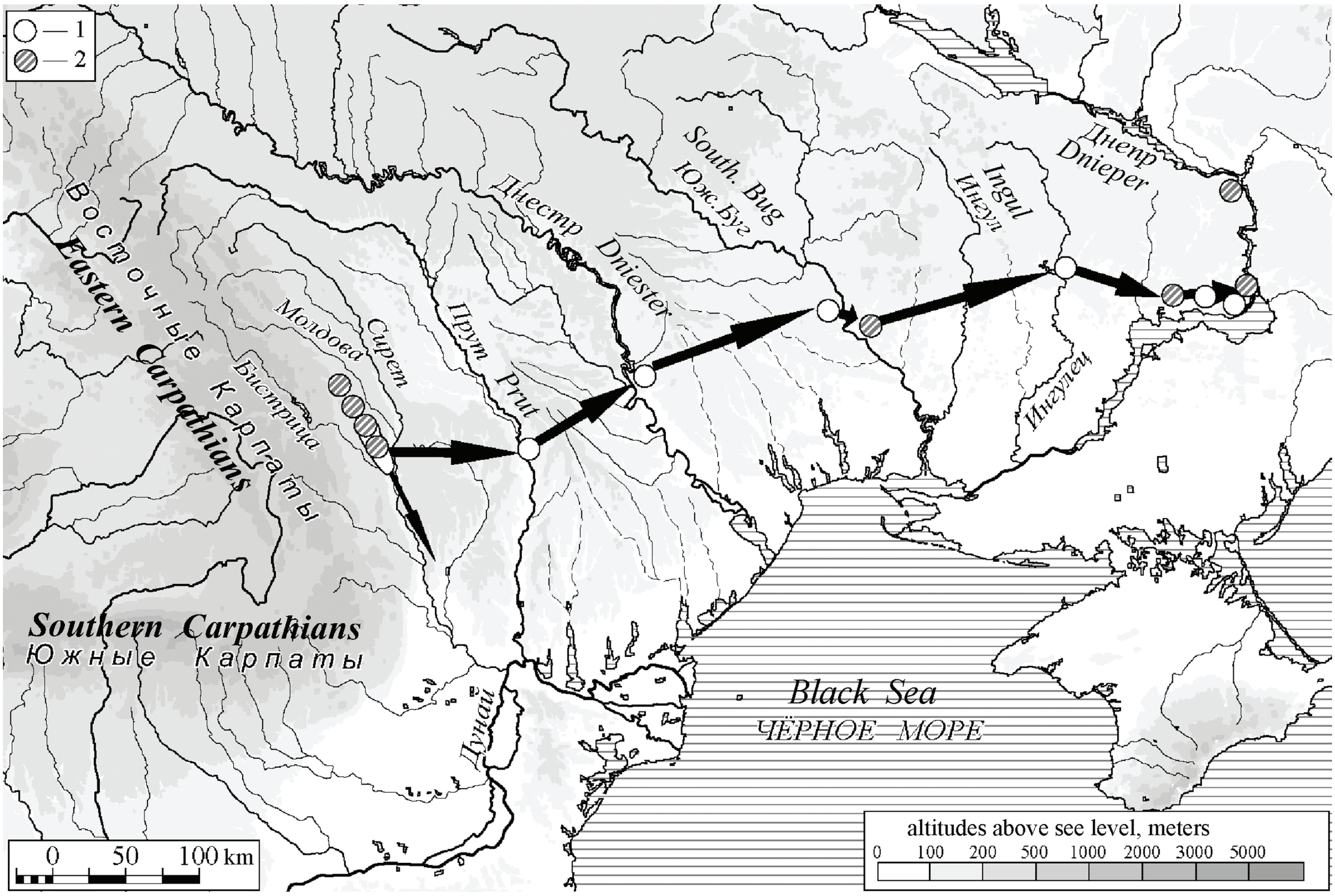

Figure 2 – The site of Mira. Layer I. Probable rout of migration of the group settled the layer, based on data of raw materials analysis. Circles mark areas of probable origins of siliceous (1) and not siliceous (2) rocks

provenance. The absence of typical flint raw materials known in the upper and middle segments of the Dniester valley, and the lack of characteristic Lower Danubian flints strengthen the justification of this direction of movement. The quantitative prevalence of the most remote raw materials points to the notion of comparatively rapid movement from the Carpathians to the Dnieper. Paragenetic association of zeolitised tuffs, actinolitites, amphibolites, and effusives also points to Carpathian origins, while sandstones, quartz milonite-ultramilonite, migmatite or gneiss, and probably quartz-diabase have local origins. Typomorphic peculiarities of flints and non-siliceous rocks allow to trace rather precisely West-to-East about 750 km long movement of Mira layer I occupants (Petrougne 2002-2003) (Fig. 2).

4 – Mira layer I lithic assemblage

As it was revealed by the petrographical analysis, the major portion of flint artifacts and almost all non-siliceous artifacts which were recovered in the uppermost (I) layer might be defined as originated from the fairly remote locales, likely East Carpathian. Practically all further flints were also collected rather far from the site. Worthy to note, by the way, that the overall weight of presumably East Carpathian flints and stones from the layer I not exceed 5 kilos grams.

The complete absence of primary local flint outcrops in the area of localization of the site, seasonal constraints in acquisition of any available redeposited lithics, and, therefore, the impossibility of any significant renewing of initial stock of lithic raw materials had resulted in the situation that might be described as a permanent acute shortage of lithics for knapping, literally the "starvation" of stone industry. Two processes were might potentially be turned on due to this dire shortage of stones. These two are: *a)* intensification of physical exploitation of available flints, i.e. working until compete exhausting, intensive re-use, re-shaping and re-sharpening, and b) invention of more sophisticated ways of exploitation of available lithics, which would allow to get the desired result at a lower cost of raw materials.

Many technological and typological features witness for intensive utilization of available raw materials. Layer I flint assemblage provides obvious and expressive instance of extremely transformed industry, which exhausted appearance resulted from the intensive utilization and re-utilization of limited number of initially thoroughly sorted lithic artifacts.

Mira layer I assemblage contains very rare and critically exhausted "secondary" cores, that is the forms prepared on either flakes or bifacial pieces, followed by few small fragments of raw materials, series of flakes, flake tools, bifacial tools, and crucially predominate chips or micro-flake-wastes of bifacial and flake tools' knapping, sharpening and reshaping (Stepanchuk, 2005; 2011a).The assemblage of Mira, layer I currently consists of preponderant micro-flakes but its definition as flake-oriented and micro would be wrong. As it revealed by the detailed analysis, in fact we deal with industry basically oriented to production of large blades and bifacial tools. There are definite indications of utilization of single platform cores. The preparation of crest at the pre-core stage is anticipated and revealed by the presence of crested products in the assemblage.

Thus, the initial composition of lithics which were included in tool-sets of occupants of Mira layer I at the beginning of their migration to the Dnieper valley was likely represented by large, massive, and wide blades, likely products of utilization of parallel single-platform volumetric cores, and large bifacial pieces. Retouched flake tools and bifacial tools and/or semi-products, and probably few pieces of raw materials in form of blanks and tested fragments were also delivered at the site. Different techniques were applied for the further transformation of the initial set of flint artifacts, among these are: intentional fragmentation, reshaping and rejuvenation, various thinnings, including core-like thinning, core-mode knapping of bifacial artifacts and larger blades and flakes, and regular knapping of fragments of raw materials. Should be stressed that assemblage includes no indisputable cores on fragments of raw materials, common products of regular knapping are rare (fig. 3), while the small-sized wastes of routine curation of stone tools are extremely numerous.

5 – Technological aspect of Mira layer I industry

Only limited number of technologically meaningful aspects of the industry under discussion can be discussed. At least one important aspect is completely impossible to investigate, because Mira layer I provides literally no cores. Therefore, the features of lithic technology might only be traced in available series of flake products and bifacial pieces.

The series of flakes, bladey flakes, and blades of Mira layer I represents rather complex conglomerate of products which were appeared at different stages of utilization and re-utilization of initially not numerous number of lithics.

Technical indices of Mira layer I assemblage are represented in table 3. They were calculated upon a series of 650 comparatively large flakes, including retouched ones, recovered during the field season of 2000.

The series demonstrates comparatively high percentage of faceted butts, medium range of index of blades, and rather high quota of flakes with centripetal pattern of dorsal surface. There are frequent signs of soft hammer stone technology, as well.

Flakes, which were appeared – either as end-products or as waste-products - in course of that or those biface or uniface operational sequences, sometimes are characterized by rather clearly recognizable morphological features. This fact provides an opportunity to conduct more differentiated evaluation of technical indices (Tabl. 4). Large number of faceted butts might be evaluated as a marker of the specificity and archaism of applied knapping technique. Generally correct, this notion should be critically interpreted in the case of Mira assemblage. It is quite possible that the certain quota of flakes with

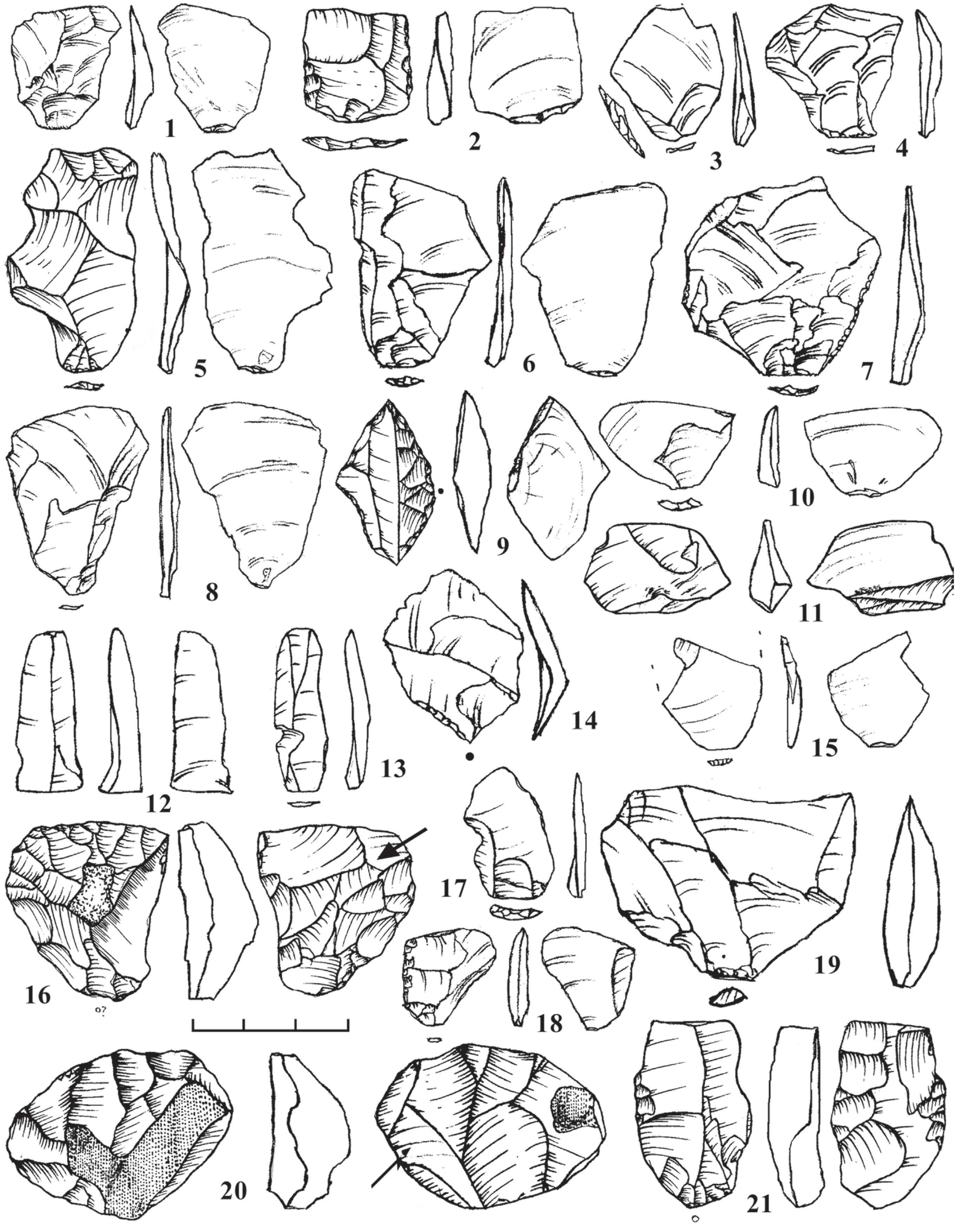

Figure 3 – The site of Mira. Layer I. 1, 2, 4-8 – products of knapping of bifaces; 9, 14 – products of transversal knapping of blades; 3, 10, 15, 17 – products of knapping (thinning) on ventral surface of flakes; 11-13, 18 – products of longitudinal knapping of flakes (12, 13 – blades); 16 – «core» - an instance of knapping of massive endscraper *; 19 – regular flake; 20 - «core» - an instance of knapping of massive flake *; 21 - «core» - an instance of knapping of massive blade. * arrow points to survived area of ventral surface of initial flake

faceted butts recognized in assemblage of Mira layer I and identified as likely products of knapping of cores with facetted striking platforms (Tabl. 4), represents, in fact, either by-products or end-products of treatment of bifaces, which were might served as cores.

Should be emphasized, that the site of Mira is localized outside of zone of development of Upper Paleolithic with bifacial tools, but in the zone of fairly intensive development of bifacial Middle Paleolithic industries, instead. That is why any manifestation of bifacial technology might be regarded as reminiscences of earlier traditions.

As to bifacial pieces, the mode of rough shaping and further finishing of retouched edges finds the close similarity with so called Middle Paleolithic Micoquian technology (Wetzel & Bosinski 1969). Plano-convex sections are predominating. Thoroughly retouched edges are localized on more convex surfaces. Signs of technological innovations elsewhere recognized in Upper Paleolithic context (Bradley, *et al.,* 1995; Girya, 1997) are not visible in the assemblage of layer I. Bone retouchers were likely broadly involved into biface curation, at least these artifacts are rather frequent among finds. Once again, these tools show no difference with their Middle Paleolithic analogies.

The relatively large quota of facetted butts may indicates the application of the Middle Paleolithic way of curation of working zones of cores. Flake-wastes of bifacial treatment are identical with standard Middle Paleolithic products of this kind.

By the other hand, high frequency of flakes with lips allows to conclude about the intensive use of soft hammer technique. Very frequent reduction of the outer zone of striking area on flakes signalizes the commonly Upper Paleolithic way of controlling the parameters of striking zone (Girya & Nekhoroshev, 1993).

In general, the uppermost layer of the site demonstrates, in certain sense, a mixture of Middle and Upper Paleolithic technological features, or, if to formulate more cautiously, some mixture of more sophisticated and "progressive" and less developed and "archaic" lithic technologies.

Examination of metric parameters of initial flake-blanks was performed for 39 secondary retouched artifacts. 27 of them (69%) were manufactured on blades and

Mira layer I. The main technical indices of the series of flake products							
Index of flakes with parallel dorsal pattern	Index of flakes with centripetal dorsal pattern	IF	IFs	Index of flakes with punctiform butts	I lam	Index of flakes with lipped butts	Index of flakes with reducted striking zone
43.14	14.51	31.6	26.57	14.62	15.56	60.48	44.36

Table 3 – Mira. Layer I. The main technical indices of the series of flake products

	products of regular knapping of raw materials		waste-products of working of bifacial pieces		waste-products of ventral thinning of flake pieces		products of regular knapping of raw materials		waste-products of working of bifacial pieces	
	N=257		N=336		N=34		N=659		N=1286	
	N	index	N	index	N	index	N	index	N	index
IF	11	12,09	145	53,31	12	66,67	18	5,56	186	26,23
IFs	7	7,69	140	51,47	10	55,56	17	5,25	174	24,54
Ilam	47	38,52	16	2,38	1	2,94	107	16,24	171	13,29

Table 4 – Mira. Layer I. The main technical indices of series of flakes appeared at various stages of exploitation of raw materials

		"MP *vs.* UP" habitus of the series of flake tools					
The type of initial blank		MP	UP	micro-component	indefinite	Total, N	Total, %
	(0) piece of raw materials	-	-	-	1	1	0,14
	(1) Product of testing of raw materials	6	9	7	21	43	5,96
	(1 or 2) Product of either testing or decorticage	-	1	3	7	11	1,53
	(2) Product of decorticage of initial raw material pieces	9	21	29	57	116	16,0
	(3) Product of reshaping of core or bifacial blank	-	2	-	-	2	0,27
	(4a) Product of reshaping and resharpening of flake tools	3	3	178	49	233	32,3
	(4b) Product of reshaping and resharpening of bifacial tools	1	1	34	34	70	9,71
	(4c) Product of modification of already finished tool	7	12	2	24	45	6,24
	(??) Product of undefined position	10	10	23	157	200	27,7
	Total N	36	59	276	350	721	
	Total %	4,99	8,18	38,28	48,54		99,9

Table 5 – Mira. Layer I. Correlation of "MP vs. UP" habitus of flake tools and the type of initial blank

bladey flakes. Their average width and thickness constitute 24,96 and 8,59 mm, respectively. Likely length of these products varied between 10 and 15 cm.

This data witnesses for rather developed blade standard of Mira layer I industry. The practically lack of products with bi-directional parallel dorsal pattern (cf. Tabl.5) probably points to predominant exploitation of (semi) volumetric cores with one striking platform, with likely formation of crest at the early stage of core reduction.

As it is expected coming from raw material shortage, the bifacial artifacts of the initial tool set were rather big and, undoubtedly, larger than forms currently represented in the assemblage of the uppermost Paleolithic layer of the site. Such a notion is supported by the fact of presence of relatively large flake-wastes of bifacial treatment in the Mira layer I assemblage. These flakes are metrically obviously not correspond to available bifacial pieces and were struck from the evidently larger tools.

Table 6 contains some statistics concerning the flakes or pieces of raw materials which were used for production of tools, with special reference to their expected position in the technological operational sequence.

Following stages of this latter were distinguished, namely: 0 – piece of raw materials, 1 - testing of raw materials, 2 – decorticage of initial raw material pieces, 3 – reshaping of core or bifacial blank, 4a – reshaping and resharpening of flake tools, 4b - reshaping and resharpening of bifacial tools, 4c - modification of already finished tool, ? – undefined position.

Worthy to stress that there is no clear interdependence between the type of flake and type of secondary retouched tool.

Summarizing the Mira layer I industry in its technological aspect it would probably be more accurate to define it as basically Upper Paleolithic but possessing expressive archaic features.

dorsal pattern/ type of flake	flakes most likely appeared in course of utilisation of cores					waste-flakes of biface working			waste-flakes of utilization of flake tool			Total	
	flakes	blades	flake tools	blade tools	*Total*	flakes	tools	*Total*	flakes	tools	*Total*		
plain	3		4		7							7	7
cortex	2		2		5				2		2	6	7
cortex+crest			1									1	
convergent	1	1	4		9	45	5	50	11	5	20	72	79
convergent+cortex			2	1					2	2		7	
centripetal		1	2			51	5		2	1		62	
centripetal + cortex			1		4	1		57			3	2	64
parallel	2	2	4	6		7			5	2		28	
parallel + crest				1								1	
parallel + cortex	2		1	3	38			42	1		49	7	129
subparallel	4		7			26	5		31	7		80	
subparallel + cortex	2	1	2	1		3	1		3			13	
bipolar	1					2	3					6	
bipolar + cortex					2	1		6				1	8
bipolar + cortex + crest	1											1	
perpendicular	1		4	1		6			6	3		21	
perpendicular + cortex	1	1	2	1	17	1		26		1	20	7	63
subperpendicular	1		1	1		17	1		9	1		31	
subperpendicular + cortex	1		2			1						4	
retouched			11				1			1		13	30
indefinable	3		11		25			1	2	1	4	17	
TOTAL	25	6	61	15	107	161	21	182	74	24	98	387	387

Table 6 – Mira. Layer I. Correlation of "MP vs. UP" habitus of flake tools and the type of initial blank

Quantitative shortages of raw materials influenced to a considerable transformation of the original appearance of the industry. The industry, initially focused on production of large blades, ultimately looks like a flake-oriented. Bifacial tools that were originally large, were almost completely exhausted through use as a mobile reserve of flint raw materials.

6 – Typological aspect of Mira layer I industry

The industry under discussion is characterized by certain mixture of more developed or "progressive" and less sophisticated or "archaic" features in typology, as well. To be more strongly expressed, this difference is described – conditionally, of course – as Middle Paleolithic and Upper Paleolithic features (Tabl. 7).

The following characteristics of the industry under discussion should be emphasized, these are: developed blade-oriented technology, skilled application of bifacial technology, combination of Middle and Upper Paleolithic typological elements, certain techno-typological features usually regarded as typically Aurignacian, and also certain Gravettian techno-typological features.

Middle Paleolithic flake tool types are represented by the points and sidescrapers (Fig. 4: 2, 10, 11). There are canted points and sidescrapers, including forms with dorsal thinning of area opposite to the point, and also sidescrapers with thinned dorsal surface, including pieces with base thinning. Certain tools referred to the group of so called convergent forms might be defined in different way. For instance, some among secondary worked pieces might be regarded as point on blade or as pointed blade, and further conclusions clearly depend on this very subtle difference in definitions. The typological status of one more artifact is also uncertain. It might be defined as either point, or pointed area on the angle of truncated blade. Worthy to note the large blades and their fragments equally served as the most preferable blank for both conditionally Middle Paleolithic and Upper Paleolithic tool types. This type of flake blank is followed by struck flakes from bifacial pieces, and completed by the far less frequent products of regular knapping.

Mousterian points	13	Krems or El-Wad points	4
Canted points	3	Micro-points	7
Simple sidescrapers	3	Dufour bladelets	15
Double sidescrapers	2	Mira type microliths	138
Canted sidescrapers	5	Truncated pcs.	6
Convergent sidescrapers	2	Piece esquilles	20
Limaces	2	Percoir	8
Sidescrapers	3	Retouched blades and bladelets	45
Combined tools	15	Retouched micro-blades	50
Endscrapers	36	Retouched flakes	81
Burins	5	Retouched nicro-flakes	87
Pointed flake pcs	18	Fragments of tools	153
Total 721 pcs.			

Table 7 – Mira, layer I. Typological structure of flake tools, recovered in 2000

layer	Laboratory code	age, years BP, uncalibrated dates	age, years BP, calibrated dates, Fairbanks0107 calibr. curve
I	Ki-8152	27600±370	32943±420
I	Ki-8153a	27200±380	32518±434
I	Ki-8154	27300±390	32625±442
I	Ki-8158	27050±350	32359±403
I	Ki-10283	26610±400	31888±456
I	Ki-10284	27080±400	32391±453
I	Ki-8381	28450±1100	33822±11490
I	GrA-20019	26590±490/460	31866±548/516
II/1	Ki-8155	26800±390	32092±443
II/1	Ki-10346	27160±390	32476±445
II/1	GrA-20020	27830±580/540	33184±631/588
II/2	Ki-8156	27200±360	32519±413
II/2	Ki-8201	27510±400	32847±451
II/2	GrA-20033	27750±590/550	33090±642/601

Table 8 – Mira. Absolute radiocarbon age: AMS and conventional *Uncal* and *Cal* dates

Upper Paleolithic types are represented by points, *piece esquilles* (Fig. 4: 5), sometimes rather intensively retouched blades (Fig. 4: 9), endscrapers, numerous and embracing a raw of variations, the subtriangle laterally retouched subtype of which is the most common in Mira layer I materials (Fig. 4: 1, 3, 4, 7). Typically Aurignacian endscrapers are few, though endscrapers made on "thick" blanks are quite common and tools of *á museau* type are also represented. Burins are also not frequent, both angle and carinated forms are represented (Fig. 4: 6). Some of bladey flakes demonstrate alternatively disposed blunted edges and resemble artifacts of Dufour type, though this resemblance is probably incidental.

Bifacially worked tools recovered in the context of the uppermost layer of Mira are represented by 16 complete and fragmented (mainly constituted by pieces of tips) leafpoints or points (Fig. 5), including bipointed slightly asymmetrical shape (Fig. 5: 10), followed by convergent sidescraper, and also by 15 further indeterminable fragments.

As it was stressed above, the bifacial tools of Mira layer I seemingly correspond to the Middle Paleolithic technological pattern. It is true for virtually all artifacts; probably save for the above mentioned isolated bipointed foliate. This latter artifact also has pronouncedly plano-convex section, but appeared to be more carefully manufactured, even maybe with application of pressure flaking technique.

The presence of so thoroughly manufactured bifacial item in the context of Mira layer I makes a reason to regard the majority of other bifacial artifacts as just that they look as, i.e. as - sometimes reutilized - products of the processes of reduction of the initial set of larger foliates as a cores. In its turn, it probably means that the main techno-typological idea of Mira layer I tool-makers was to prepare the bifacial foliates, only one of which survived intact, while other were used as mobile flint reserves under the terms of raw materials shortage and lose their shape.

Typical for Mira layer I assemblage, the series of so-called combined tools represents various combinations of endscrapers, sidescrapers, points, scaled thinnings etc. Such a very expressive instances as endscrapers-Mousterian points (Fig. 4: 1, 7) provide good analogy for above-mentioned subtriangular laterally retouched endscrapers (Fig. 4: 3, 4).

Retouched or used - i.e., with retouch of utilization - bladelets comprise several dozen pieces (Fig. 6: 17-25). Rather atypical Krems-points (Fig. 6: 1-4), inversely retouched bladelets of Dufour (Fig. 6: 5-11) and Roc-de-Comb (Fig. 6: 12-16) types, and also micro-truncations, micro-points (Fig. 6: 26-30; 54-56) and considerable series of micro-flakes with light, often partial, edge retouch are represented in the Mira layer I assemblage.

The major portion of these artifacts represents the products of slightly elongated micro-flakes (chips) appearing in the course of reshaping and rejuvenation of tools on flakes and more rarely of bifacial tools. Their proportions are rather short, and they occasionally have a twisted profile.

Dufour-like bladelets recovered in the uppermost layer of Mira are rather atypical, and artifacts more similar either to the Dufour or the Roc de Comb subtypes might be defined. There is no need to suppose the reduction of core-like pieces to explain the origins of these artifacts, though certain artifacts is possible to regard as cores for lamellar products (Fig. 4: 5). By the other hand, so abundant in the Mira layer I assemblage micro-wastes of retouching and resharpening yield numerous atypical bladelets. Among of more than four hundred atypical bladelets, there are 149 straight in profile, 136 slightly curved, 73 curved, and 72 twisted. Worth noting is the presence of regular retouched bladelets, as well.

Presence of micro-component in the layer I of Mira is of great importance, because points clearly to the very likely exploitation of composite tools. Of course, the usage of composite tools is not revolutionary thing neither from the viewpoint of Mira layer I chronology (ca. 30 ky BP) nor its context (Early Upper Paleolithic). Nevertheless, this point deserves a special attention from the viewpoint of probable consequences of raw materials shortage in the uppermost Paleolithic layer of Mira.

The next highly unique feature of the Mira layer I assemblage is the presence of a large (more than 140 pieces) series of micro-flakes with retouched edges. They represent mostly short trapeze-like chips with blunted transversal edge (Fig. 6: 31-53, 57). Sometimes the retouched edge is obliquely to the striking platform, or along the

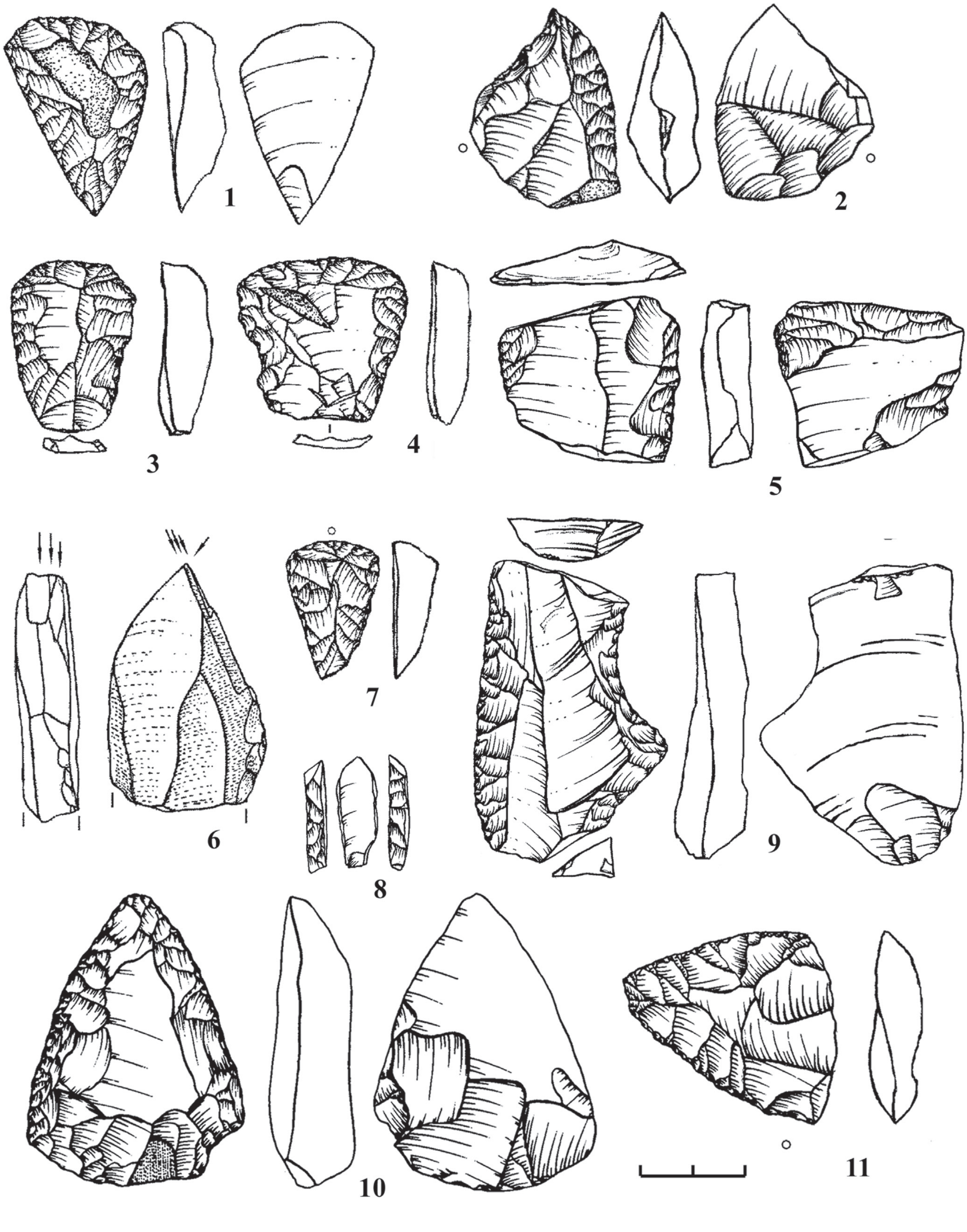

Figure 4 – The site of Mira. Layer I. 1, 7 – endscraper combined with point/ bilaterally retouched subtriangle endscraper; 2 – base thinned flake point; 3, 4 – endscrapers; 5 – piece esquille on fragment of large blade; 6 – burin; 8 – micro-tool with abruptly blunted edges; 9 – intensively retouched and reshaped large blade; 10 – base thinned point/ convergent sidescraper; 11 – canted sidescraper

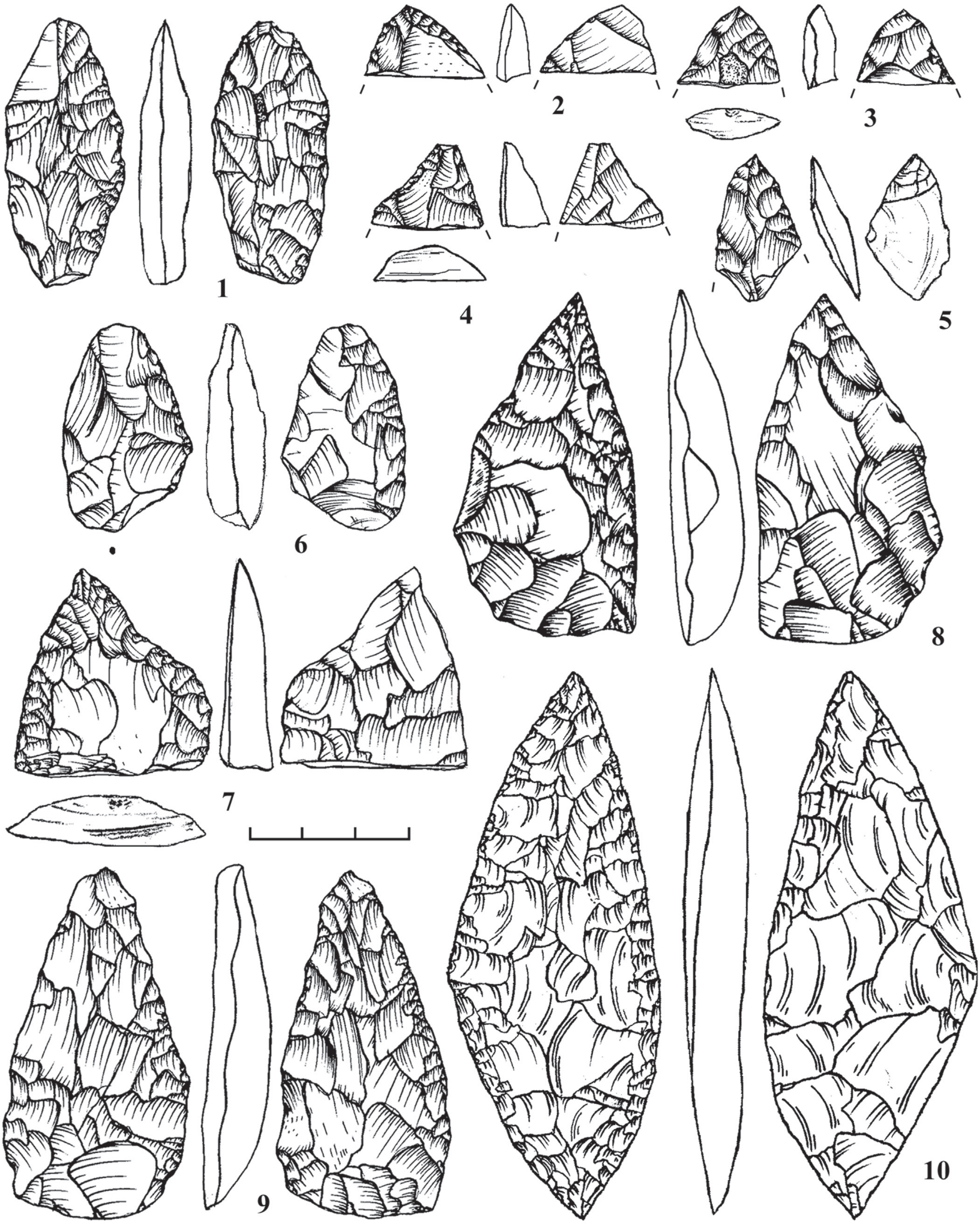

Figure 5 – The site of Mira. Layer I. Complete (1, 6, 8-10) and fragmented bifacial artifacts. 1 – exhausted bifacial foliate artifact used as piece of raw materials; 2-5 – fragments of tips of foliate pieces; 6 – massive flake used for core-like knapping and resulted in partial bifacial artifact; 7-9 – bifacial foliates used as raw material pieces and later reshaped in various extent; 10 – thoroughly reshaped bifacial foliate

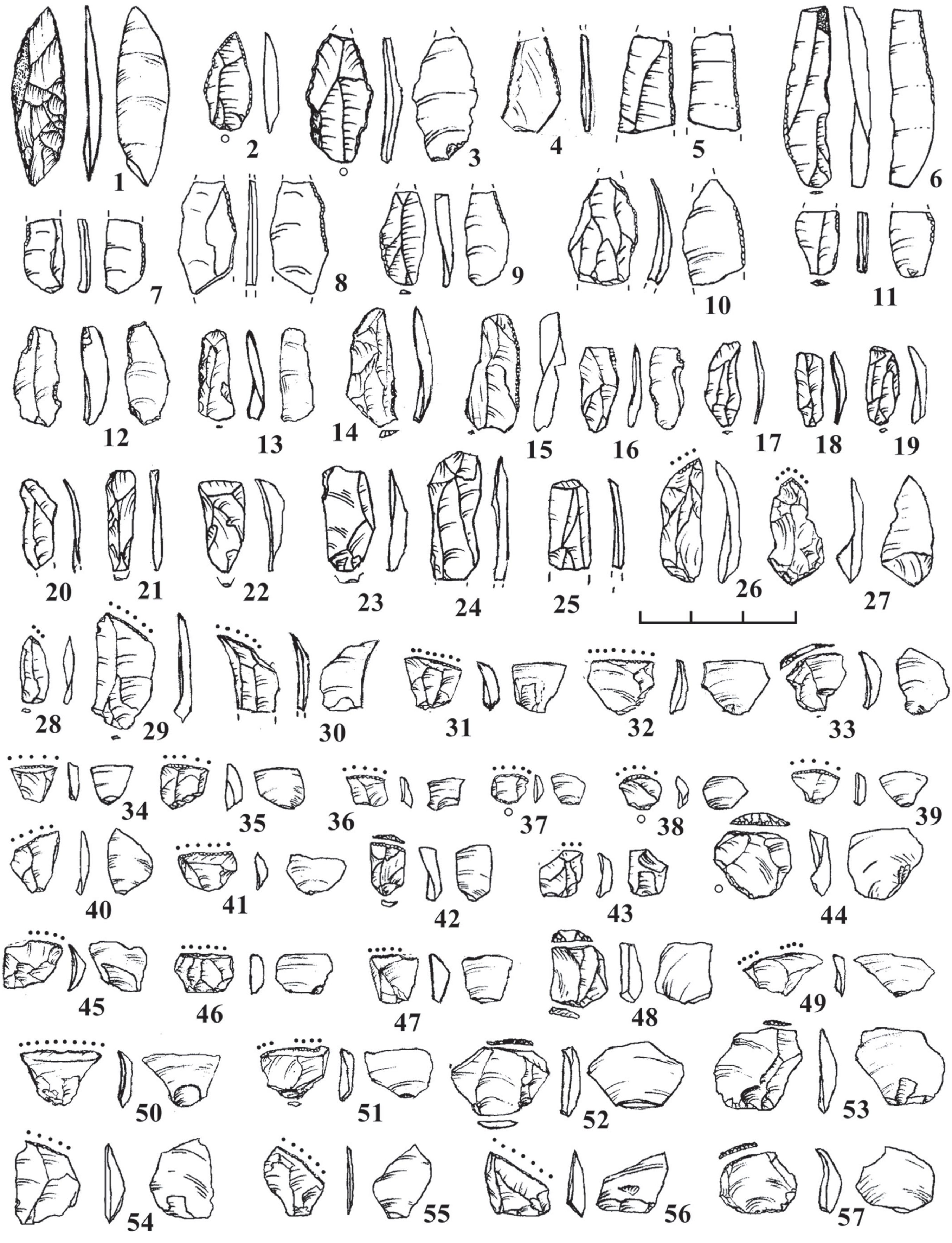

Figure 6 – The site of Mira. Layer I. 1- artifacts similar to Krems points; 5-16 – artifacts similar to Dufour bladelets of Dufour (5-11) and Roc-de-Comb varieties (12-16); 17-25 – micro-blades; 26-30, 54-56 – oblique micro-points; 31-53, 57 – microliths of Mira type

striking axis; double-edge artifacts are rare. Some specimens bear what seems to have been the result of use-wear damage (?) (Fig. 6: 31, 36, 43).

Non-geometrical microliths of Mira type represent analogies of East European Epi-Aurignacian assemblages of Zolotovka-Muralovka type (Praslov and Shchelinskij 1996). These assemblages are dated to 22-20 ky BP and include numerous non-geometrical microliths technologically similar to Mira type artifacts, although morphologically not completely compatible.

Generally speaking, microliths of Mira and Zolotovka-Muralovka types are of the same technological idea as Aurignacian Dufour bladelets of Roc-de-Comb subtype. The most common feature of these two is that micro-flakes which were appeared in course of retouching of comparatively thick flake tools and were characterized by mostly shortened proportions were used as blanks for manufacture of non-geometrical microliths. In fact, in certain chronological and typological sense, Mira layer I represents some intermediate link between earlier Aurignacian industries and later Epi-Aurignacian assemblages of the steppe area of the South of the Estern Europe.

Mira layer I assemblage also includes not numerous microlithis with abrupt blunted retouch along the perimeter (Fig. 4: 8). To these one can add the certain number of fragments of bladelets and micro-blades with similar abrupt retouch disposed along edges. Technological features of their manufacture make them more likely as product of Gravettian circle of industries.

Therefore, at the baseline, the industry of Mira layer I was aimed to manufacture of big blades and flakes, and also of bifacial pieces. Later, under the terms of raw materials shortage, the forcedly intensive transformations of the initial set of lithic artifacts were resulted in formation of flakey appearance of the assemblage, its microlithitisation, and distortion of morphological features of the inventory. As it seems, Mira layer I tool-makers were rather sophisticated and open-mind experts for independent invention and intensive applying of micro-tools and insert technologies.

At the moment of discard, Mira layer I assemblage comprises flake points and sidescrapers of Middle Paleolithic appearance, and also typically Upper Paleolithic endscrapers on flakes and fragments of blades, and few burins. Bifacial forms includes foliates, points, backed forms of mainly Middle Paleolithic exterior. This tool-set was complemented by numerous non-geometric microliths of Mira type, the series of atypical inversely retouched bladelets and atypical Krems-Dufour points, micro-truncations etc.

There are grounds to believe that the initial Mira layer I assemblage was composed by a wide and long retouched blades, endscrapers on such blades, few burins, and bifacial leafpoints. This set was likely complemented by sidescrapers and points, as well. But it also seems very likely that the micro-tools prepared on wastes of rejuvenation and re-shaping initial set were not included in initial tool-kit, and were invented already in Dnieper valley, somewhere ca. 30 ky BP.

The major portion of these micro-artifacts represents products of slightly elongated micro-flakes appeared in course of reshaping and rejuvenation of flake and more rarely of bifacial tools. There are some grounds to believe that appearance of original micro-component of Mira layer I, as well as Aurignacian-like products, might be explained as an independent innovation under the circumstances of scarcity of available raw materials.

7 – Mira layer I industry: concluding remarks

The initial appearance of the assemblage of Mira layer I was essentially transformed under the terms of raw materials shortage and acquired its current look due to the intensive exploitation and repeated reshaping of a limited number of probably carefully sorted artifacts. This initial set of artifacts was probably represented by big massive and wide blades and large plano-convex bifaces, most likely, foliated.

Cores – or rather core-like artifacts - are few. Already knapped pieces of raw materials, like flakes, flake tools, bifacial pieces were used as blanks for knapping. Centripetal manner of knapping prevailed. Both the faceting and trimming were applied for curation of properties of striking area. The overwhelming majority of the assemblage is represented by micro-wastes of rejuvenation of bifacial and flake tools.

By the typological point of view, Mira layer I assemblage contains points, sidescrapers, endscrapers, combined tools (mostly various combinations of endscraper-sidescraper-point), burins, pointed blades, *pieces esquielles*, retouched flakes, blades and bladelets.

Bifacially worked artifacts include complete and fragmented foliates, points, convergent sidescraper, indefinable pieces.

Micro-component consists of Krems points, Dufour bladelets. These Aurignacian-like elements of the assemblage are rather atypical although well recognizable and complemented by micro-points on bladelets, micro-truncations, and specific blunted pieces.

The highly specific non-geometric artifacts defined as microlithis of Mira type is quite original and represents completely distinct typological feature of Mira layer I industry.

Mira layer I assemblage also includes numerous bone retouchers, fragments of points, needles (?), polishers, pierced fox and polar fox tooth, pieces of bone objects with engravings, amber pendant.

Mira is dated by the means of radiocarbon method to 28-27 uncalibrated ky BP (Table VIII). The calibration procedure according the curve Fairbanks0107 points to the calendar age of 33-32 ky BP. Calibration curves CALPAL 2005 SFCP and Fairbanks0805 settle Mira occupations between 31-29 ky BP (Kiosak 2008). Absolute dates are in good accordance with geological, palinological, paleontological, and archaeological evidence.

The lithic industry of the layer I is rather original and multi-component. Different contexts may provide parallels for the Mira layer I assemblage. For instance, the industry might be defined as Szeletoide or post-Micoquian and found analogies in regional East European Middle Paleolithic with bifacial leafpoints, i.e. in para-Micoquian (Stepanchuk 2006). In this sense, the morphologically, chronologically, and spatially most close analogy of Mira I is provided by the Kiik-Koba MP industry of the Eastern Crimea.

At the same time, the industry is similar to archaic Streletskaya and Gorodtsovskaya EUP industries of Middle Don area. In this sense, Mira I is most close to Gorodtsovskaya, although it is differentiating by the more developed bifacial component. The most essential difference with Streletskaya is absence of triangular bifacial points in the context of Mira. Certain *Aurignacoïdeness* is specific for Mira layer I but this feature is not unknown in the context of Gorodtsovskaya sites, as well (Stepanchuk 2011b).

Territorially most remote though techno-typologically rather close analogies of Mira layer I are represented by East European archaic EUP industries of Zaozerye, which age is defined between 34-33 ^{14}C ky BP, and Byzovaya (29-28 ^{14}C ky BP) (Kanivets 1976; Pavlov 2009; Svendsen *et al.,* 2010) reported for the Kama and Pechora basins in the north-east of European Russia.

Less remote analogies in area between Dniester and Carpathians might be seen in such assemblages as Gordineshti I, Ceahlău-Cetătica, layer 1, Brynzeny I: III. An important aspect of these and similar industries is a combination of archaic and advanced Upper Paleolithic, often Aurignacian, components, as well as familiarity with the bifacial technology (Anikovich *et al.,* 2007; Borziac 2008; Păunescu 1993; 1998; Noiret 2004).

Thus, there are several options to define the industry of Mira layer I, more or less comparable by their validity. It might be regarded as post-Micoquian (or Szeletian), as archaic (symbiotic) Gorodtsovskaya industry or its analogy, as Aurignacian industry rich in bifacial component (similar idea was recently argued by J. Hoffeker (2011), finally, as original phenomenon of the Southern East European steppe.

Whatever it was, this industry demonstrates impressive picture of deformation of its initial habitus by multiple re-workings of limited number of initially available lithics. Raw materials shortage was clearly impacted on intensive microlithisation of the inventory, stimulated the transformation of typo-morphological pattern of the assemblage, and likely promoted the independent invention of original category of flint implements.

To date, the site of Mira represents a unique instance of well-documented archaeological records recovered in the continental Ukraine and directly related to the final stages of the period of coexistence of Middle and various kinds of Upper Paleolithic cultures in Eastern Europe. One of its highly peculiar features is relying on very remote raw materials. Long-distance migration, followed by the rather durable stay in area devoid of suitable siliceous rocks was resulted in specific Mira case of raw material exploitation

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M. Yamada & A. Ono
Lithic raw material exploitation and circulation in Préhistory. A comparative perspective in diverse palaeoenvironments
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2.5. Obsidian exploitation and circulation in Late Pleistocene Hokkaido in the northern part of the Japanese Archipelago

Résumé
L'obsidienne était la matière première la plus importante à la fin du Pléistocène à Hokkaido au nord de l'archipel japonais. Des 21 sources archéologiques d'obsidienne à Hokkaido, 8 ont été employées au Paléolithique supérieur (35-10 ka cal BP.). Dans notre étude nous nous sommes intéressés à reconstruire l'histoire de l'exploitation de l'obsidienne au Paléolithique supérieur en examinant les analyses publiées sur l'approvisionnement en obsidienne et en les comparant aux proportions d'obsidiennes dans les diverses sources actuelles dans les assemblages archéologiques de 6 régions à Hokkaido.

Durant toute la période du Paléolithique supérieur, les sources d'obsidienne les plus utilisées se trouvaient à proximité des sites ; l'exploitation des autres sources variait selon la période et l'industrie lithique. Parmi les quatre sources principales d'obsidienne, Shirataki, Tokachi, Oketo et Akaigawa les deux premières (Shirataki et Tokachi) étaient largement utilisées sur place à partir de l'E.U.P. (35-25 ka cal BP). Par contre les deux dernières approvisionnaient les sites voisins durant l'E.U.P. et eurent une grande diffusion à l'L.U.P. (25-10 ka cal BP). La quantité d'obsidiennes de ces dernières sources était moins importante que celle des deux premiers. L'utilisation de l'obsidienne d'Oketo et de Akaigawa semble avoir été complémentaire. En fonction de la proportion des différents types d'obsidienne trouvés dans les assemblages, il semble que le changement dans les stratégies d'obtention ne corresponde pas à la transition de l'E.U.P. vers l'L.U.P. – période de l'apparition de l'industrie sur microlame – mais à la transition de l'industrie ancienne sur microlame (sous-phase 1 : 25-21 ka cal BP) à l'industrie tardive sur microlame (sous-phase 2 : 19-16 ka cal BP), ce qui coïncide aussi avec l'apparition cette méthode d'obtention à Yubetsu à Hokkaïdo. Durant la période tardive de l'industrie sur microlame (sous phase 3 : 16-10 ka cal BP) il apparaît que les industries lithiques spécifiques sont associées à des sources spécifiques. Nos résultats sur les modèles d'exploitation des sources de l'obsidienne confirment les résultats des recherches de Kimura (1995) et Yamada (2006) sur le rapport entre résidence et mobilité. Cependant la taille des échantillons analysés est assez restreinte et c'est pourquoi nous aimerions augmenter nos analyses pour augmenter notre compréhension des modalités d'exploitation de l'obsidienne.

Abstract
Obsidian was the main lithic raw material in Late Pleistocene Hokkaido, in the northern part of the Japanese archipelago. Out of 21 archaeological obsidian sources in Hokkaido, 8 were used during the Upper Palaeolithic (35-10 ka cal BP). In our study we are interested in producing a history of Upper Palaeolithic obsidian exploitation by looking at published obsidian sourcing analyses and comparing them to the proportions of obsidian from the various sources present in archaeological assemblages from 6 areas in Hokkaido.

Throughout the Upper Palaeolithic the obsidian sources mostly used where the ones nearest to the sites. The exploitation of the other sources varied depending on the period and lithic industry. Among the four major obsidian sources, Shirataki, Tokachi, Oketo and Akaigawa, the former two used widely from the Early Upper Palaeolithic (35-25 ka cal BP) on ward. In contrast, the latter two supplied the sites in their vicinity during the Early Upper Palaeolithic, and in the Late Upper Palaeolithic (25-10 ka cal BP) their use expanded widely. The volume of Oketo and Akaigawa obsidian used was less than that of the other two sources. The use of Oketo and Akaigawa obsidian seems to have been complementary.

In terms of the proportions of different types of obsidian found in the assemblages, it seems that the change in procurement strategies does not correspond to the transition from the Early to the Late Upper Palaeolithic –a time when we witness the appearance of microblade industries— but to the transition from the early Early Microblade Industry (Subphase 1: 25-21 ka cal BP) to the late Early Microblade Industry (Subphase 2: 19-16 ka cal BP), which coincides also with the appearance of the fully developed Yubetsu method in Hokkaido. During the Late Microblade Industry (Subphase 3: 16-10 ka cal BP), it appears that specific lithic industries are associated with specific sources. Our results on the obsidian source exploitation patterns confirm the research results of Kimura's (1995) and Yamada's (2006) residential mobility approach. However, the sample sizes of the materials analyzed are still quite small, therefore we would like to stress how important it is to increase our data in order to increase our understanding of obsidian exploitation strategies.

Keywords: Obsidian, Late Pleistocene, Hokkaido, Upper Palaeolithic, Microblade,Shirataki, Oketo, Tokachi, Akaigawa

1 – Introduction

In recent years obsidian sourcing has been a burgeoning field yielding valuable data for the prehistory of the Circum-Japan Sea area (e.g. Kuzmin and Popov 2000; Kuzmin and Glascock 2010). Consequently, our increased knowledge of the exploitation of each obsidian source has allowed us for the first time to engage in meaningful discussions on crucial topics such as the emergence of modern human behavior in the Japanese archipelago, the human adaptation to the environment, and the networks in place for the circulation of lithic raw materials. For instance, we now know that on the island of Honshu very distant obsidian sources were used and these were exploited already from the beginning of the Upper Palaeolithic (Kunitake 2009). Another example would be the research conducted on the Kozushima obsidian source located on a remote island in the Pacific Ocean, which we know with certainty was an island during the Palaeolithic as well. Kozushima obsidian was used intensively from the Early Upper Palaeolithic (hereafter EUP) onwards, and its exploitation is a clear indication of the seafaring skills modern humans must have had in order to navigate the Japanese archipelago and reach this remote island (Shimada 2009; Shimada and Ikeya 2011).

These early modern humans of the Circum-Japan Sea area practiced long distance mobility and used blade and microblade industries for their subsistence needs; the preferred raw material for their tools became obsidian. Several obsidian sources were known in the Russian Maritime Provinces, the middle Amur River and the border between China and North Korea (Kuzmin and Glascock 2010), making obsidian source analysis central in revealing interaction and circulation networks in the region. For example, it is well known that obsidian from the Shirataki source was transported to Sakhalin in the UP (Kuzmin et al. 2002). In contrast, obsidian from Hokkaido never made its way to the continental region of the Russian Far East (Sato 2004a; 2011b). The microblade industries of Hokkaido, for which obsidian was primarily used, are characterized by a high degree of specialization and standardization of microblade core types in comparison to those of neighboring regions (Sato 2010). In considering the possible reasons behind such a contrast, it is necessary to evaluate the quality and size of obsidian nodules from each of the sources, the distance between the sources, and whether there is a correlation between sources and lithic industries.

In order for us to maximize the precision of obsidian source analysis, we examined the chemical composition of each obsidian source using Instrumental Neutron Activation Analysis (INAA), Electron Probe Micro-Analyzer (EPMA), and Energy Dispersive X-ray Fluorescence (EDXRF). By using these techniques we were able not only to analyze excavated obsidian artifacts, but also to investigate the geological formation process of the obsidian sources. Since such studies have recently started to increase (e.g. Izuho et al. 2008; Wada and Sano 2011), we think it will be useful to provide in this paper a review of the obsidian sourcing studies published thus far, in an effort to compile a diachronic overview of obsidian exploitation for every region, industry and site on Hokkaido.

2 – Materials and Methods

A – Materials

The obsidian sourcing data for the UP Hokkaido published up to April 2012, comprise 6,368 samples from 83 sites, analyzed mainly using X-ray fluorescence (XRF). Those samples that yielded inconclusive results have been excluded from the present analysis, leaving us with 5,323 samples from 80 sites in total (Tab.1). The lithic raw materials used in UP Hokkaido were siliceous shale, chert, agate, chalcedony and andesite, with obsidian consistently comprising the majority of any given assemblage. At present, we are aware of 21 obsidian sources that were used in prehistory (Izuho et al.2008), out of which only 8 were used in UP Hokkaido (Tab.2). Among them 4, namely Shirataki, Tokachi, Oketo, Akaigawa are the major sources, while others, such as Keshomappu, Chikabumidai, Nayoro, and Toyoizumi are considered to be minor. Although thus far a vast plethora of obsidian artifacts have been unearthed in archaeological excavations, only very few were made available for sourcing analysis. The number of Palaeolithic sites in Hokkaido as of February 2010 was 861 (Japanese Palaeolithic Research Association 2010); out of these only 80 sites have produced sourcing data amounting to a mere 9.3 % of the whole. Even though the results of our study are based on a fraction of the sites, we are confident that the general trends in UP Hokkaido can be safely deduced from this sample.

B – Chronology, industries and areas where used obsidian

During the Late Pleistocene the Japanese archipelago was very different from today both geomorphologically and ecologically, mainly due to the drop of sea level during the glacial period. The present-day islands Honshu, Shikoku and Kyushu were once one single island mass, the so-called Palaeo-Honshu Island, whereas Hokkaido was part of the Palaeo-Hokkaido Peninsula, which was connected to the continent along with Sakhalin and the southern part of the Kuril Islands (Sato et al. 2011; Iwase et al. 2012) (Fig.1). Accordingly, the periodization of the UP in Hokkaido is different from that of Honshu and the South. In Hokkaido, the UP is divided into two periods: the Early Upper Palaeolithic (EUP) (35-25 ka cal BP) which consists of various lithic industries (microblade technology has not yet appeared), and the Late Upper Palaeolithic (LUP) (25-10 ka cal BP) consisting of various microblade industries and other industries with points, stemmed points and boat-shaped (also known as 'naviform') tools[1] (Sato2003) (Tabl.3).

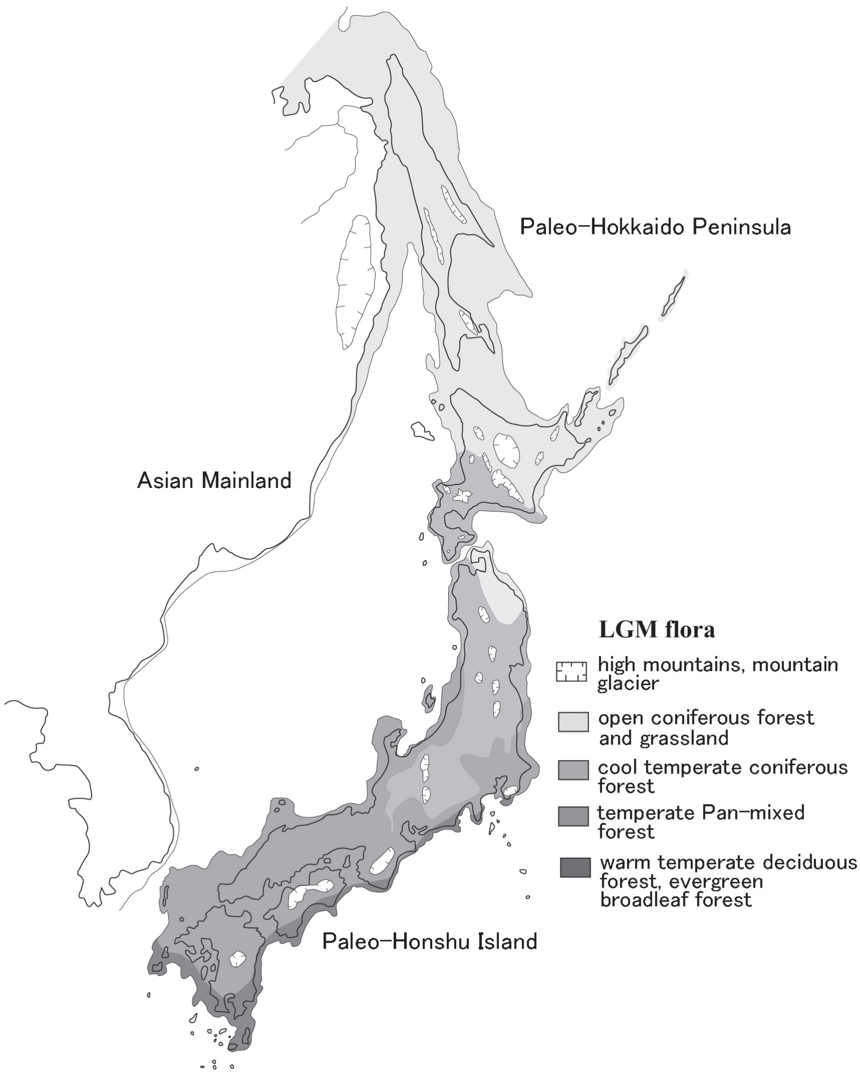


Figure 1 – Physiographic features of Late Pleistocene in the Japanese Archipelago (Iwase et al. 2012)

Although the EUP can be further subdivided, in this paper we treat it as one period. The LUP is subdivided to 3 phases; the early Early Microblade Industry (25-21 ka cal BP), the late Early Microblade Industry (19-16 ka cal BP), and the Late Microblade Industry (16-10 ka cal BP). The early Early Microblade Industry (Subphase 1) includes the Rankoshi, Tougeshita 1 and Pirika type microblade industries. The Late Early Microblade Industry (Subphase 2) includes the Sakkotsu and Tougeshita 2 type microblade industries. The Late Microblade Industry (Subphase 3) includes the Shirataki, Oshorokko 1 and 2, Hirosato, Momijiyama microblade industries and non-microblade industries such as the small boat-shaped tool types 1 and 2, and industries with points and stemmed points (Fig.2). The abovementioned industries constitute the chronological markers used in our analysis (Yamada 2006). Hokkaido was divided into six areas, namely Tokachi, Kitami, Shirataki, Kamikawa, Ishikari Lowland and Southern Hokkaido, according to the distribution patterns of archaeological sites and geological environments (Fig.3).

3 – A diachronic perspective of obsidian exploitation patterns in Palaeo-Hokkaido Peninsula

A – Early Upper Palaeolithic 35 - 25 ka cal BP

The majority of obsidian used in EUP sites comes from the sources nearest to the sites. Specifically, at the sites located in the Shirataki, Kitami, and Tokachi areas, we find obsidian coming from the Shirataki, and Oketo and Tokachi sources respectively,

Area	No.	Site	Industry	Number of analyzed material	Number of excavated materials	Shirataki	Oketo	Tokachi	Akaigawa	Minor sources	Unknown
Shirataki	1	Hattoridai 2	1	3	7	2				K1	
			2-B-2	3	Unknown	2			1		
			2-C-1	3	Unknown	3					
			2-C-3	5	1022	5					
			2-C-4	1	Unknown	1					
			2-C-5	6	10173	6					
			2-C-8	23	30959	14	6	1		K2	
			2	27	67747	20	3		3		1
			1 and 2	7		3	2			K1	1
	2	Shirataki hattoridai	2-B-2	8	31693	7					1
			2-C-1	67		61	1			N1	4
			2-C-5	9		9					
			2-C-8	2		1	1				
			2	78		73					5
			1 and 2	1905		1509	11	3	1	N7, K3	371
	3	Okushirataki 1	1	9	1289	8				K1	
			2-C-3	15	2706	15					
			2-C-8	28	58020	19	6		1		2
			1 and 2	8	29939	4	2	1		K1	
	4	Kamishirataki 2	2-B-1	5	5888	5					
			2-C-2	3	1799	2	1				
			2-C-5	2	5766	2					
			2-C-8	5	35538	5					
	5	Kamishirataki 5	2-B-1	3	94	3					
			2-C-5	27	9758	21	3			K3	
			2-C-8	14	11315	14					
	6	Kamishirataki 6	2-C-8	6	1343	6					
	7	Kamishirataki 7	1	54	2339	54					
			2-C-8	11	1987	11					
	8	Kamishirataki 8	1	41	60818	41					
			2-A-1	1	Unknown	1					
			2-A-2	10	26522	9				K1	
			2-A-3	1	Unknown	1					
			2-C-4	6	2788	3	1				2
			2-C-5	3	28783	3					
			2-C-8	15	65023	8	3	2		K2	
			2	17	206818	17					
			1 and 2	12	215783	4	6		1	K1	
	9	Shirataki 3	2-C-5	33	1009	32		1			
			2-C-8	4	41271	4					
			2	5		3				K2	
			1 and 2	16		11	1			K4	
	10	Shirataki 8	2-B-2	5	138	5					
			2	4	4030	4					
	11	Shirataki 18	2-C-8	41	23331	41					
	12	Shirataki Loc. 30	2-B-2	2	6085	2					
			2-C-5	4	4835	4					
			2-C-6	1	1109					K1	
			2-C-8	3	8954	2	1				
			2	11	71249	5	1			K4	1
			1 and 2	8		3				K4	1
	13	Horokazawa I	2-C-4	3	2185	3					
			2-C-8	2	10237	1		1			
			2	20	115574	19	1				
			1 and 2	7		7					
	14	Kitashiyubetsu 4	2-C-8	2	6559		2				
	15	Kyushirataki 5	1	4	32731	4					
			2-A-2	15		14				K1	
			2-C-2	1		1					
			2	44	261571	41			1	K1, C1	
			1 and 2	7		7					
	16	Kyushirataki 15	2-A-1	7	12961	3				K4	
			2-B-2	5	10079	5					
			2-C-4	13		11		2			
			2-C-7	1						K1	
			2-C-8	3	12318	2	1				
			2	5	35541	5					
			1 and 2	13		1	2	4		K6	
	17	Kyushirataki 16	1	7	1807	2				K5	
Kitami	18	Motomachi 2	2	140	148	45	71	1		K1	22
	19	Midori 1	2	119	653	58	30	5		K3	23
	20	Toyooka 7	2-C-7	107	>114		83	2		K1	21
	21	Hirosato 8	1	13	14218	1	11				1
			1 and 2	7			7				
	22	Hirosato maruyama	2-C-2	10	276		10				
	23	Kitakamidaichi	2-C-7	40	40	1	30	1			8
	24	Kitakami 4	2-B-2	21	3055		17	4			
			2-C-4	4	380		4				
			2-C-8	5	153		5				
			2	20	1095	1	18	1			
	25	Rankokubashi	2	5	(3232)		5				
	26	Kawahigashi 16	2-B-2	3	(32889)		1			K1	1
			2-C-2	1			1				
			2-C-4	2			1	1			
			2-C-7	2			1				1
			2	75		4	60	1		K6	4
	27	Kawahigashi 3	2-B-2	1	(26639)		1				
			2-C-5	13		3	7	3			
			2	43		12	24	2		K5	
Kitami	28	Hokushin	2-A-2	120	2126	10	85	5			20
	29	Momijiyama	2-C-3	106	2185	2	70			K34	
			2-C-5	6		6					
			2	13		2	5			K6	
	30	Yoshiizawa Loc.B	2-C-7	10	1157		7	1			2
		Yoshiizawa Loc.UT	2-C-7	22	13694	3	15			K3	1
	31	Oketoazumi	1	14	>40,000		11	2			1
			2-B-1	18		2	14				2
			2-C-1	17		1	14	1		K1	
			2-C-2	9			7				2
			2-C-3	10			5	5			
			2-C-4	3		1		2			
			2	24		3	18	2			1
			1 and 2	377		5	279	17	1	K3	72
Tokachi	32	Yukuepira chashiato	2-C-1	1	Unknown					K1	
	33	Shimohororo 15	2-C-8	1	2			1			
	34	Hokuto	2-C-8	1	1484	1					
	35	Oribe 16	2-C-5	2	2124			2			
			2	4				4			
	36	Oribe 17	2-C-6	12	29549			12			
	37	Kukominami A	1	2	30	1		1			
	38	Kukominami B	2-B-2	3	898			3			
	39	Wakabanomori	1	6	9701			6			
	40	Ozora	2-C-6	5	3997	1	1	2	1		
	41	Inada 1	1	7	163			7			
			1 and 2	3	43		3				
	42	Kawanishi C	1	14	19326		4	10			
			2-C-4	6	608			3	2		1
	43	Minamimachi 1	2-C-5	14	30227		1	11			2
	44	Minamimachi 2	1	6	2228			5			1
			2-B-1	4	574	4					
			2	4	652			2	2		
	45	Akatsuki	2-B-1, 2-B-2	70	>14186	30	10	30			
			2-C-2	1			1				
	46	Ochiai	2-C-5	22	7069	6		16			
	47	Satsunai N	1	7	589			7			
			2-C-8	10	51084		8	2			
	48	Satsunai K	2-C-5	14	1055		4	10			
			2	2	95			2			
	49	Nisshin F	2	3	478			3			
	50	Kamiitaira	1	3	39			3			
			2-B-1	30	488	16		14			
	51	Seo	2-C-4	1	419			1			
	52	Kagawa	2-C-7	25	3092		1	24			
	53	Kitafushiko 2	2	8	974	6		2			
	54	Kyouei 3	1	33	1539			33			
			1 and 2	5	1086		1	4			
Kamikawa	55	Higashirokugo 1	2-C-8	79	2744	3	14	17			45
			2-C-4	1	1						1
	56	Higashirokugo 2	2-C-6	123	4603	101					22
	57	Sakuraoka 5	2	5	468	5					
	58	Arashiyama 2	2-C-7	32	1750	25	2			C3	2
	59	Nitto	2-C-2	20	2708	1	11				8
	60	Higashimachi	2-B-2	1	2	1					
	61	Nisshin 2	1	13	23	2	2	2	3	C1	3
			2-B-2	12	1324	10					2
			1 and 2	62		36	2	3	2	N11	8
Ishikari Lowland	62	Kamihoronaimoi	2-B-1	134	1412	8		112	1		13
	63	Bibi 4	1	1	1			1			
			2	2	10			2			
	64	Shukubai sankakuyama	1	12	211	2			10		
	65	Kashiwadai 1	1	13	29213	4			8	T1	
	66	Ankarito 7	2-B-2	3	23	3					
			2-C-2	12	2030				12		
	67	Oruika 2	2-B-1	5	2671	2		1			2
	68	Kiusu 5	2	15	494				14		1
	69	Kiusu 7	2-B-2	16	396			13	1		2
	70	Osatsu 16	2-B-2	12	2260	5		4	3		
			2-C-7	8	32266				8		
	71	Yukanboshi E10	2-B-2	14	43				14		
	72	Yukanboshi C15	1	3	3	2		1			
Southern Hokkaido	73	Miyako	2	10	5173				10		
	74	Sakaemachi 5	2-C-8	1	1				1		
	75	Obarubetsu 2	1	1	127				1		
			2-A-1	3	4305				3		
	76	Pirika 1	2-A-1	3	63412				3		
			2-C-5	8	4832	1			6		1
			2	107	110316	8	4	1	92		2
	77	Kamioka 2	1	1	1466				1		
			2-C-4	4	6229	1		1	1		1
	78	Ishikawa 1	2-C-1	6	8781	6					
	79	Shinmichi 4	2-A-2, 2-A-3	26	23263				12		14
	80	Yunosato 4	1	1	ca.20,000				1		
			2-B-2	105		12		52	3		38
			2-C-8	1		1					
Total				5323	>1,589,808	2678	1041	501	224	139	740

References are omitted

In the column of "Minor sources", K: Keshomappu, C: Chikabumidai, N: Nayoro, T: Toyoizumi

Legend

1	Early Upper Paleolithic	2-A-3	Pirika type microblade industry	2-C-1	Shirataki type microblade industry	2-C-5	Small boat-shaped tool 2 type industry
2	Late Upper Paleolithic	2-B	late Early Microblade Industry	2-C-2	Hirosato type microblade industry	2-C-6	Oshorokko1 type microblade industry
2-A	early Early Microblade Industry	2-B-1	Sakkotsu type microblade industry	2-C-3	Momijiyama type microblade industry	2-C-7	Oshorokko 2 type microblade industry
2-A-1	Rankoshi type microblade industry	2-B-2	Tougeshita 2 type microblade industry	2-C-4	Small boat-shaped tool 1 type industry	2-C-8	bifacial point or stemmed point industry
2-A-2	Tougeshita 1 type microblade industry	2-C	Late Microblade Industry				

Sources	Areas	Scale	Names among researchers (integrated in this study)
Shirataki	Shirataki	major	Akaishiyama, Shirataki I・II, Hachigousawa, Hakudonosawa, Akaishiyama I・II, Akaishiyama A・B, Horokazawa, Ajisaitaki, Tokachiishizawa A・B, Tokachiishizawa : aj, na
Tokachi	Tokachi	major	Tokachimitumata, Biman, Tokachi I・II, Kamishihoro・Biman A
Oketo	Kitami	major	Oketoyama, Tokoroyama, Kitatokoroyama, Tokoroyama III
Akaigawa	Southern Hokkaido	major	Akaigawa
Keshomappu	Shirataki	minor	Rubeshibe I・II, Kouwa forestry area 49, Keshomappu group 1・2
Chikabumidai	Kamikawa	minor	Chikabumidai
Nayoro	Kamikawa	minor	Nayoro A
Toyoizumi	Ishikari Lowland	minor	Toyoizumi
Unknown			Tokorogawa group 4
			KS artifact group : Kiusu 4 site A-R area
			HS1, 2 artifact group : Hokushin site
			FR1, 2, 3 artifact group : Higashirokugo 1, 2 site
			Sapporo K19 artifact group : K39 site

Early Upper Paleolithic (35 - 25 ka cal BP)		Trapezoid
		Hirosato type pointed tool
		Pointed blade tool with retouched base
		Kawanishi C type blade
		Shimaki type
Late Upper Paleolithic (25 - 10 ka cal BP)	1. early Early Microblade Industry (25 - 21 ka cal BP)	Rankoshi Microblade
		Tougeshita 1 Microblade
		Pirika Microblade
	2. late Early Microblade Industry (19 - 16 ka cal BP)	Sakkotsu Microblade
		Tougeshita 2 Microblade
	3. Late Microblade Industry (16 - 10 ka cal BP)	Shirataki Microblade
		Hirosato Microblade
		Momijiyama Microblade
		Oshorokko 1 Microblade
		Oshorokko 2 Microblade
		Point and stemmed point
		Small boat-shaped tool, type 1
		Small boat-shaped tool, type 2

Table 1 (Left page) – List of obsidian source analyses published in Hokkaido – Each number correspond to the number of the site shown in Fig. 3 -7, 11-14

Table 2 – Name of obsidian sources mentioned in this article

Table 3 – LChronology of the Upper Palaeolithic of Hokkaido

whereas in the Ishikari Lowland and southern Hokkaido we mostly find obsidian from the Akaigawa source (Fig.4). However, there are exceptions to these trends; such is the case of the Kyushirataki 16 site in Shirataki where obsidian from the Keshomappu source, which is generally considered a minor source, was used more than that from the major Shirataki source (Ibutsu Zairyo Kenkyujo 2009). Unlike obsidian from other minor sources, the Keshomappu obsidian was used complementarily in the Shirataki area throughout the UP, except for the phase of the late Early Microblade Industry.

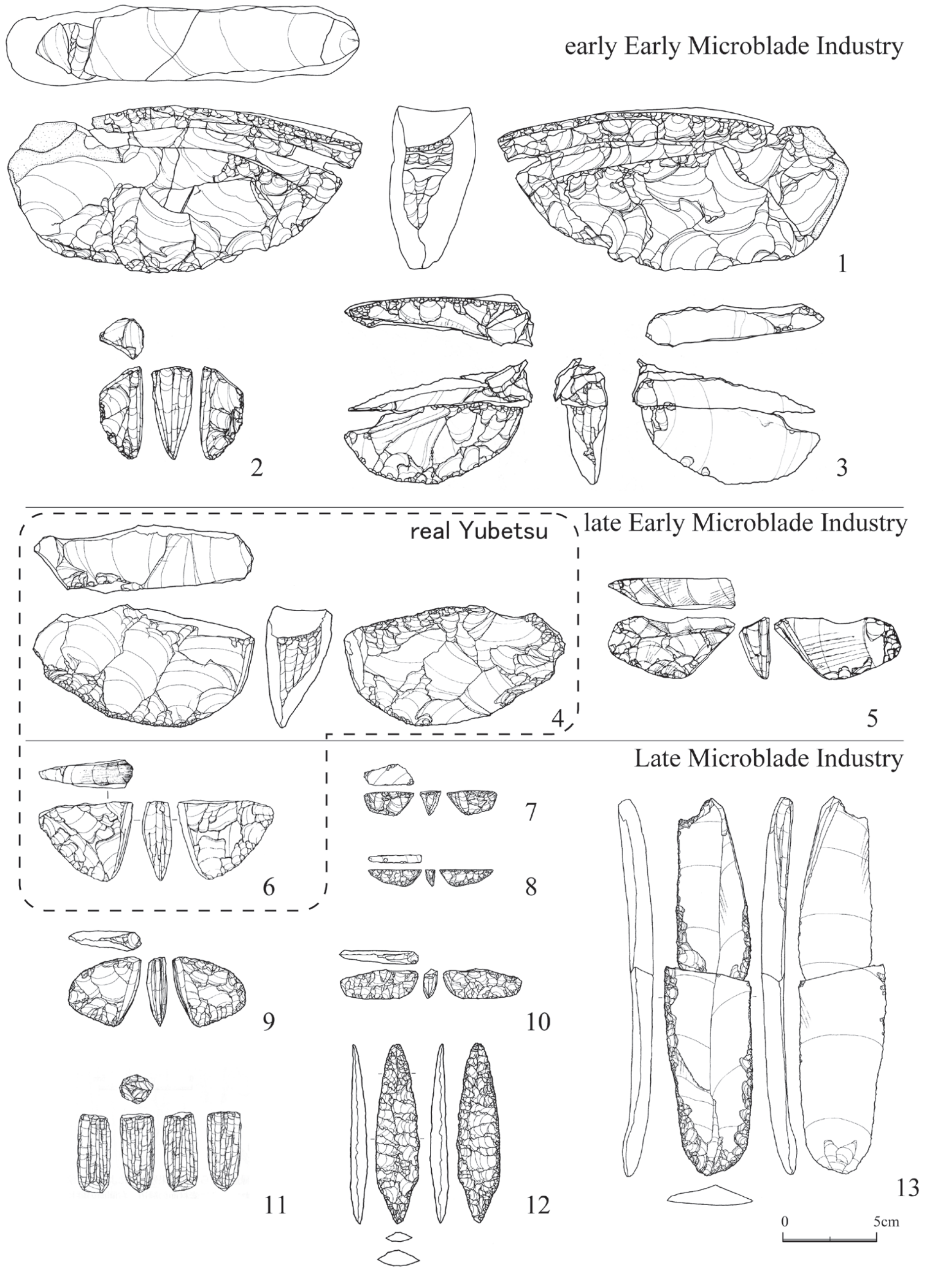
The Ishikari Lowland presents us with a unique case: the Akaigawa source, which was mostly used in the area is located relatively close to the Ishikari Lowland, but it was not the only source used. Quite distant from the Ishikari Lowland, the Eastern Hokkaido sources such as the Tokachi and Shirataki (150 km and 170 km away, respectively, in a straight line) were also used, albeit as secondary sources. The most probable explanation why both types of obsidian were brought into this area already from the earliest phase was because the Ishikari Lowland is equidistant from the two sources. As for correlations between specific sources and industries, there seem to be none. A characteristic trait of this period seems to be the transportation of obsidian over long distances. For example, Tokachi obsidian was found at the Bibi 4 site in the Ishikari Lowland, which is a long 150 km journey (in a straight line) through some major geological barriers such as the Hidaka Mountains (Kondo 1985). This is undoubtedly one of the earliest examples of long distance transportation of obsidian in Hokkaido.

B – Late Upper Palaeolithic, 25 - 10 ka cal BP: Overview

The EUP pattern of exploiting the major obsidian source closest to the site does not change during the LUP. Compared to the EUP, however, there is more obsidian arriving from different sources at the sites during this period (Fig.5). Moreover, the second most used obsidian was not always from the second closest source. It should

Figure 2 – Microblade cores and tools of each Late Upper Palaeolithic industry from Hokkaido

1. Pirika type microblade core (hereafter MC) (Naganuma 1985); 2. Rankoshi type MC (Fukui and Koshida 1999); 3. Tougeshita 1 type MC (Onuma et al. 1988); 4. Sakkotsu type MC (Naganuma and Suzuki 2001); 5. Tougeshita 2 type MC (Sato and Kitazawa 1985,); 6. Shirataki type MC (Sugihara and Tozawa 1975); 7. Small boat-shaped tool type 1 (Kitazawa 2000); 8. Small boat-shaped tool type 2 (Yamahara 1999); 9. Oshorokko 1 type MC (Oya 2001); 10. Oshorokko 2 type MC (Oshima 1997); 11. Momijiyama type MC (Oda 2009); 12;.Stemmed point, (Naganuma and Suzuki 2001); 13. Hirosato type MC (Naganuma and Suzuki 2001)



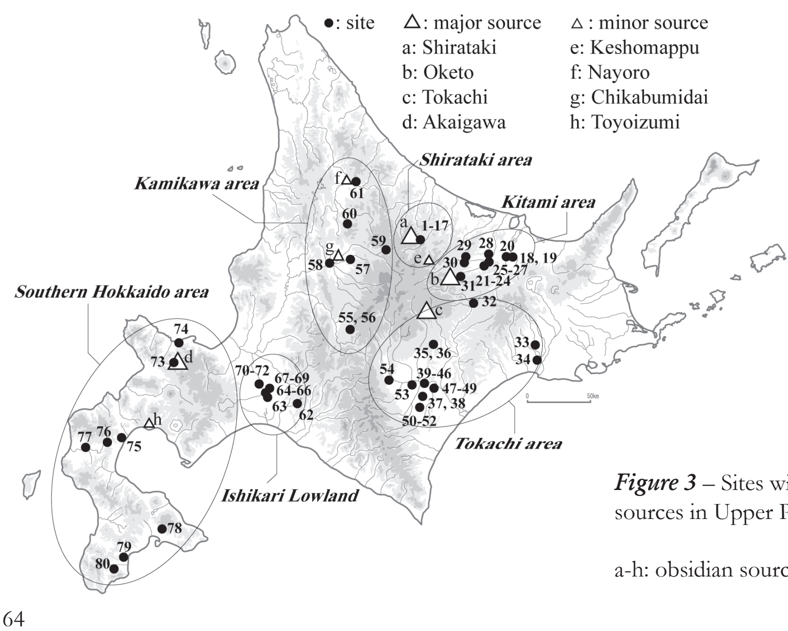


Figure 3 – Sites with obsidian sourcing data, archaeological areas, and obsidian sources in Upper Palaeolithic Hokkaido

a-h: obsidian sources (site number corresponds to those in Tab.1) be noted that obsidian from minor sources, such as the Chikabumidai and Nayoro sources, was used in the Kamikawa and Shirataki areas, showing that the minor sources were starting to be exploited.

Looking at long-term developments, we see that the exploitation of secondary sources in the Shirataki and Kitami areas varies from one phase to the next, and also that the use of the primary sources in Tokachi similarly varies. It is worth noting that the obsidian mostly used at the Ishikari Lowland during the late Early Microblade Industry was not from the nearest Akaigawa source, but from the Tokachi source. In the areas of Kamikawa and southern Hokkaido, it is difficult to talk about change in the LUP due to the very limited sourcing analysis undertaken in these areas. Since the obsidian exploitation patterns during the LUP exhibit specific trends that vary according to chronological phases and specific industries, we have decided to outline them in detail below.

Subphase 1: early Early Microblade Industry, 25 - 21 ka cal BP

Obsidian sourcing studies were carried out only in the areas of Shirataki, Kitami, and in southern Hokkaido. Although archaeological sites of this phase have been found in the Ishikari Lowland, and the Kamikawa and Tokachi areas, sourcing analyses have not yet been undertaken. The basic trend was that obsidian from the nearest major source was primarily used, making obsidian from other sources quite scarce. It is noteworthy that Tokachi obsidian was used little throughout Hokkaido during this phase (Fig.6). The sites in the Tokachi area have yielded Tougeshita 1 type microblade industry, but unfortunately no obsidian sourcing study has yet been conducted (Yamada 2006). Tokachi obsidian is also used at the Hokushin site located in Kitami adjacent to the Tokachi region, which leads us to assume that Tokachi obsidian would have been used near the Tokachi source, but not widely elsewhere.

Comparing the trends of obsidian exploitation of this phase with those of the entire LUP (Fig.5), it is evident that fewer sources were exploited during this subphase, a trend that seems rather similar to that of the EUP. The greatest peculiarity of this phase and the EUP is that obsidian is not transported often over longer distances.

Subphase 2: late Early Microblade Industry, 19 - 16 ka cal BP

In the late Early Microblade Industry the obsidian exploitation patterns changed drastically. Even though the preference towards the nearest major source did not change significantly, we see at the same time that obsidian from the major sources is now circulating more widely, and that diversity of the sources used in each site is much more increased (Fig.7). The main trends of this phase are that minor sources are no longer used whereas the major ones are used almost exclusively. No correlations between sources and industries have been observed during this phase.

Shirataki obsidian was extensively used in Tokachi, Kamikawa and Ishikari Lowland beyond the Shirataki area. In southern Hokkaido a certain amount of Shirataki obsidian was used at the site Yunosato 4, located 350 km in a straight line away from the Shirataki obsidian source (Warashina and Higashimura 1985). Tokachi obsidian was used not only in the nearby areas of Kitami and Shirataki, but also in Ishikari Lowland and southern Hokkaido. Tokachi obsidian was used predominantly at some of the sites in these areas. Obsidian from the Shirataki and Tokachi sources, located in eastern Hokkaido, were transported already before this period all the way to western Hokkaido across the Backbone Range. In contrast, obsidian from the Akaigawa source in western Hokkaido was used only at the EUP site Nisshin 2 in Kamikawa (Koshimizu 1988a). In the late Early Microblade Industry Akaigawa obsidian was used for the first time at Shirataki, across the Backbone Range, but was not used in eastern Hokkaido before this period. The Keshomappu source, a minor source near the Shirataki source, was used secondarily in all periods but this one. Obsidian from Oketo, one of the major sources, was used mainly in the nearby Kitami area, and only slightly used in Tokachi until the late Early Microblade Industry.

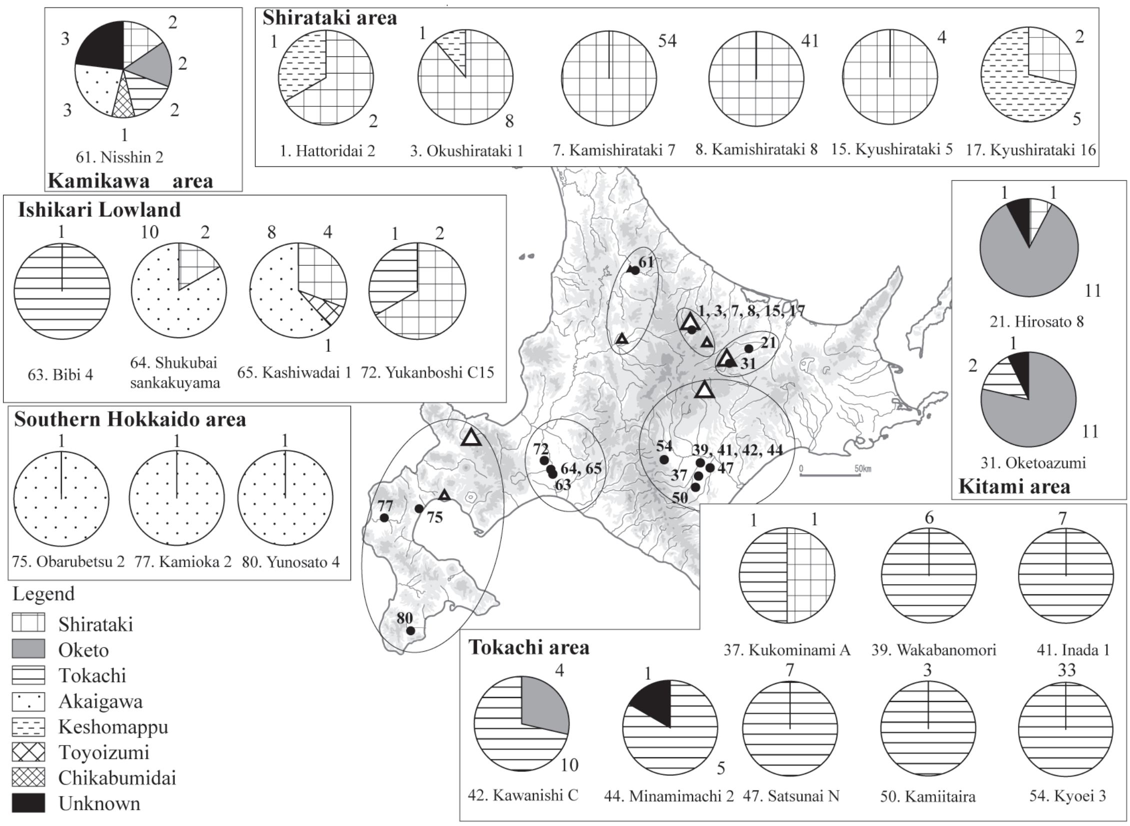
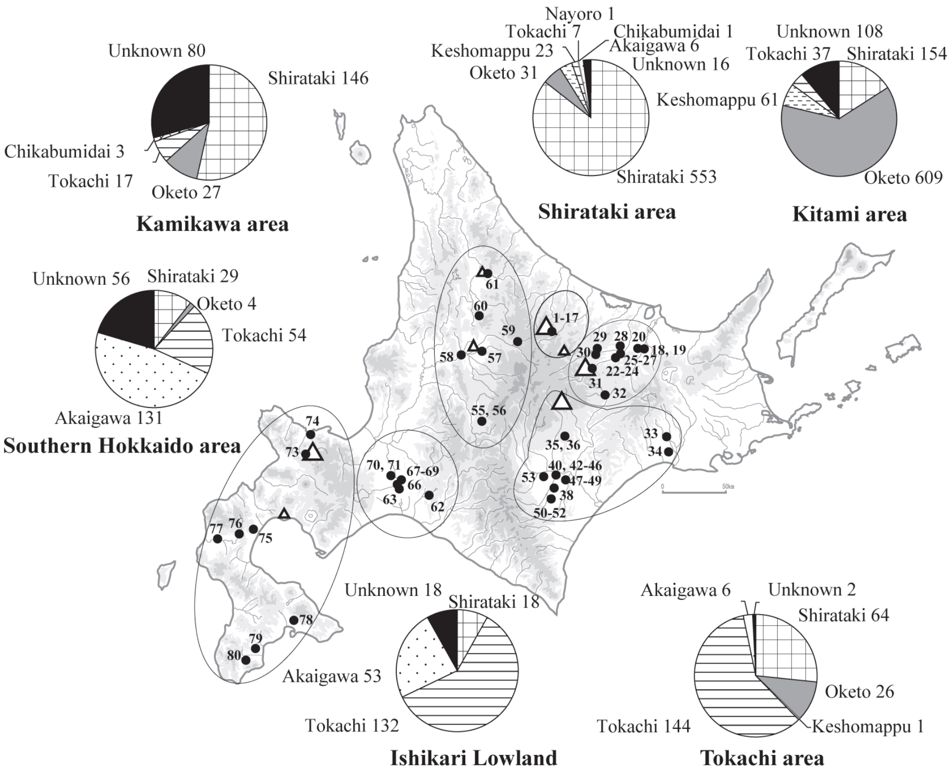


Figure 4 – Obsidian exploitation patterns during the Early Upper Palaeolithic, 35 – 25 ka cal BP

Δ; utilized source,
▲; non-utilized source (hereafter same)

Figure 5 – Obsidian exploitation patterns in Late Upper Palaeolithic, 25 – 10 ka cal BP



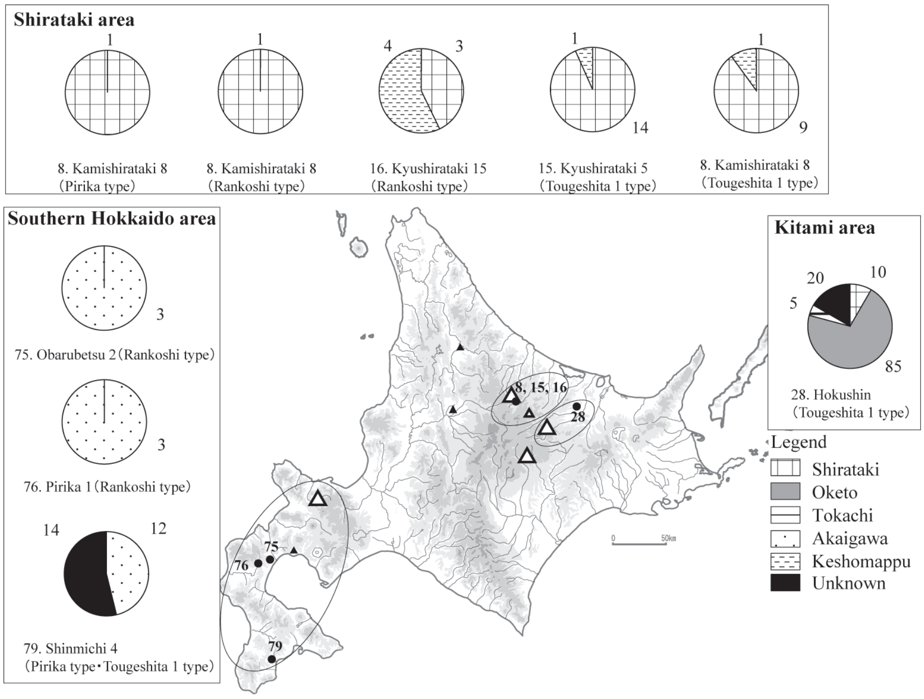
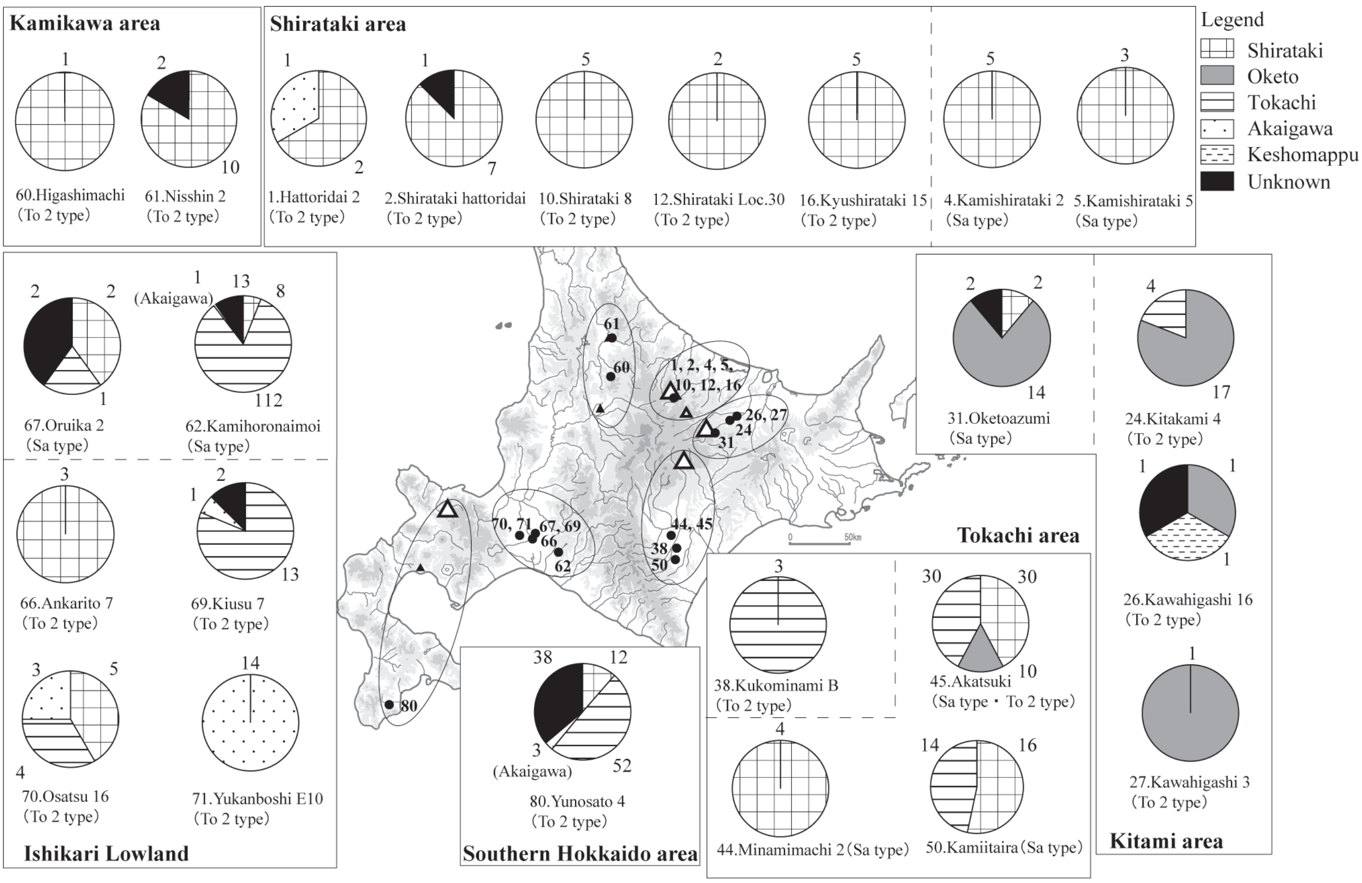


Figure 6 – Obsidian exploitation patterns in the subphase 1 of early Early Microblade Industry, 25 – 21 ka cal BP

Figure 7 – Obsidian exploitation patterns in the subphase 2 of late Early Microblade Industry, 19 – 16 ka cal BP

Sa; Sakkostu type, To2; Tougeshita 2 type



Comparing the proportions of obsidian from different sources used in each area, we notice that the nearest major sources were mostly used in Shirataki, Kitami and Kamikawa. On the other hand, in Ishikari Lowland obsidian from Tokachi (170 km away) was predominantly used, while the nearby Akaigawa source was exploited much less. It is well known that at some sites in Ishikari Lowland, Shirataki obsidian was strongly preferred for the production of the Sakkotsu type microblade industry (Akai 2009); this trend seems to hold up in our research as well, with the exception of the Kamihoronaimoi site (Fig.7). We analyzed the chemical composition of 83 Sakkotsu type microblades from Kamihoronaimoi which yielded the following results: 92% were made of Tokachi obsidian, 7% of Shirataki obsidian, and only 1% of Akaigawa. The Sakkotsu type microblade industry was usually made of Shirataki obsidian, therefore Kamihoronaimoi is unique and different from other sites producing Sakkotsu type microblade industries (Fig.8). In the Ishikari Lowland Akaigawa obsidian, which is the nearest major source, was mainly used throughout the UP, although during the late Early Microblade Industry we witness an increased use of Tokachi obsidian.

In southern Hokkaido the Tokachi source was the mostly used one, after which come the Shirataki, and the Akaigawa sources. An exception to this trend is the Yunosato 4 site which yielded Tougeshita 2 type microblade industry (Warashina and Higashimura 1985). Microblades made of Shirataki obsidian are usually assumed to have come from Sakkotsu type microblade cores on the basis of morphological criteria (Terasaki 2005; Yamada 2006). This shows the strong correlation between the Sakkotsu type microblade cores and Shirataki obsidian, and between the Toigeshita 2 type and Tokachi obsidian or obsidian from other local major sources.

In the Tokachi area the ratio of sources used is clearly different for every industry. Shirataki obsidian was mainly used at the sites with Sakkotsu type microblade industries, whereas Tokachi obsidian was preferred for the Tougeshita 2 type microblade industry. In the Akatsuki site the Sakkotsu type microblade cores were made entirely of Shirataki obsidian (n=14), whereas Tougeshita 2 type microblade cores were made of obsidian from Tokachi (n=18), Oketo (n=4), and Shirataki (n=1) (Kitazawa 1996) (Fig.9). This result demonstrates that the preference to Shirataki obsidian for the production of the Sakkotsu type microblade industry exists in eastern Hokkaido as well (Shirataki, Kitami, and Tokachi areas).

As mentioned above, except for the Ishikari Lowland, Sakkotsu type microblade cores were made of Shirataki obsidian in all areas. On the contrary, the Tougeshita 2 type microblade industry tends to be made of obsidian from the nearest major source in eastern Hokkaido (Fig.10).

As Yamada (2006) has shown, the Sakkotsu type microblade industry requires large nodules of high quality, which would make its preparation at the primary sources necessary, therefore making Shirataki the most suitable source for the procurement of such raw material. On the other hand, in the Tougeshita 2 type microblade industry, which also makes use of round pebbles and small debris or angular nodules, we expected that it would be popular in the Tokachi and Ishikari Lowland areas, in which high quality large obsidian nodules are relatively scarce. The results of this study confirm Yamada's (2006) hypothesis. Furthermore, our results are consistent with the hypothesis that Sakkotsu type microblade cores were transported over a long distance with uniting to Shirataki obsidian, whereas the Tougeshita type microblade cores were made of obsidian available near the sites (Kimura 1995).

Subphase 3: Late Microblade Industry, 16 - 10 ka cal BP

This phase is characterized by the increased exploitation of the minor sources compared to the previous phases. Moreover, the most characteristic trait of this phase is that all industries show peculiarities in the way they use obsidian. As in previous phases, the tendency of using the nearest major sources persists in the Late Microblade Industry as well.

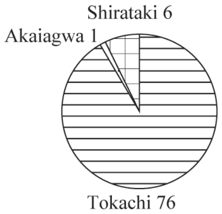


Figure 8 – Obsidian source ratios from Kamihoronaimoi site in the Ishikari Lowland in the subphase 2

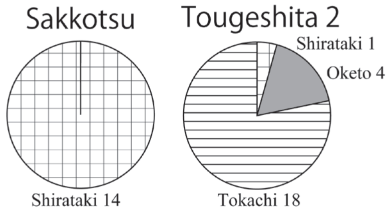


Figure 9 – Obsidian source ratios of Sakkotsu and Tougeshita 2 type microblade cores found at the Akatsuki site in the Tokachi area in the subphase 2

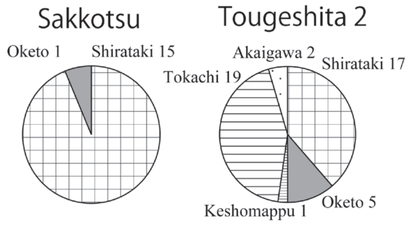


Figure 10 – Obsidian source ratios of Sakkotsu and Tougeshita 2 type microblade cores in whole Hokkaido in the subphase 2

For example, in the Oshorokko 1 and 2 type microblade industries (Fig.11) and the points and stemmed points industry (Fig.12) the nearest major obsidian sources were used mainly, however, at the same time the minor source of Chikabumidai also started being used. Obsidian nodules from such minor sources are usually small and scarce, but they were nevertheless used often much later, in the Jomon period (Tomoda 1996). This is the beginning of new exploitation strategies by the sedentary hunter-gatherers of Holocene Japan, which start at the Jomon period and continue after this period. In eastern Hokkaido the types of obsidian used for the Oshorokko 2 type microblade industry vary, whereas in western Hokkaido (Ishikari Lowland and southern Hokkaido areas) the picture seems to be simpler. It is quite difficult to explain this pattern, as only a few sourcing analyses have been conducted thus far; what we can say however, is that this tendency is largely different from the previous phase of the late Early Microblade Industry, when even western Hokkaido witnesses the use of a variety of obsidian sources. Moreover, an important common trait is the transportation of obsidian from the various sources in the form of finished tools (e.g., points, bifaces etc.) or cores (e.g., microblade cores). For instance, in the microblade industry Oshorokko 1 of the Tokachi area the cores are made of obsidian from a distant source and then brought to the area (Fig.11: Ozora site [Higashimura and Warashina 1995; Kitazawa 1993]). In the Oshorokko 2 type microblade industry of the Shirataki area, one flake refitted to a microblade core was analyzed and showed that its provenance was from the Keshomappu minor source (Fig.11: Kyushirataki 15 site [Ibutsu zairyo kenkyujo 2012a, Naoe 2012]). In the Tokachi area an Oshorokko 2 type microblade core made of Oketo obsidian was recovered during excavations (Fig.11: Kagawa site [Ibutsu zairyo kenkyujo 2012b; Murata et al. 2012]). Similarly, in the points and stemmed points industry, stemmed points are made of obsidian from distant sources and are often transported into the Shirataki area.

Akaigawa obsidian was transported into the Shirataki and Tokachi areas in the form of Tougeshita 2 type microblade industry of the late Early Microblade Industry phase; this tendency is also common in the Late Microblade Industry including the Oshorokko 1 type microblade industry and the points and stemmed points industry. This characteristic is especially evident in the small boat-shaped tool type 1 and 2 industries (Fig.13). These examples of Akaigawa obsidian being transported into eastern Hokkaido are incompatible with the general tendency to exploit nearby sources which prevails in this period.

Similarly to the previous period, some industries seem to be made of specific types of obsidian. For example, the Oketo source, which is not the nearest major source for the Tokachi and Kamikawa areas, was the obsidian mostly preferred for the production of Hirosato type microblades (Fig.14). Even though Oketo obsidian was less frequently transported into distant areas, we see however, that it was brought to these areas exclusively for the purpose of producing this industry. The Hirosato type microblade industry made on high quality fine-grained raw material such as obsidian or shale, it is found in the Kitami area where the Oketo obsidian source is located. It is known that this industry is also found around the Ustinovka shale zone in the Russian Maritime

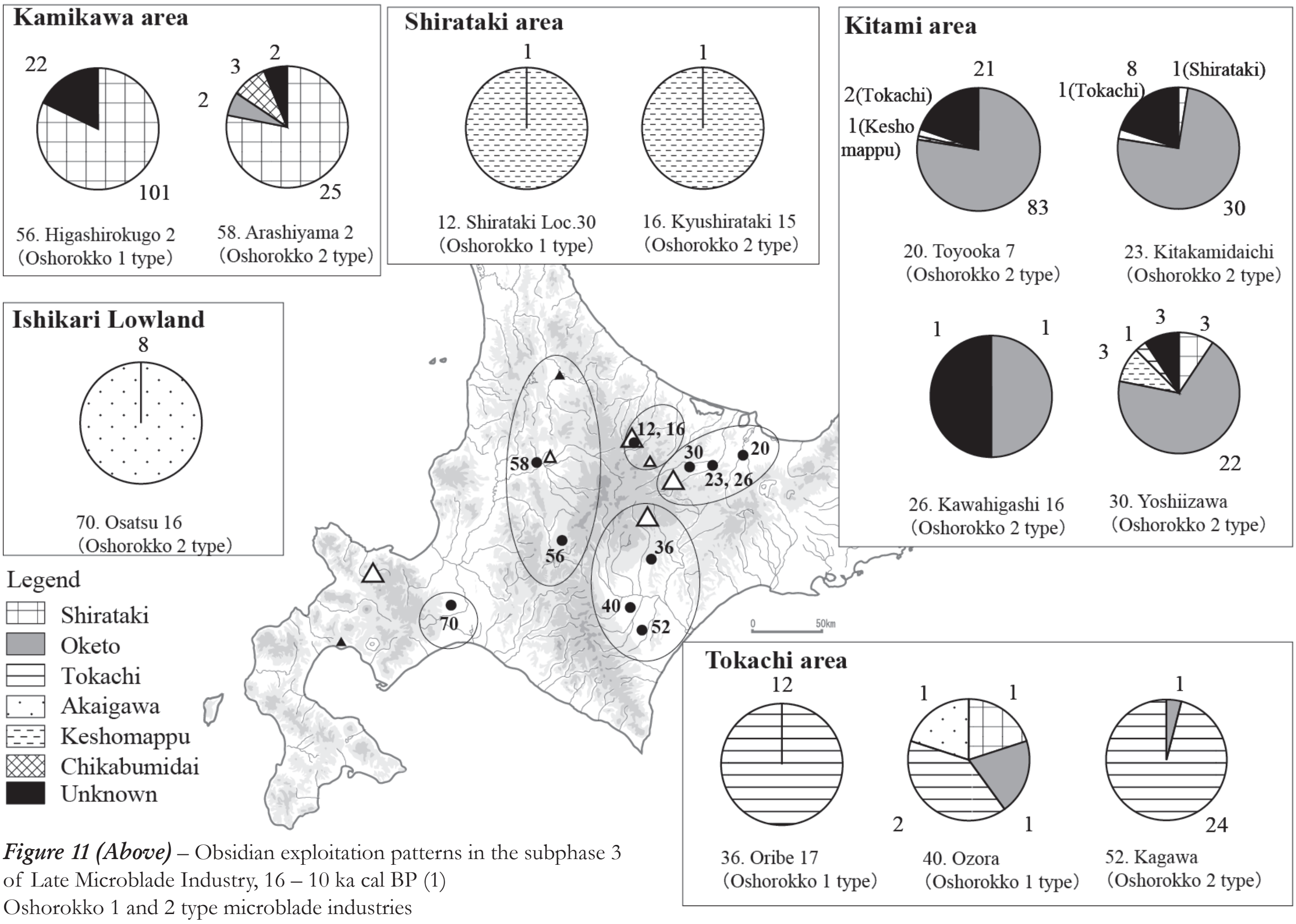
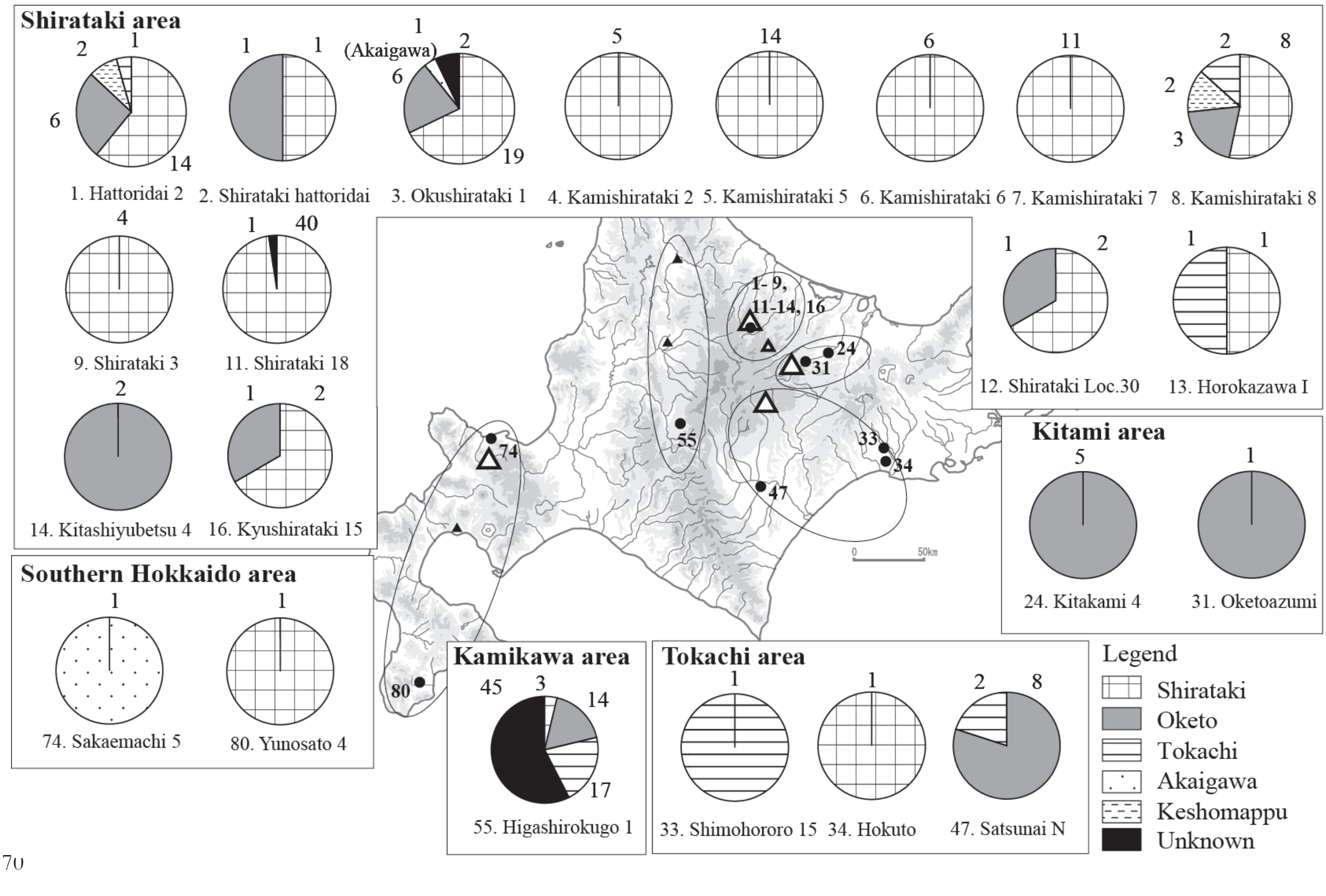


Figure 11 (Above) – Obsidian exploitation patterns in the subphase 3 of Late Microblade Industry, 16 – 10 ka cal BP (1) Oshorokko 1 and 2 type microblade industries

Figure 12 (Below) – Obsidian exploitation patterns in the subphase 3 of Late Microblade Industry, 16 – 10 ka cal BP (2) – Industry with points and stemmed points



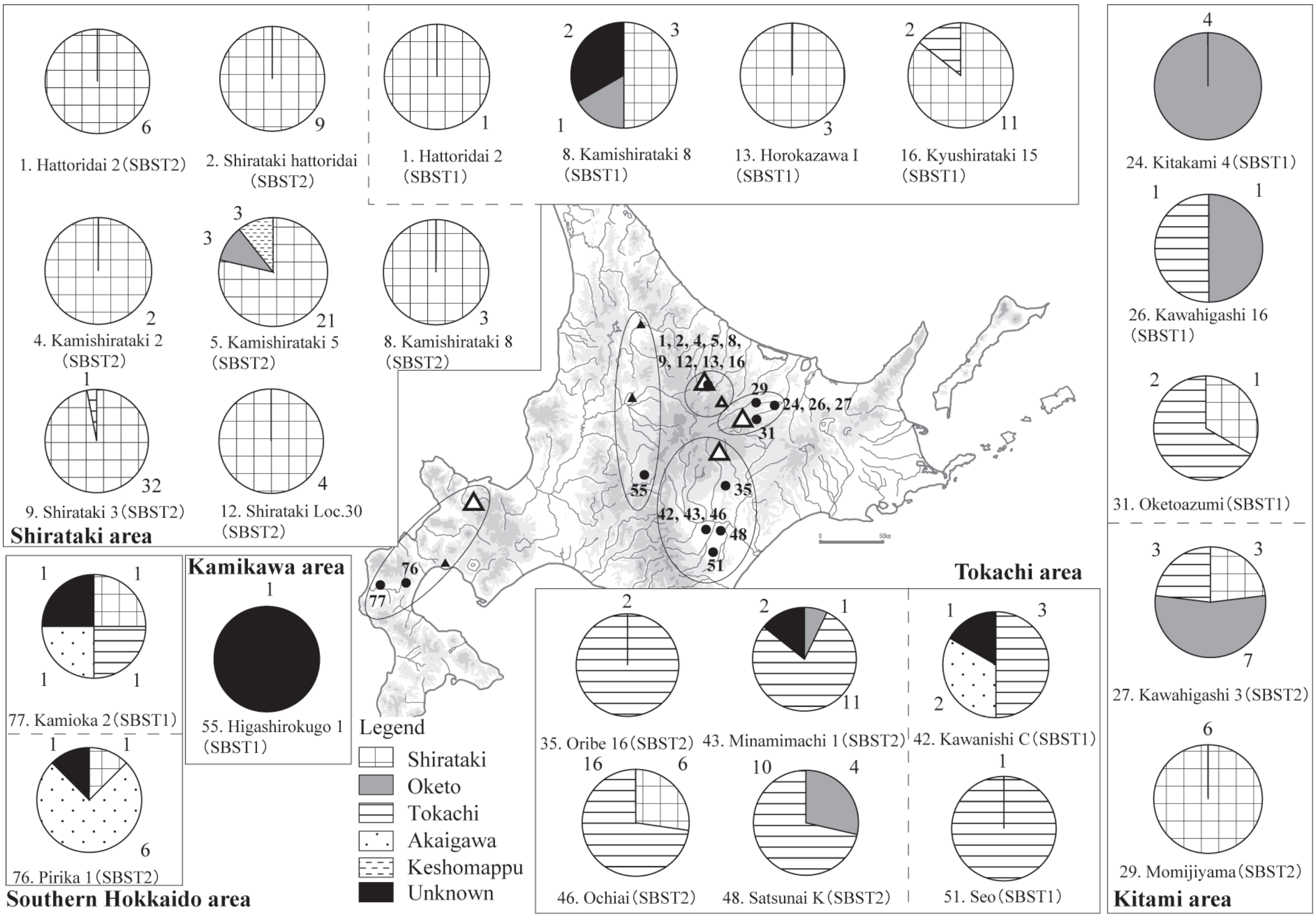
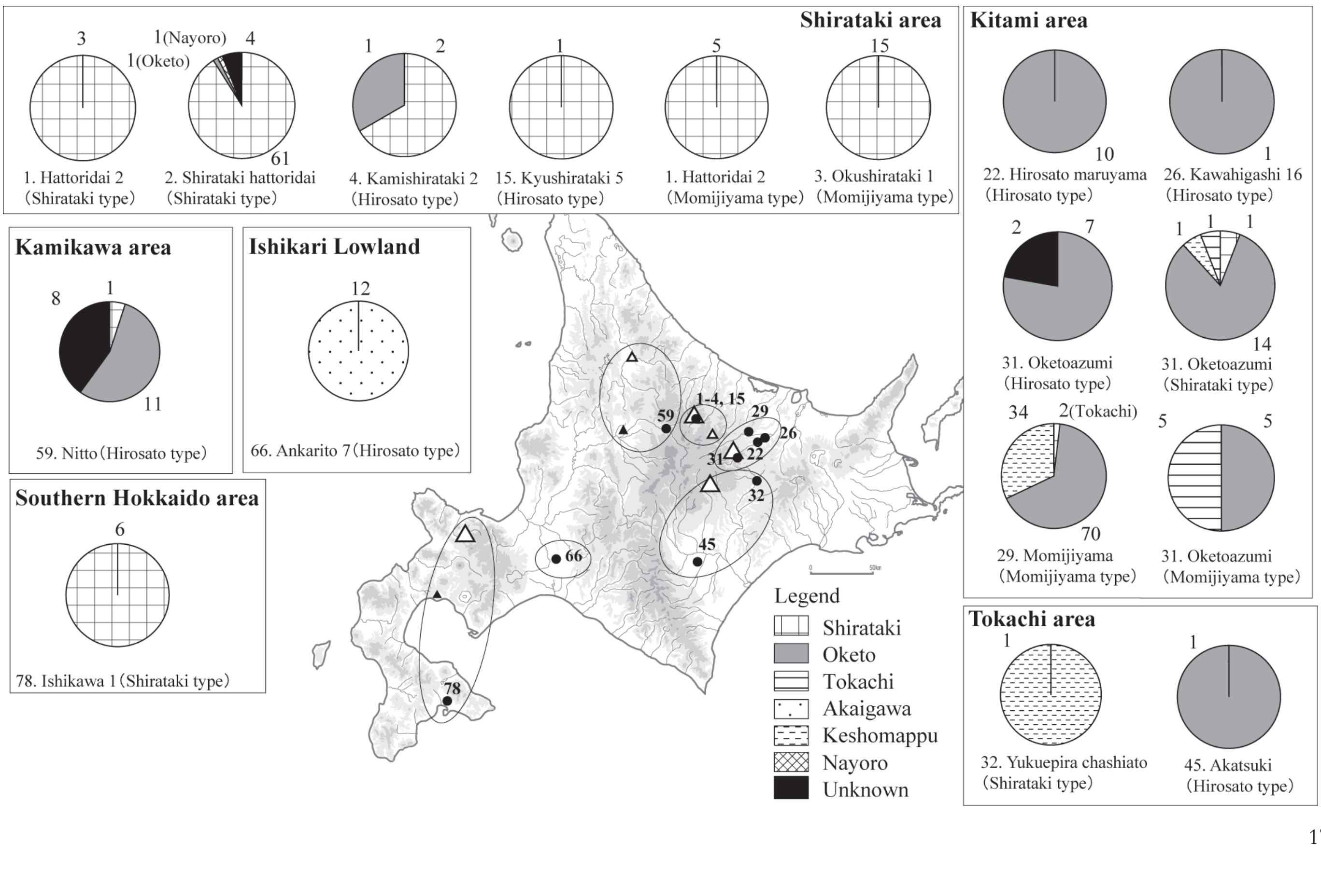


Figure 13 (Above) – Obsidian exploitation patterns in the subphase 3 of Late Microblade Industry, 16 – 10 ka cal BP (3)
Small boat-shaped tool type 1 and 2 industries – SBST1; small boat-shaped tool, type 1 industry – SBST2; small boat-shaped tool, type 2 industry
Figure 14 (Below) – Obsidian exploitation patterns in the subphase 3 of Late Microblade Industry, 16 – 10 ka cal BP (4) – Shirataki, Hirosato and Momijiyama type microblade industries



Provinces and the Baekdu Mountain obsidian source (Sato 2004a; 2004b). In the Ishikari Lowland however, this industry was made exclusively of Akaigawa obsidian. In southern Hokkaido, which is a long way from the obsidian sources but has abundant shale, it was shale that served as a raw material for the Hirosato type microblade industry. As mentioned already, it seems that in western Hokkaido (Ishikari Lowland and southern Hokkaido), the raw material procurement strategies were different from those in eastern Hokkaido. Nevertheless, the Hirosato type microblade industry in Hokkaido was made of obsidian from the Oketo source.

The Shirataki type microblade industry was analyzed only in 4 sites. The results show that Shirataki obsidian was almost exclusively used for this industry, with the sole exception of the Oketoazumi site, which lies very close to the Oketo source. Shirataki obsidian was transported for the production of this industry at the Ishikawa 1 site at the southernmost part of Hokkaido (Koshimizu 1988b), therefore showing that this industry is so strongly associated with Shirataki obsidian that it would be transported especially for this purpose over a very long distance.

The Shirataki type microblade industry in this period employs the fully developed Yubetsu method; together with the Sakkotsu type microblade industry of the previous period, the late Early Microblade Industry, they share some common characteristics with the wedge-shaped microblade industry, which is widely distributed over Northern Eurasia (e.g., in Siberia). Almost all of the microblade industries in Hokkaido were scantly distributed in the Palaeo-Hokkaido Peninsula; a plausible explanation for that would be that the UP socio-cultural boundary was defined by the Tsugaru Strait between the Palaeo-Hokkaido Peninsula and the Palaeo-Honshu Island during the Pleistocene. The Sakkotsu type and the Shirataki type microblade industries however, are found all over northeastern Japan and even in the South across this boundary. We have made a case elsewhere that the morphology of the lithic technology was dictated by the long distance mobility strategy which we regard as the determining behavioral factor for the choices the UP peoples made (Sato 1993, 2000, 2005, 2010, 2011b); this is further attested by the fact that both industries strongly depend on Shirataki obsidian, which the present study also showed.

4 – Discussion

A – Characteristics of the obsidian procurement and circulation pattern of the major sources

It seems there is a difference in the way the major sources Shirataki, Tokachi on one hand and Oketo and Akaigawa one the other, were exploited throughout the Palaeolithic period. Obsidian from Shirataki and Tokachi was transported to distant areas already from the EUP, and was intensively used throughout Hokkaido during the LUP. Shirataki obsidian was used mostly locally throughout the Upper Palaeolithic; during the EUP it was transported to the Ishikari Lowland, but during the LUP, it is found even in the distant southern Hokkaido. It should also be noted that a small amount of Shirataki obsidian was transported to the nearby Kitami area where the Oketo source is the nearest major source. During the EUP the circulation of Tokachi obsidian was limited to the local areas of Tokachi and Kamikawa or the Ishikari Lowland located relatively near Tokachi area, after the LUP, however, this type of obsidian is found over the entire area of Hokkaido. It is noteworthy that obsidian from other areas was not transported into the Kitami area, apart from Oketo obsidian.

In contrast, Oketo and Akaigawa obsidian can be found at sites near the two sources during the EUP, and later, in the LUP, their distribution seems to have expanded widely. However, unlike the Shirataki and Tokachi obsidian, their use was relatively limited. A small amount of obsidian from Shirataki was transported to Kitami, whereas larger amounts of obsidian from the Oketo source in Kitami were transported to the Shirataki area. The use of Akaigawa obsidian expanded remarkably after the LUP. During the EUP it was mainly used in the west Kamikawa areas, and specifically in the Ishikari Lowland and southern Hokkaido, but after the LUP, Akaigawa obsidian is found all the way to the Shirataki and Tokachi areas in eastern Hokkaido. Throughout the LUP, a relatively large amount of obsidian from eastern Hokkaido (Shirataki and Tokachi sources) was transported into western Hokkaido (Ishikari Lowland and southern Hokkaido), while the amount of Akaigawa obsidian transported into eastern Hokkaido (Tokachi, Kitami, Kamikawa and Shirataki areas) was quite small. This might be explained by the limited quantity of Akaigawa obsidian available.

Compared with other major sources, Oketo obsidian was mainly used locally in Kitami, and rarely used in other areas. In the Ishikari Lowland this obsidian is barely used, except for the production of the Hirosato type microblade industry. The procurement and use of Akaigawa obsidian in southern Hokkaido and Oketo obsidian in eastern Hokkaido seem to be complementary to each other. On the island of Sakhalin only Shirataki obsidian was used during the LUP, whereas Oketo obsidian was not used there until the Neolithic period (Kuzmin et al. 2002).

B – Comparison with studies for residential mobility and behavioral strategy

Kimura (1995) suggested that obsidian was transported over long distances during the period that microblade industries flourished, but before and after that period, local raw materials were mainly utilized. Yamada (2006) modeled the residential mobility system of the prehistoric people that used microblade industries according to the scheme of residential and logistic mobility. Although the results of our study corroborate these hypotheses, we appreciate that the dynamics of behavioral strategies are much more complicated than what this kind of studies can hypothesize, which explains in part why so many questions remain still unresolved.

C – Cultures, ecosystems and obsidian source analysis

We have written extensively on the undoubtedly strong relationship between human cultures on one hand, and vegetation, fauna, landscape and palaeoclimate on the other, in an attempt to map the historical process of socio-ecological and cultural change in the northern Circum-Japan Sea Area through the lens of cultural ecology (Sato 2008, 2009, 2011a, 2012; Sato et al. 2011). The emergence of microblade industries in Hokkaido at the beginning of the early Early Microblade Industry coincides with the transition from Marine Isotope Stage 3 to 2 (MIS3 to MIS2). The Last Glacial Maximum (LGM) also began during this period, while the mammal resource structure changed radically from the southern *Palaeoloxodon-Sinomegaceroides* complex to the northern mammoth fauna. It must be noted however, that the ratios of obsidian from different sources present at each site did not change significantly during this time, implying that it is possible that the behavioral strategy during the early Early Microblade Industry did not change immediately to adapt to the changes in the resources.

In other words, the diversification of obsidian sources used and the relation between specific sources and industries were not seen until the transition from the early to the late Early Microblade Industry. Therefore, the changes in the obsidian exploitation patterns did not necessarily coincide with the changes in technology, subsistence, residential mobility and behavioral strategies caused by the introduction of the microblade technology. Rather, it seems that the obsidian exploitation patterns changed in the late Early Microblade Industry at the same time the fully developed Yubetsu technique appeared, the famous microblade knapping technique of northern Eurasia. The prehistoric people of the late Early Microblade Industry developed a long distance mobility strategy suitable for hunting large fauna, such as mammoth and giant deer, which in turn meant organizing efficiently the production of microblade industries, which is also reflected in the manner in which obsidian sources were exploited. It is generally assumed that the extinction of large mammals in Hokkaido occurred about 18 ka cal BP (Takahashi 2007; 2011). If this assumption is correct, it corresponds to the middle of the late Early Microblade Industry. Consequently, the game gradually became smaller in size, which brought about the various obsidian procurement strategies pertaining to each industry in the Late Microblade Industry.

The first human occupation in Hokkaido dates back to the beginning of the Upper Palaeolithic, and obsidian remained the main lithic raw material from this time until the end of the Palaeolithic period. At present no sites have been found dating to the period between early and late Early Microblade Industry (21-19 ka cal BP). Unfortunately, radiocarbon dates for Palaeolithic sites in Hokkaido are very few; hence, it is difficult to determine whether this lack of sites is due to a population decrease caused by extreme environmental conditions, such as severely cold climate similar to the one during the LGM, or simply because we are lacking securely dated Palaeolithic sites.

5 – Summary and concluding remarks

There are 21 obsidian sources archaeologically in Hokkaido, out of which only 8 were used during the UP. Throughout the UP, the sites located in the vicinity of the major obsidian sources Shirataki, Tokachi, Oketo and Akaigawa, tended to use these primarily for the procurement of obsidian; however, the obsidian sources that are deemed secondary show different exploitation patterns depending on the period and industry. In Kamikawa and the Ishikari Lowland, where no major obsidian sources exist nearby, the ratios of obsidian from different sources vary among periods and industries. In particular, the Ishikari Lowland is 70 km away in a straight line from the Akaigawa source, 150 km from the Tokachi source, 170 km from the Shirataki source, and 180 km from the Oketo source. Knowing which sources were used for which industry is crucial to our understanding of raw material procurement strategies as well as the process of creating territorial boundaries.

Among the four major sources, Shirataki, Tokachi, Oketo and Akaigawa, the former two were distributed widely from the beginning of the EUP, while the latter two were used in sites near them in the EUP, and were not widely distributed until the LUP. Even during the LUP, the amount of obsidian circulated from Oketo and Akaigawa was relatively small. We should also note that Oketo and Akaigawa obsidian were complementary to each other.

From the perspective of ratios of different types of obsidian, the turning point for the obsidian exploitation strategies did not coincide with the appearance of microblade industries during the transition from EUP to LUP, but with the development of the fully developed Yubetsu technique during the transitional period from the early to the late Early Microblade Industry. The Sakkotsu type microblade industry in this period was strongly tied to Shirataki obsidian; Oketo and Tokachi obsidian were used in the Kitami and Ishikari Lowland areas respectively. In contrast, the contemporaneous Tougeshita 2 type microblade industry tends to be made of local obsidian from nearby sources. During the Late Microblade Industry, the relationship between specific sources and industries became more pronounced. Apart from the Sakkotsu type microblade industry, Shirataki obsidian was also used for the production of Shirataki type microblade industries knapped using the fully developed Yubetsu technique. Oketo obsidian was not used much throughout the UP, but it was the preferred raw material for the Hirosato type microblade industry. Exploitation of minor sources such as Chikabumidai and Nayoro is characteristic of the LUP. The obsidian exploitation patterns we explore here are generally consistent with the residential mobility system studies of Kimura (1995) and Yamada (2006), but we should note once again that the scant sourcing data create a bias that needs to be addressed to further our understanding. The more we increase the number of sourced obsidian artifacts, the more precise our interpretations can be about the circulation of obsidian and the exploitation of every obsidian source.

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Note (1) – Palaeolithic in the Palaeo-Honshu Island is divided into Early Upper Palaeolithic (38-29 ka cal BP), Late Upper Palaeolithic (29-18 ka cal BP) and Final Upper Palaeolithic (18-16 ka cal BP). In particular, please notice that the subphases of the EUP and LUP in Hokkaido are different from those of the Palaeo-Honshu Island.

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Lithic raw material exploitation and circulation in Préhistory. A comparative perspective in diverse palaeoenvironments
Liège, ERAUL 138, 2014, p. 179-203

2.6. Upper Palaeolithic obsidian use in central Japan: the origins of obsidian source exploitation

Résumé

Cet article fait une mise au point sur la découverte des sources d'obsidienne et leur exploitation au centre du Japon durant la première moitié du Paléolithique supérieur récent (ca 38 000 – 35 000 cal B.P.). Car il n'existe pas de preuve fiable remontant avant 40 000 ans cal B.P. au centre du Japon et donc nous allons essayer de les rechercher grâce à l'étude des relations entre l'apparition de l'exploitation lointaine de l'obsidienne et les stratégies mobiles des populations de l'EUP. Cette étude permet de fournir des informations significatives sur l'adaptation de l'homme moderne dans des paysages peu familiers. Nous allons examiner les changements, dans l'utilisation de l'obsidienne, du modèle de distribution de l'obsidienne basé sur l'analyse de sa provenance, et des stratégies de mobilité des chasseurs-cueilleurs à partir de la phase élémentaire et jusqu'à la phase développée durant l'EUP. Bien qu'il n'y ait qu'un faible pourcentage de produits d'obsidienne dans l'ensemble lithique, nous pouvons identifier toutes les sources d'obsidienne: le centre du Japon et l'îlot de Kose-Onbase, dans l'Océan Pacifique. La phase développée se caractérise par une augmentation de l'utilisation d'obsidienne et l'apparition d'une implantation circulaire. En particulier la population de l'EUP du lac Nojiri a montré une activité importante. Les modèles de distribution d'obsidienne durant cette période se caractérisent par une circulation sur de longues distances dépassant leurs aires résidentielles. La région montagneuse centrale du Japon a joué un rôle important comme axe de ces déplacements. Il semble que les chasseurs cueilleurs pouvaient considérer cette région comme une place centrale de ces mouvements sur de longues distances et l'homme préhistorique avait chassé les grands herbivores qui avaient finalement disparu pendant le maximum de la dernière glaciation dans l'ensemble des sites du lac Nojiri. L'EUP développé succédait à la phase initiale d'exploitation et de migration dans les îles japonaises.

Abstract

This paper focuses on the discovery of obsidian sources and the establishment of obsidian use in central Japan in the early part of the Early Upper Palaeolithic (eEUP: ca. 38,000-35,000 cal BP). Because there is no reliable archaeological and palaeoanthropological evidence dating back to before 40,000 cal BP in central Japan, elucidating the relationship between the first establishment of obsidian procurement system and the mobility strategies of the eEUP populations would provide significant information with regard to modern human adaptations to unfamiliar landscapes. Temporal changes in obsidian use from the initial eEUP to the developed eEUP, obsidian distribution patterns based on provenance analysis, and the mobility strategies of eEUP hunter-gatherers are examined. Although the initial eEUP is characterized by an extremely low degree of obsidian use in lithic assemblages, all obsidian sources in central Japan and the Kozu-Onbase Islet on the Pacific Ocean that have been discovered, indicate that an initial exploration of the natural resource environment took place. The developed eEUP is characterized by an increase in obsidian use and the appearance of circular settlements. In particular, the Lake Nojiri site group shows intensive land use by the developed eEUP population. The obsidian distribution pattern in the eEUP indicates an overarching distribution of Central Highlands obsidian throughout central Japan, regardless of the distance from residential areas. The Central Highlands played a role as the focal point that linked the procurement routes extending from residential areas. The hunter-gatherers of the eEUP used the Central Highlands as a hub for far-reaching mobile routes and they aggregated at the Lake Nojiri site group to hunt the large herbivores that would become extinct during the Last Glacial Maximum. The developed eEUP represents a settling-in phase following the initial exploration of and migration into the Japanese Islands.

Keywords: Obsidian use, Early Upper Palaeolithic, Japanese Islands

1 – Introduction

Preceding chronological studies have constructed a basic chronostratigraphic framework for the Upper Palaeolithic industries of central Japan using the wide-ranging distribution of the Pleistocene deposits (e.g., the Kanto loam, which are aeolian sediments originating from the detritus of Quaternary volcanos), tephrochronology, and radiocarbon dating (Tamura 2006; Takao 2006; Suto 2006; Kosuge and Nishii 2010; Suwama *et al.,* 2010; Nakamura and Sato 2010; Kudo 2012). The Upper Palaeolithic sequence is divided into the Early and the Late Upper Palaeolithic by the Aira-Tn volcanic ash that formed one of the key tephra beds dated to ca. 28,000-29,000 cal BP and which fell in a wide area across the Japanese Islands of Honshu, Shikoku, and Kyushu (Machida and Arai 2003: 64-70). The Early Upper Palaeolithic (EUP) is assigned to the period spanning from ca. 38,000 to ca. 30,000 cal BP, and the Late

Upper Palaeolithic (LUP) is assigned to the period spanning from ca. 30,000 to ca. 16,000 cal BP (Kudo 2012: Fig. 6-12). The earliest pottery emerged in ca. 16,000 cal BP, indicating the beginning of the Jomon Period (Kudo 2012).

The establishment of a lithic technology represented by knife-shaped tools and a particular blade technique divides the EUP into the early (eEUP) and late (lEUP) (Sato 1992; Ono *et al.,* 2002). The eEUP industries are characterized by trapezoids and edge-ground stone axes (Tsutsumi 2012). Radiocarbon dating assigns the eEUP to the period spanning from ca. 38,000 to ca. 34,500 cal BP (Miyoshi 2011). Figure 1 shows stratigraphic changes in the eEUP industries and the sequence of the loam sediments in the Ashitaka region of the Shizuoka Prefecture in central Japan.

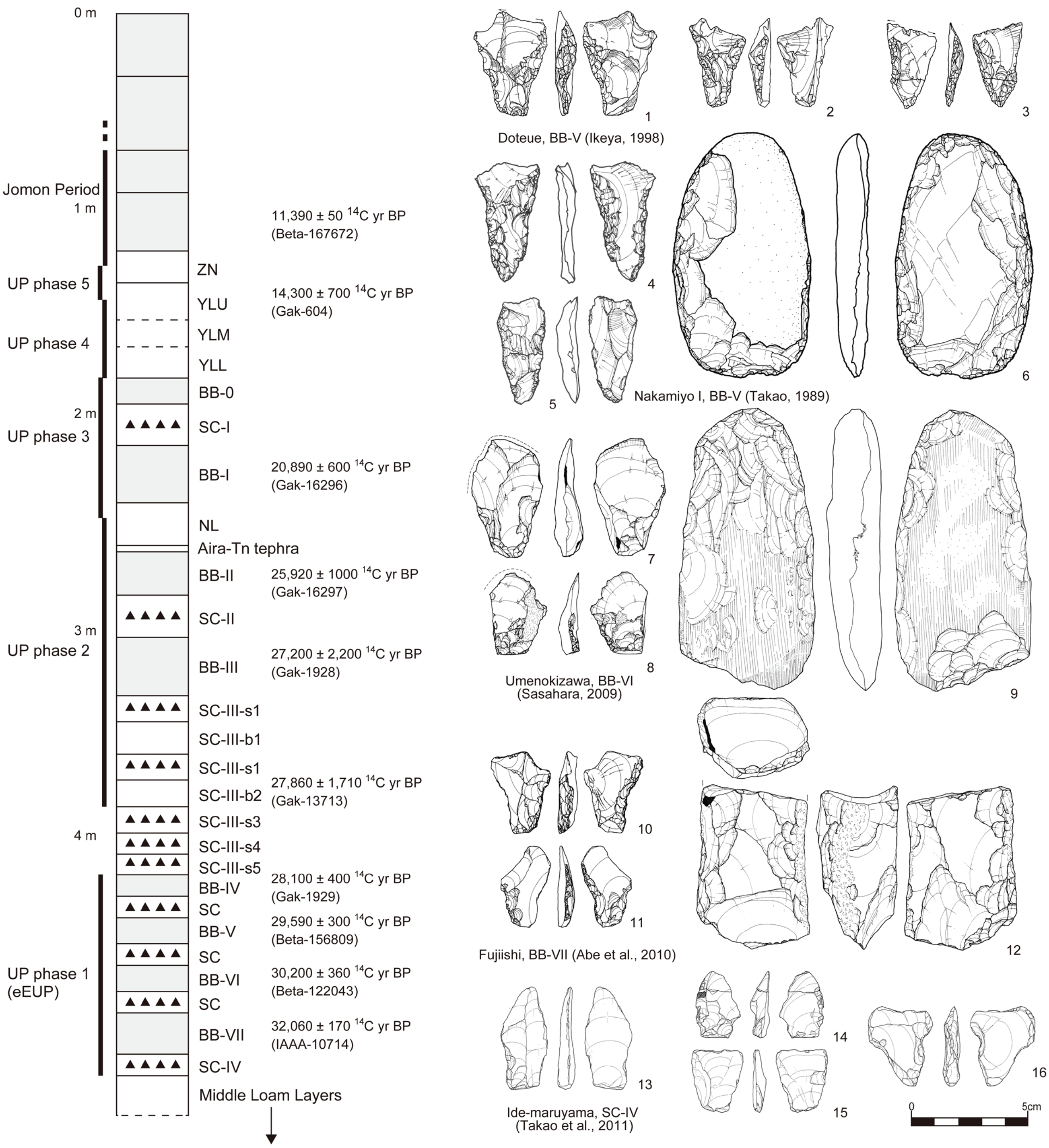
The eEUP is divided into the initial eEUP and the developed eEUP by stratigraphic changes in the lithic industries, such as the appearance of a prototype blade technique, the emergence of circular settlements, an increase in obsidian use, and an increase in the number of trapezoids (Suwama *et al.,* 2010). The heavy-duty core tools dominate the lithic tool-kit of the initial eEUP, although by the developed eEUP they seem to have disappeared. The edge-ground stone axes continued to exist from the initial eEUP to the developed eEUP with some changes in their morphology, and then disappeared from the lithic assemblages in the lEUP (Tsutsumi 2012). Apart from the disappearance of edge-ground stone axes, changes in the lithic industries from the eEUP to the lEUP are represented by an increase in the number of knife-shaped tools, burins and scrapers, the establishment of a particular blade technique, a decrease in the number of trapezoids with some changes in lithic technology, an increase in obsidian use in the later part of the lEUP, and the disappearance of the circular settlements (Sato 1992).

This paper examines obsidian procurement and consumption in the lithic industries of the eEUP that are distributed throughout central Japan (Fig. 2). The eEUP industries represent the first traces of human habitation in the Japanese Islands. There are two main research objectives in this study of obsidian use in the eEUP: firstly, to clarify the timeline of the discovery of obsidian sources as well as any changes in obsidian use through time; and secondly, to understand the basic structure of the mobility strategy adopted by the eEUP population on a macroscale. These examinations lead us to evaluate the essence of adaptive behavior when modern humans first settled in an unfamiliar land, i.e., the Japanese Islands. Focusing the research on obsidian use is useful for the following reasons. Firstly, the obsidian sources in central Japan are located at relatively farther distances from main Upper Palaeolithic residential areas than the sources of other lithic raw materials (Fig. 2; Tabl. 1). Secondly, a large amount of obsidian provenance data obtained through chemical analysis has accumulated since the 1970s and is currently available in the form of a database.

Although a distinctive increase in obsidian use, along with the chronostratigraphic sequence from the eEUP to the lEUP, has already been researched (Tamura *et al.,*

Table 1 – Supposed distance between obsidian source areas and residential areas in central Japan

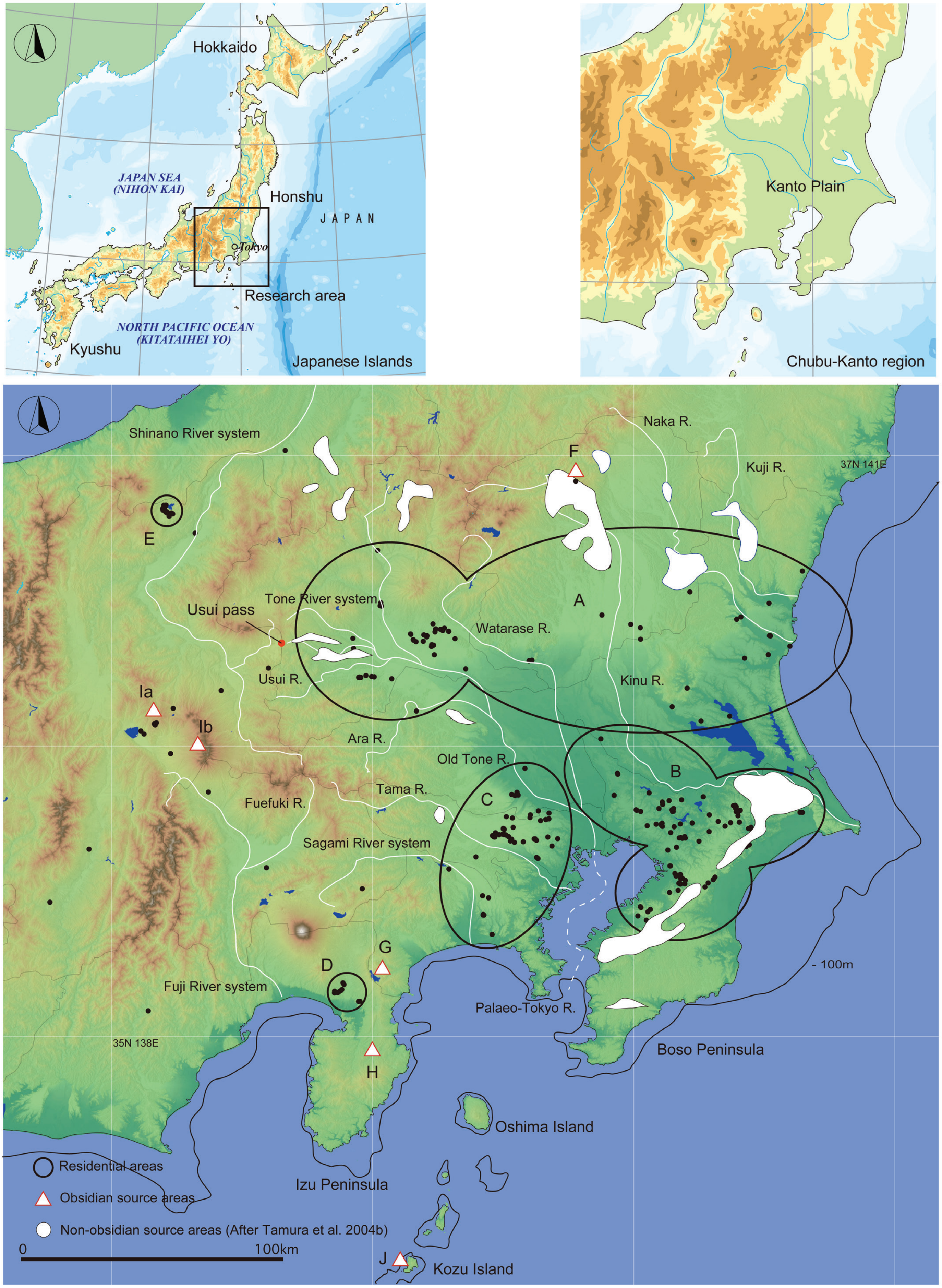
Regions \ Sources	Central Highlands (Kirigamine area)	Mt.Takahara	Hakone	Amagi	Kozu-Onbase
Northern Kanto	~100km (western area) (via Tone and Shinano Rivers)	~80km (eastern area) (via Kinu River)			
Eastern Kanto	~220km (via Kinu, Watarase, Tone, and Shinano Rivers)	~145km (via Kinu River)			~100km (LGM) (to the south tip of Boso Peninsula via Izu Islands)
Western Kanto	~160km (via Tama and Shinano Rives) ~180km (via Ara and Shinano Rivers)		~80km (in a straight line)	~100km (in a straight line)	
Ashitaka	~155km (via Fuji River)		~20km (in a straight line)	~35km (in a straight line)	~40km (LGM) (to the south tip of Izu Peninsula)
Lake Nojiri	~100km (via Shinano River)				



1987: 126-137; Kanayama 1990; Yamaoka 2004a, 2004b, 2006), a comparative analysis of obsidian use between the initial eEUP and the developed eEUP has not yet been undertaken. It is estimated that a comparative analysis from the latter perspective will elucidate the dynamics between the discovery of distant obsidian sources and the integration of obsidian into regional stone tool production. Moreover, examining the origin and establishment of obsidian use in the eEUP from a socio-economic perspective will contribute to an understanding of the essence of the mobility strategies adopted in the eEUP. Regarding the socio-economic aspects of the eEUP industries, this paper examines the relations between the diversity of the circular settlements and human activities in the developed eEUP.

Figure 1 – Schematic stratigraphy of the Upper Loam Layers of the Ashitaka Loam (modified from Takao 2006) and the eEUP industries in the Ashitaka region. 1-5, 7, 8, 10, 11, 15, 16: trapezoids; 13, 14: small points with retouched base; 6, 9: edge-ground stone axes; 12: stone ax. ZN: transitional layer; YL: Yasumiba loam; NL: Nise loam; BB: black band; SC: scoria layer

For the purposes of this study I have distinguished five residential areas or regional site clusters in central Japan on the basis of the distribution of eEUP industries in order to show more clearly the obsidian distribution patterns and changes in obsidian use from a regional perspective. As Figure 2 shows, these five residential areas are northern Kanto, eastern Kanto, western Kanto, the Ashitaka region, and the Lake


Hokkaido
JAPAN SEA
(NIHON KAI)
Honshu
J A P A N
Tokyo
Research area
NORTH PACIFIC OCEAN
(KITATAIHEI YO)
Kyushu
Japanese Islands
Kanto Plain
Chubu-Kanto region
Shinano River system
Naka R.
F
Kuji R.
37N 141E
E
Tone River system
Usui pass
A
Watarase R.
Usui R.
Kinu R.
Ia
Ib
Ara R.
Old Tone R.
B
Tama R.
C
Fuefuki R.
Sagami River system
G
D
- 100m
Fuji River system
Palaeo-Tokyo R.
35N 138E
Boso Peninsula
H
Oshima Island
Residential areas
Obsidian source areas
Non-obsidian source areas (After Tamura et al. 2004b)
Izu Peninsula
0
100km
J
Kozu Island

Nojiri site group. The Kanto Plain, which includes three residential areas, is the largest plain in the Japanese Islands, with an area of 17,000 square kilometers. The Ashitaka region is located in the Shizuoka Prefecture. The Lake Nojiri site group is located in the northern part of the Nagano Prefecture, where Upper Palaeolithic sites are densely distributed in a narrow area around Lake Nojiri.

2 – Background

A – Obsidian source areas in central Japan

Tamura *et al.,* (2003; 2004a; 2004b) and Tamura and Kunitake (2006) have shown that the sources (rocky areas) of lithic raw materials including obsidian used by the Upper Palaeolithic populations are arranged concentrically around the Kanto Plain (Fig. 2). According to this view, the obsidian sources are located in the farthest concentric circle from the Kanto Plain. Regarding the locations of obsidian source areas, there are five representative areas, that is, the Mt. Takahara source area (Tochigi Prefecture) is arranged to the north, the Central Highlands source area (Nagano Prefecture) to the west, the Hakone source area (Kanagawa and Shizuoka Prefectures), and the Amagi source area (Shizuoka Prefecture) to the southwest of the Kanto Plain. The concentric circle containing the obsidian source distribution extends from the mainland of Honshu and reaches the Kozu-Onbase Islet (Tokyo Metropolis) on the Pacific Ocean. Since the 1970s, chemical analysts have made databases of geological obsidian collected from various sources in central Japan and have accumulated obsidian provenance data. Although the Neutron Activation Analysis (NAA) was initially used for sourcing obsidian artifacts, Energy Dispersive X-Ray Fluorescence Spectrometry (EDXRF) became a mainstream analytical method (e.g., Suzuki 1969; 1970; 1971; Warashina *et al.,* 1984; Tamura *et al.,* 1987; Mochizuki *et al.,* 1994; Sugihara and Kobayashi 2004). The analysis usually classifies the obsidian artifacts derived from a certain source area into several subdivided groups on the basis of geochemical composition. In the Central Highlands, for example, Sugihara (2011) classified geological obsidian sampled from 23 outcrops or collection zones into six geochemical groups: Nishi-Kirigamine, Wada-toge, Takayama, Omegura, Mugikusa-toge/Tsumetayama, and Yokodake; and compiled these geochemical groups into two geographical areas: Kirigamine and Kita-Yatsugatake. However, all of the provenance data used in this paper are assigned to the above-mentioned representative five source areas in central Japan, and not to the subdivided geochemical groups in each source area, because the nomenclature of the source categories employed and the details for discrimination of the geochemical groups vary among analysts.

B – River systems as stone procurement routes

Each of the five residential areas in central Japan has its own character in terms of variety and combination of lithic raw material use. Accessibility to lithic sources is a primary reason that determines the representative combination of the lithic raw materials for regional stone tool production (Tamura *et al.,* 1987: 123-126; Shibata 1994). The author believes that accessibility from a certain residential area to lithic sources depended on large river systems that are geographically related to lithic source distribution including obsidian sources (Fig. 2). Moreover, the distribution of the eEUP sites in central Japan from a regional perspective clearly shows a close relationship with the large river systems, the basins of which extend for more than 100 km. Non-obsidian sources that Tamura *et al.,* (2004b) illustrated are located around the upper reaches of these river systems. Even the eEUP sites located farther from the main residential areas, are situated in places where the large river systems can connect them with the main residential areas. Accordingly, it is very likely that these large river systems played a significant role in the Late Pleistocene as prehistoric routes or paths for lithic raw material procurement.

When we discuss the exploitation of obsidian sources in central Japan, there is no need to assume a mobility strategy that was focused on only the long-distance transportation of obsidian. Although obsidian artifacts in the Kanto Plain tend to be recognized as

Figure 2 – Research area, distribution of the eEUP industries, and locations of lithic raw material sources in central Japan. Black dots: eEUP industries; A: northern Kanto region; B: eastern Kanto region; C: western Kanto region; D: Ashitaka region; E: Lake Nojiri site group; F: Mt. Takahara; G: Hakone; H: Amagi; Ia (Kirigamine) and Ib (Kita-Yatsugatake): Central Highlands; J: Kozu-Onbase. The site distribution is based on the work of the Japanese Palaeolithic Research Association (2010)

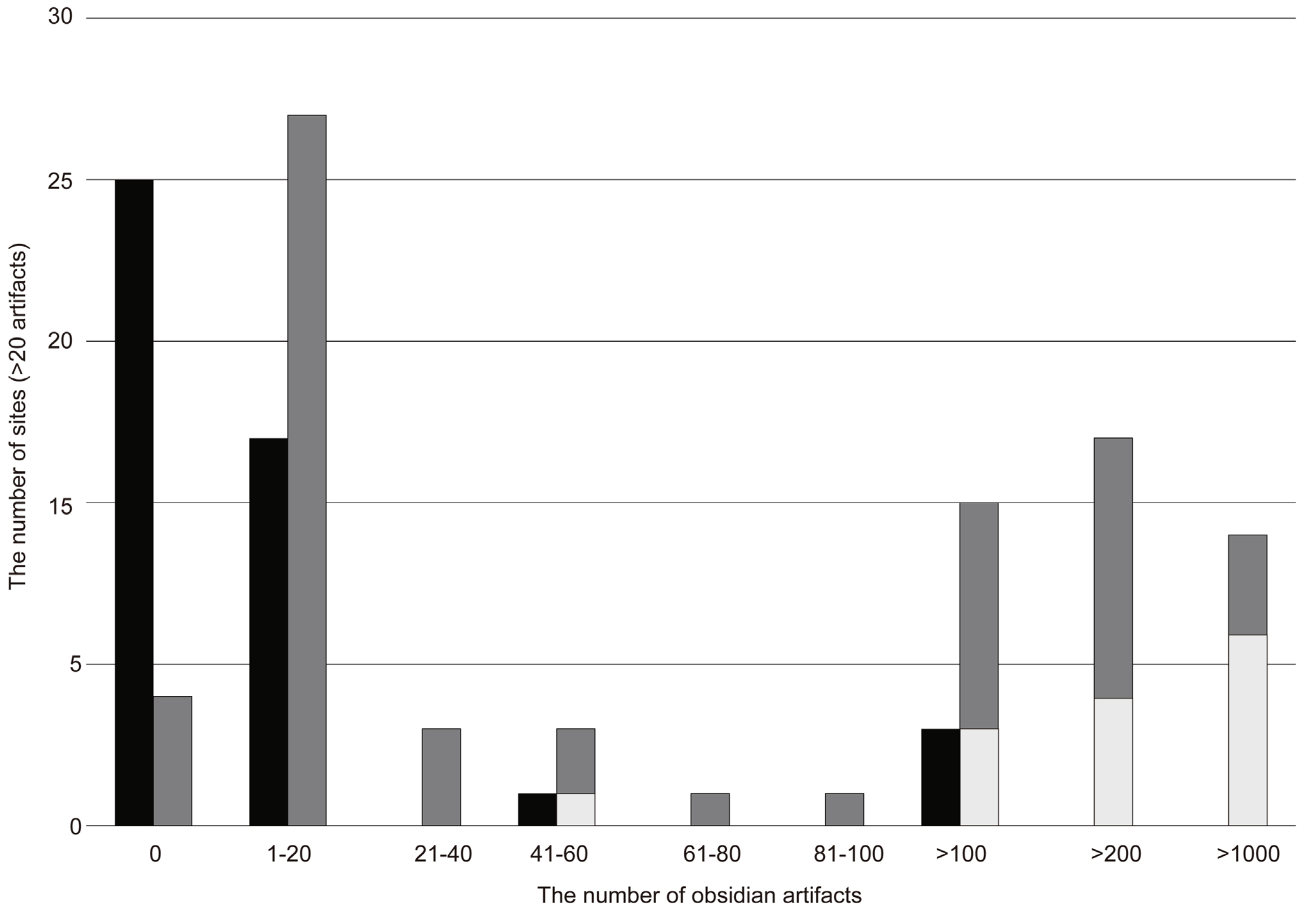


Figure 3 – Quantitative frequency of obsidian artifacts in the eEUP industries (source: appendix tables 1 and 2). Black: the initial eEUP industries (N = 35 sites); dark grey: the developed eEUP industries except for the Lake Nojiri site group (N = 50 sites); light grey: the developed eEUP industries from the Lake Nojiri site group (N = 14 sites)

a representative of non-local lithic raw materials, categorizing the lithic raw materials that were used in the Kanto Plain according to the dichotomy of local and non-local is meaningless, because all sources are distributed outside the Upper Palaeolithic residential areas (Tamura and Kunitake 2006). When we consider that large river systems played a significant role for lithic raw material procurement, obsidian sources can be accessed by the short extra trips of the prehistoric hunter-gatherers across multiple river systems from non-obsidian sources around the Kanto Plain, or, in any other case, a part of the sources of non-obsidian geographically overlaps with obsidian sources (e.g., Mt. Takahara obsidian source area). The main issue to be examined is to what degree and how obsidian were integrated with non-obsidian procurement in the hunter-gatherer mobility strategies.

3 – Data and analysis

A – Changes in obsidian use in the eEUP industries

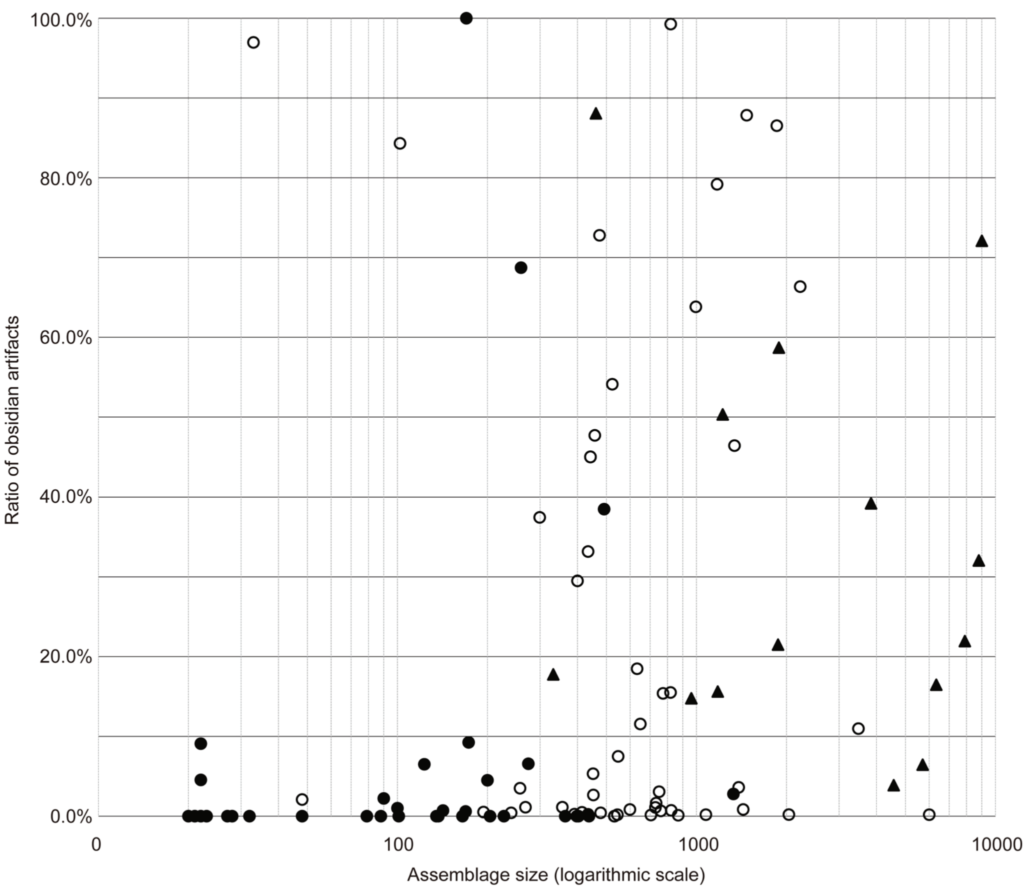
To understand the origin of obsidian source exploitation, obsidian use is compared between the initial eEUP and the developed eEUP industries (Appendix Tables 1 and 2). The individual obsidian assemblages obtained from 35 sites having more than 20 lithic artifacts in the initial eEUP and from 64 sites in the developed eEUP are classified into nine groups according to the quantity of obsidian artifacts. They are grouped as follows, by number of pieces: 0, 1-20, 21-40, 41-60, 61-80, 81-100, >100, >200, and >1,000. Figure 3 shows the quantitative frequency of obsidian artifacts in the individual sites. The initial eEUP industries show a high frequency of appearance in the groups with 0 and 1-20 pieces. Only three sites appear in the group with >100 pieces and they are independently distributed in eastern Kanto, western Kanto, and the Ashitaka region, whereas sites appearing in the groups with between 21-40 and 81-100 pieces in the initial eEUP are very rare (one site).

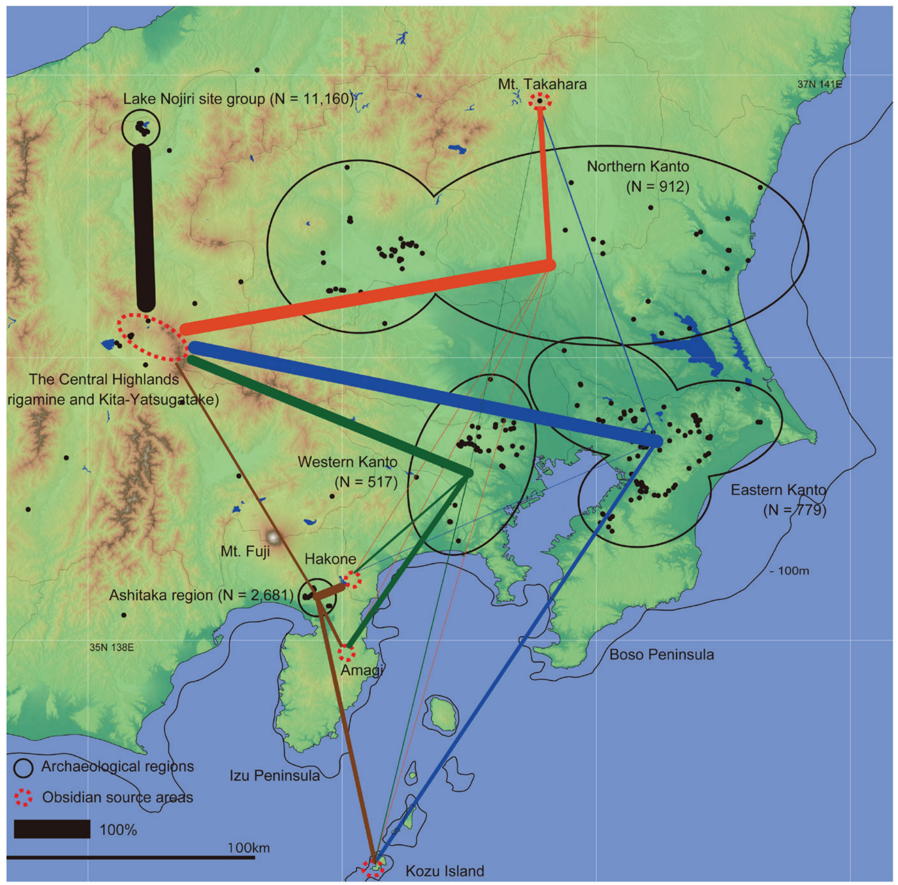
A regional absence of site distribution is observed in the initial eEUP industries (Appendix Table 1). Whereas a few small lithic assemblages have been found in

	Central Highlands		Mt.Takahara		Hakone		Amagi		Kozu-Onbase		Obsidian total (analysis)	Obsidian total (assemblage)	analysis/assemblage	Num. of sites
Northern Kanto	617	67.7%	280	30.7%	2	0.2%	2	0.2%	11	1.2%	912	Not available	-	14
Eastern Kanto	556	71.4%	57	7.3%	1	0.1%	0	0.0%	165	21.2%	779	2,630	29.6%	9
Western Kanto	271	52.4%	11	2.1%	60	11.6%	149	28.8%	26	5.0%	517	Not available	-	14
Ashitaka	385	14.4%	0	0.0%	1,203	44.9%	464	17.3%	629	23.5%	2,681	4,047	66.2%	15
Total	1,829	37.4%	348	7.1%	1,266	25.9%	615	12.6%	831	17.0%	4,889	-	-	52
Lake Nojiri	11,160	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	11,160	17,056	65.4%	15
Total	12,989	80.9%	348	2.2%	1,266	7.9%	615	3.8%	831	5.2%	16,049	-	-	67

Table 2 (Above) – Regional variability in obsidian procurement of the eEUP (source: appendix table 3)

Figure 4 (Below, left) – Correlation diagram between lithic assemblage size and ratio of obsidian artifacts (source: appendix tables 1 and 2). Black dots: the initial eEUP industries; circles: the developed eEUP industries except for the Lake Nojiri site group; triangles: the developed eEUP industries from the Lake Nojiri site group
Figure 5 (Below, ritght) – Obsidian distribution patterns in the eEUP in central Japan. The bars extending from each archaeological region show the ratio of obsidian artifacts classified into five source areas by provenance analysis (XRF, NAA). Black dots: the eEUP industries





the eastern part of the northern Kanto region, no initial eEUP industry has been discovered in the Lake Nojiri site group and the western part of northern Kanto. The geographical distribution of the developed eEUP industries extended all over the residential areas of central Japan, including the northern Kanto region and the Lake Nojiri site groups, where traces of human habitation were previously absent (Appendix Table 2).

During the developed eEUP (Fig. 3), there is a clear decrease in the frequency of zero pieces appearing, while a high frequency of appearance in the groups with 1-20 pieces is observable. A particular difference from the initial eEUP is that the sites appearing in the groups with >200 and >1,000 pieces consistently exist throughout the period. Although at a low frequency, the groups with between 21-40 and 81-100 pieces newly appeared in the developed eEUP industries. Figure 3 also shows the frequency of appearance that is limited to the eEUP industries in the Lake Nojiri site group. Thirteen out of 14 sites in the Lake Nojiri site group appear in the groups with >100, >200 and >1,000 pieces, clearly indicating that a larger quantity of obsidian was consumed in the individual sites in comparison with the other residential areas.

Figure 4 is a correlation diagram showing the proportion of obsidian artifacts to the total number of lithic assemblages. Overall, the diagram shows that the assemblage sizes of the initial eEUP industries appear to be smaller than those of the developed eEUP industries. Almost all of the initial eEUP industries yielding obsidian artifacts are shown to be less than 10% in proportion to the total number of lithic artifacts. In the developed eEUP industries, relatively larger assemblage sizes than those of the initial eEUP industries are dominant. In particular, this is notable for the lithic industries of the Lake Nojiri site group. The diagram also shows that the distribution of the obsidian artifact proportion to the total number of lithic assemblages in the developed eEUP industries is represented by a scattered pattern ranging from between 0% to 100% regardless of assemblage size. As Figure 4 shows, in the developed eEUP industries of the Lake Nojiri site group that consumed a relatively large amount of obsidian in central Japan, the distribution of the obsidian artifact proportion to the total number of lithic assemblages shows a scattered pattern similar to those of other residential areas.

Because there are basically no essential differences in the size or depth of excavation areas between the initial and the developed eEUP industries, an increase in obsidian use and the enlargement of the lithic assemblage size are evaluated as temporal changes in the chronological sequence of the eEUP. The pattern of obsidian use in the initial eEUP is summarized as follows: 1) The pattern of quantitative frequency is polarized at a few sites that yielded more than 100 pieces of obsidian artifacts and the majority of sites that yielded 0 or 1-20 pieces, and 2) the proportion of obsidian artifacts to the total number of lithic assemblages is concentrated at less than 10%, reflecting that stone tool manufacturing generally depends on a high percentage of non-obsidian exploitation.

The main patterns of obsidian use in the developed eEUP are the following: 1) The sites lacking obsidian artifacts appear to have decreased in number, and sites in which obsidian reduction was undertaken, at which 1-20 pieces were found, increased; 2) the sites that appear in the groups with >100, >200, and >1,000 pieces were consistently formed during the period; 3) the sites that appear in the groups with between 21-40 and 81-100 pieces were a new addition to this consumption pattern; 4) the proportion of obsidian artifacts to the total number of lithic assemblages varies widely, regardless of assemblage size, reflecting that there were diverse circumstances for obsidian use among the developed eEUP industries; and 5) the Lake Nojiri site group, which was established for the first time during the developed eEUP, is the place where obsidian use was relatively higher among the residential areas in central Japan. Nevertheless, the proportion of obsidian artifacts to the total number of lithic assemblages also varies widely among the sites, similarly to the other residential areas. Accordingly, the formation of large assemblages in comparison with the other residential areas is the main cause for the large quantity of obsidian use in the individual sites of the Lake Nojiri site group.

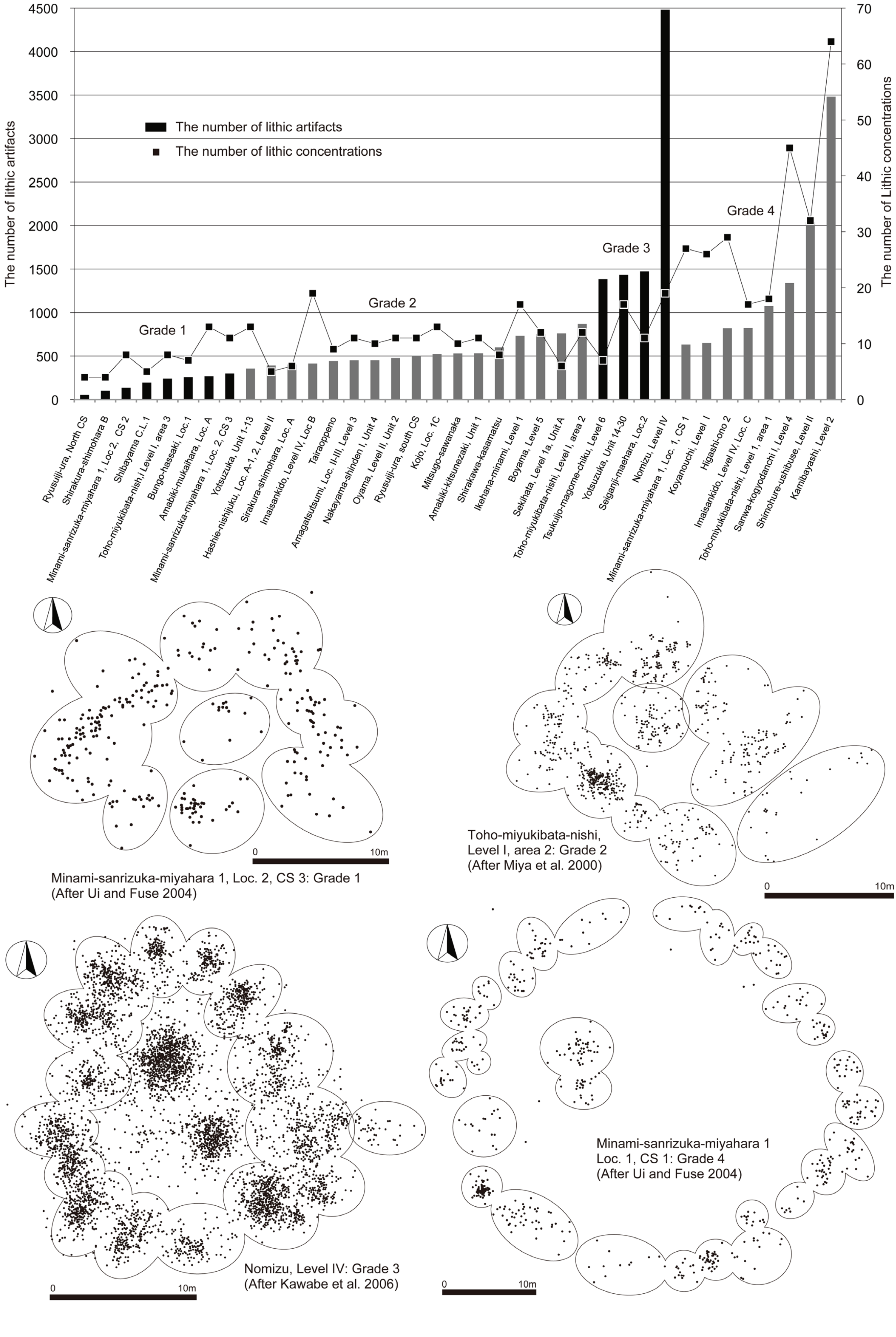
B – Obsidian distribution patterns in the eEUP

Serizawa *et al.,* (2011) have compiled obsidian provenance data accumulated since the 1970s, from the lithic industries of the Upper Palaeolithic, Jomon, and Yayoi periods in the Kanto Plain. The data demonstrated that the total number of obsidian artifacts identified with a source from all of the Upper Palaeolithic industries in the Kanto Plain reaches 38,235 pieces. Appendix Table 3 is a list of provenance data collected from the eEUP industries in the Kanto Plain, the Ashitaka region, and the Lake Nojiri site group. Table 2 shows the total values of the provenance data separated into five source areas within each residential area with the number of pieces and its proportion to the total. Since the initial eEUP has had few samples applied to provenance analysis, all of the provenance data obtained from the initial eEUP and the developed eEUP have been compiled together in Table 2 and Figure 5.

There are three distinctive patterns for obsidian artifacts distribution in the eEUP. Distance of obsidian sources from the perspective of residential areas causes biased distributions of obsidian artifacts derived from the source areas of Mt. Takahara, Hakone, Amagi, and the Kozu-Onbase Islet (Tabl. 1 & 2; Fig. 5). The obsidian artifacts made from Mt. Takahara obsidian are primarily distributed throughout northern Kanto (~80 km, 30.7% of the total number of analyzed pieces in that region; the same applies below) and eastern Kanto (~145 km, 7.3%), whereas a small number of them have been found in western Kanto (2.1%). Mt. Takahara obsidian has not been found in the Ashitaka region and the Lake Nojiri site group. The obsidian artifacts made from Hakone obsidian are primarily distributed in the Ashitaka region (~20 km, 44.9%) and have also been found in western Kanto to a certain degree (~80 km, 11.6%), whereas they are very rare in northern Kanto (0.2%) and eastern Kanto (0.1%). No Hakone obsidian has been identified in the Lake Nojiri site group. The obsidian artifacts made from Amagi obsidian are primarily distributed in western Kanto (~100 km, 28.8%) and the Ashitaka region (~35 km, 17.3%), but they are very rare in northern Kanto (0.2%). Amagi obsidian is not distributed throughout eastern Kanto and the Lake Nojiri site group. The obsidian artifacts made from Kozu-Onbase obsidian are primarily distributed in the Ashitaka region (~40 km by sea, 23.5%) and eastern Kanto (~100 km by sea, 21.2%). A small number of them have been identified in western Kanto (5.0%) and northern Kanto (1.2%), whereas no Kozu-Onbase obsidian has been identified in the Lake Nojiri site group.

Contrary to the obsidian distribution pattern indicating the above-mentioned regional biases, the obsidian artifacts made from Central Highlands obsidian are characterized by their overarching distribution all over central Japan (Tabl. 1 & 2; Fig. 5). In particular, they account for the highest percentage of the source composition in all residential areas including northern Kanto (~100 km, 67.7%), eastern Kanto (~220 km, 71.4%), western Kanto (~160-180 km, 52.4%), and the Lake Nojiri site group (~100 km, 100%); the Ashitaka region is the exception (155 km, 14.4%), being located close to the obsidian sources of Hakone and Amagi (totaling 62.2% in the Ashitaka region). Notice that the Central Highlands obsidian had been exclusively used for the production of stone tools in the Lake Nojiri site group, from which more than 10,000 obsidian artifacts from the developed eEUP industries have been applied to provenance analysis.

It should also be noted that all residential areas, except for the Lake Nojiri region, contain obsidian that had always been transported complementarily into the regions and consumed in small quantities, indicating that obsidian procurement never depended on a single obsidian source. The obsidian consumed complementarily in each residential area is as follows (Tabl. 2; Fig. 5): northern Kanto is represented by obsidian from Kozu-Onbase (1.2%), Hakone (0.2%), and Amagi (0.2%); eastern Kanto is represented by obsidian from Hakone (0.1%); western Kanto is represented by obsidian from Kozu-Onbase (5.0%) and Mt. Takahara (2.1%); the Ashitaka region is represented by obsidian from the Central Highlands (14.4%). It can be seen that these complementary types of obsidian are lithic raw materials that had been transported from sources located at a relatively farther distance from the residential area.



4500
4000
3500
3000
2500
2000
1500
1000
500
0
70
60
50
40
30
20
10
0
The number of lithic artifacts
The number of Lithic concentrations
The number of lithic artifacts
The number of lithic concentrations
Grade 1
Grade 2
Grade 3
Grade 4
Ryusuiji-ura, North CS
Shirakura-shimohara B
Minami-sanrizuka-miyahara 1, Loc 2, CS 2
Shibayama C.L.1
Toho-miyukibata-nishi,i Level I, area 3
Bungo-hassaki, Loc.1
Amabiki-mukaihara, Loc.A
Minami-sanrizuka-miyahara 1, Loc. 2, CS 3
Yotsuzuka, Unit 1-13
Hashie-nishijuku, Loc. A-1, 2, Level II
Sirakura-shimohara, Loc. A
Imaisankido, Level IV, Loc B
Tairaoppeno
Amagatsutsumi, Loc. II-III, Level 3
Nakayama-shinden I, Unit 4
Oyama, Level II, Unit 2
Ryusuiji-ura, south CS
Kojo, Loc. 1C
Mitsugo-sawanaka
Amabiki-kitsunezaki, Unit 1
Shirakawa-kasamatsu
Ikehana-minami, Level 1
Boyama, Level 5
Sekihata, Level 1a, Unit A
Toho-miyukibata-nishi, Level I, area 2
Tsukuijo-magome-chiku, Level 6
Yotsuzuka, Unit 14-30
Seiganji-maehara, Loc.2
Nomizu, Level IV
Minami-sanrizuka-miyahara 1, Loc. 1, CS 1
Koyanouchi, Level I
Higashi-ono 2
Imaisankido, Level IV, Loc. C
Toho-miyukibata-nishi, Level 1, area 1
Sanwa-kogyodanchi I, Level 4
Shimohure-ushibuse, Level II
Kamibayashi, Level 2
0
10m
Minami-sanrizuka-miyahara 1, Loc. 2, CS 3: Grade 1
(After Ui and Fuse 2004)
Toho-miyukibata-nishi,
Level I, area 2: Grade 2
(After Miya et al. 2000)
0
10m
Minami-sanrizuka-miyahara 1
Loc. 1, CS 1: Grade 4
(After Ui and Fuse 2004)
Nomizu, Level IV: Grade 3
(After Kawabe et al. 2006)
0
10m
0
10m

The features of the obsidian distribution patterns of the eEUP industries in central Japan can be summarized in the following three points: 1) With regard to obsidian that had originated from all source areas except for the Central Highlands, biased distributions appear among the residential areas. This pattern reflects the geographical conditions shown by the difference in relative distance between a specific residential area and the obsidian source. The procurement of Kozu-Onbase obsidian occurred as a part of this biased distribution pattern. 2) On the contrary, the distinctive amount of artifacts made from Central Highlands obsidian prevails all over central Japan, regardless of the relative distance between the source and the residential areas. Obsidian from the Central Highlands was intensively transported to all residential areas except for the Ashitaka region, accounting for the high percentage (between 50-100%) of the source composition in each residential area. The exclusive use of Central Highlands obsidian in the Lake Nojiri site group can be understood at a first glance as the result of a biased distribution in response to the distance from the source area of the Central Highlands. However, an explanation only in terms of accessibility is insufficient in this case, when considering the different features with regard to both the large quantity of obsidian use and the large assemblage sizes observed in the Lake Nojiri site group as compared to the other residential areas. 3) Whereas the obsidian procurement in the Lake Nojiri site group depended 100% on the Central Highlands, that of the other residential areas is always composed of primary obsidian derived from a specific source and complementary obsidian derived from several other sources. The complementary obsidian often accounts for only a small percentage of the source composition and had been transported from sources located farther away from the region, and seems to be a complex network spreading between the residential areas and the sources.

C – Land use in the Lake Nojiri site group and changes in settlement landscape

The emergence of distinctive large sites that were formed by land use in the Lake Nojiri site group relate to the temporal changes in both lithic assemblage sizes and the newly employed settlement structure between the initial eEUP and the developed eEUP. These temporal changes can be explained by the emergence of circular settlements known to be a unique trait limited to the time range of the developed eEUP in the Japanese Islands (Fig. 6). To better understand the nature of land use in the Lake Nojiri site group, the features of the circular settlements will be examined below.

The initial eEUP sites are usually composed of one or several lithic concentrations that are often arranged with no regularity in the settlements, and in most cases only a small number of lithic artifacts scattered throughout the excavation areas. The circular settlements that are characterized by a regular distribution pattern of lithic concentrations appeared in the developed eEUP industries (Hashimoto 1989; Daikuhara 1990; 1991; Suto 1991). The definition of a circular settlement is one in which multiple lithic concentrations in a diameter of several meters are arranged in a circular position forming a circle of 10 to 70 meters in diameter. The lithic concentrations usually show mutual relationships, as represented by the frequent refitting of lithic artifacts across the settlements, indicating that the settlement landscapes had been formed concurrently. The circularly arranged lithic concentrations delimit the settlements' boundaries. As of 2010, 120 circular settlements from 102 sites, distributed mainly in eastern Honshu (central Japan and the Tohoku region), have been discovered (Hashimoto 2010). Almost all circular settlements can be assigned to the developed eEUP, having disappeared in the late part of the Early Upper Palaeolithic (lEUP) by ca. 35,000 cal BP (Hashimoto 2006).

For this paper 37 circular settlements discovered in the Kanto plain are selected for comparative analysis (Appendix Table 2). In these sites systematic excavations have uncovered the entire spatial distribution of the lithic artifacts. The circular settlements can be divided into four categories on the basis of the number of lithic concentrations; the mean value of the diameter of the circular arrangement measured in direction from

Figure 6 (Left page) – Classification of the circular settlements from the Kanto Plain in the eEUP north to south, and east to west; and the combination of lithic concentrations that are classified in response to the number of artifacts (Shimada 2011). Figure 6 shows the classification of the circular settlements. Grades 1 and 2 are the dominant categories, likely reflecting the basic size of the mobile groups and representing a standard for the circular settlements. Grade 3 is characterized by a dense distribution of lithic artifacts among the individual lithic concentrations, that is, the production of stone tools was carried out intensively, though the diameter of the circular arrangement and the number of lithic concentrations are similar to those of Grades 1 and 2. Grade 3 shows lithic assemblages of a larger size than those of Grades 1, 2 and 4. Grade 4 is characterized by an enlarged diameter, reaching a maximum of 74 m. The individual lithic concentrations of Grade 4 are comparable in size to those of Grades 1 and 2, indicating that the diameter of the settlements is enlarged by an increase in the number of lithic concentrations.

The author has interpreted elsewhere that the variation of the circular settlements from Grades 1 to 4 reflects the subsystems of behavior of the developed eEUP hunter-gatherers, as follows (Shimada 2011): the circular settlements of Grades 1 and 2 represent normal occupation sites that were formed by inter-site mobility accompanied by dispersing and gathering of a few mobile groups in the residential area. Grade 3 is recognized as being composed of special workshops in which subsistence activities were carried out intensively for a specific purpose, since the number of Grade 3 settlements is low in the Kanto Plain and they were not formed frequently. The formation of Grade 4 occurs when many mobile groups, which were usually dispersed, gather to live in one place. The Grade 4 settlements imply that large-sized alliance networks had been established among the developed eEUP hunter-gatherers.

From the chronological perspective of the eEUP industries, land use in the Lake Nojiri site group began along with the emergence of the circular settlements. All circular settlements of the developed eEUP sites in the Lake Nojiri site group are classified as Grade 3 (Appendix Table 2). Additionally, the other sites yielding >1,000 lithic artifacts often show settlement landscapes that have many lithic concentrations with high density closely distributed to one another over a wide settlement area, though they are not circular settlements. No other region can show this type of pattern for regional site composition. Accordingly, the Lake Nojiri site group is the place where special workshops for natural resource exploitation had been concentrated in a narrow area around Lake Nojiri instead of being used as a residential area for daily mobile life.

4 – Discussion

A – Origin of obsidian source exploitation

On the basis of currently available archaeological records, no reliable evidence indicating human habitations prior to 40,000 cal BP (i.e., before the initial eEUP) has been obtained from central Japan. On the other hand, some researchers have claimed the existence of Middle Palaeolithic industries succeeded by the initial eEUP industries (Anzai 2002; Tamura 2006; Sato 2008). Although the possibility cannot be absolutely disproved, the abrupt emergence and increase in the number of initial eEUP sites in the Japanese Islands seems to indicate that the colonization of the Japanese Islands by modern humans resulted in the establishment of the initial eEUP industries. Accordingly, the obsidian use of the initial eEUP represents the origins of obsidian source exploitation in central Japan. The initial eEUP site of Ide-Maruyama, occupation level 1 in the Ashitaka region, is one of the initial eEUP assemblages from which both radiocarbon dates and obsidian provenance data have been obtained. The provenance data indicate that three pieces have been identified as originating in the Central Highlands and 21 pieces come from the Kozu-Onbase Islet out of a total of 24 analyzed obsidian artifacts (Appendix Table 3). Radiocarbon dates obtained from charcoal associated with the lithic assemblage indicate it dates to ca. 37,000 to 38,000 cal BP (Takao and Harada 2011). In addition to Ide-Maruyama, the initial eEUP sites in which obsidian from both the Central Highlands and the Kozu-Onbase sources have been identified are the Fujiishi, occupation level BB-VII (Abe and Iwana 2010) in the

Ashitaka region, and the Musasidai, occupation level Xa (Fuchu Metropolitan Hospital site research group 1984; Hitai *et al.,* 2012) in western Kanto. Moreover, obsidian artifacts from the Mt. Takahara and the Kozu-Onbase sources are identified together from the initial eEUP site of the Kusakari-rokunodai, occupation level 1 (Shimadate and Udagawa 1994) in eastern Kanto (Appendix Table 3).

The obsidian use among the initial eEUP sites is characterized by the unimodal distribution of the quantitative frequency in less than 20 pieces (Fig. 3). The proportion of obsidian artifacts to all artifacts found in a lithic assemblage is also low at less than 10% (Fig. 4). This indicates that the initial eEUP population depended primarily on non-obsidian rocks for stone tool production and that the obsidian sources were first discovered as part of the early exploration and discovery of non-obsidian sources located closer to the Kanto plain than obsidian sources. Identifying procurement locations for lithic raw materials is assumed to have been a significant component of the natural resource exploration of the populations who first migrated to central Japan and settled in an unfamiliar land. It is likely that the first eEUP populations comprehensively explored the procurement locations by following the large river systems toward their origins (Fig. 2). Indeed, according to the provenance data (Appendix Table 3), the initial eEUP populations discovered all of the obsidian source areas including the Kozu-Onbase Islet. Although sites before discovery of obsidian sources are thought to have theoretically existed (Nakamura 2012), it is difficult to systematically distinguish and abstract them from the initial eEUP industries on the basis of the current chronological resolution.

The scenario that the early exploration of non-obsidian sources along the river systems triggered the discovery of obsidian sources, however, cannot explain the discovery of the obsidian source at the Onbase Islet near Kozu Island in the Pacific Ocean, because Kozu Island was separated from the mainland of Honshu at a distance of more than 30-40 km by the Pacific Ocean even in the Last Glacial Maximum (Tabl. 1; Fig. 2). No direct evidence, such as boats and marine products, has been obtained from Upper Palaeolithic sites in the Japanese Islands, but the distribution of artifacts made from Kozu-Onbase obsidian is collateral evidence verifying that the eEUP hunter-gatherers possessed sea navigation capabilities and carried out successfully the transportation of Kozu-Onbase obsidian over water (Ikeya and Mochizuki 1998; Ikeya et al. 2005). Accordingly, another scenario pertaining to the discovery of the Kozu-Onbase source in the initial eEUP is that subsistence activities related to marine resource exploitation resulted in the discovery of Kozu Island and its obsidian sources (Shimada 2012). The first landing at Kozu Island was probably via the water route coming down to the south from Oshima Island, which is located closer to the mainland (Fig. 2), because it is almost impossible to see Kozu Island from the mainland with the naked eye.

The initial discovery of obsidian sources and the patterns of obsidian use in the initial eEUP support the notion that the initial eEUP can be evaluated as a stage in which the integration of obsidian into the overall lithic raw material consumption was experimentally carried out, though the locations of obsidian sources were already known as a part of the natural resource environment among the eEUP hunter-gatherers. In other words, the ability to utilize the natural resource environment had remained in a developing state. This notion provides an explanation with regard to the delay of the initial land use in the regions of northern Kanto and Lake Nojiri where initial eEUP sites are absent.

B – Establishment of obsidian use

An increase in obsidian use during the developed eEUP indicates that obsidian procurement became effectively embedded in the mobility strategy. The quantitative frequency of obsidian artifacts shows a bimodal distribution in which the peaks appear in the group with 1-20 pieces and the groups with >100, >200 and >1,000 pieces (Figure 3), indicating that there was a cycle of obsidian use formed by recurrent obsidian procurement and its supply to the region, and a decrease in the amount of obsidian by successive reduction through inter-site regional mobility.

The scattered pattern seen in the correlation between assemblage size and the percentage of obsidian artifacts in a lithic assemblage (Fig. 4) represents diverse situations in the relationship between the cycle of obsidian procurement and supply, and lithic production. Even though the assemblage sizes are comparable to one another, in the site that shows a relatively lower percentage of obsidian artifacts—which indicates that obsidian had been exhausted— the lithic raw materials for stone tool production were secured by non-obsidian rock procurement.

Taking the geographical relations between the sources of obsidian and non-obsidian rocks into consideration, the procurement of non-obsidian rocks located closer to the residential areas and obsidian located relatively far from those regions were tightly integrated into the mobility strategy employed by the residential groups of the developed eEUP. The complex procurement cycle of non-obsidian rocks and obsidian was likely determined by the frequency of far-reaching travels using the large river systems and the duration of stay in a certain residential area. These observations support the notion that the developed eEUP population had become more knowledgeable than the initial eEUP population had been in terms of utilizing lithic raw material sources, as well as the entire natural resource environment.

C – Mobility strategies in the eEUP

The obsidian use in the initial eEUP represents a part of the initial situation of human adaptation to unfamiliar landscapes. It is assumed that because of the period before the emergence of the circular settlements, the residential groups were advancing in their organization of social relations. Nevertheless, the initial eEUP population discovered all of the obsidian source areas in central Japan. This fact indicates that far-reaching procurement routes were initially explored using the large river systems extending from the residential areas, connecting non-obsidian sources with obsidian sources. Although the residential areas of the initial eEUP had been less extensive in comparison with those of the following period, and details regarding mobility strategies are unclear, it is believed that the natural resource environment in central Japan was thoroughly explored.

The emergence of circular settlements in the developed eEUP drastically changed the settlement landscapes, establishing a residential pattern based on events of dispersal and congregation of the eEUP population. The organizational exploitation of natural resources was promoted by the circular settlements marked as Grade 3. As a result, the residential areas were more expanded in comparison with those of the previous period, and land use accompanied by intensive subsistence activities in the Lake Nojiri site group also appeared. The management of circular settlements increased the competence of the eEUP population in natural resource exploitation and social adaptation (Sato 2006). With changes in society and economy from the initial eEUP to the developed eEUP as a background, the developed eEUP population employed a mobility strategy that would cope with both regional adaptation and far-reaching land use in the following manner (Fig. 5).

According to comparative analysis of obsidian use between the initial eEUP and the developed eEUP, it is apparent that information literacy with regard to natural resource environment gradually increased by the developed eEUP. The obsidian distribution pattern showing regional biases reflects that regional subsistence activities had been developed, in which obsidian procurement depending on accessibility to the source areas was probably embedded. The obsidian used in the Ashitaka region mainly came from the Hakone (44.9%) and the Kozu-Onbase (23.5%) in preference to the Central Highlands (14.4%). The Kozu-Onbase obsidian indicates a biased distribution pattern. Accordingly, it is highly possible that a regional preference for Kozu-Onbase obsidian indicates that regional subsistence in the Ashitaka region focused on the exploitation of marine resources.

The transportation of obsidian that had been used complimentarily depicts a complex web between the sources and the regions. The complementary obsidian tended to be brought into residential areas from sources relatively far away, as mentioned above. It can be hypothesized that the distribution of complementary obsidian resulted from the inter-regional mobility of the eEUP population.

By integrating a trip to the Central Highlands for obsidian procurement with another for non-obsidian rocks in each residential area, the Central Highlands obsidian became the mainstream for obsidian procurement except for the Ashitaka region, and its global distribution occurred. As a result, the Central Highlands functioned as a focal point, in which the stone procurement routes extending from each residential area were connected. This hub inevitably opened a path that linked the regions of the Kanto Plain with the Lake Nojiri site group. Thus, it can be hypothesized that temporary or seasonal influxes of the developed eEUP population from the regions along the Pacific coast caused the intensive land use in the Lake Nojiri site group that led to the formation of the Grade 3 circular settlements and larger settlements. The procurement of Central Highlands obsidian and its transportation to the Lake Nojiri site group had been embedded in the far-reaching travel to the Lake Nojiri site group via the Central Highlands. This is the reason why the exclusive use of the central highlands obsidian is recognized in the Lake Nojiri site group.

The fundamental issue is to elucidate what specific subsistence activity had taken place in the Lake Nojiri site group. A promising candidate for the natural resources distributed unevenly in the Lake Nojiri site group is the extinct large herbivores, represented by Naumann's elephant (*Palaeoloxodon naumanni*) and Yabe's giant deer (*Shinomegaceros yabei*). They are believed to have become extinct during the Last Glacial Maximum (Iwase et al. 2011). Otaishi (1990) and Ono (2001) have argued that the seasonal migration routes of Naumann's elephant were extended far from the coastal areas of the Japan Sea to those of the Pacific Ocean, and that the Lake Nojiri site group was intensively used for hunting activities. Taking the difference of topographical elevation into consideration, the seasonal migration route is thought to have extended along the Shinano River system and the old Tone River system via the Usui Pass near northern Kanto (Fig. 2) (Ono 2001). On the basis of these assumptions, the land use in northern Kanto, which was a new practice during the developed eEUP, was also closely related to the exploitation of the large herbivores moving along the seasonal migration route.

A far-reaching mobility strategy over a distance of 300 km adopted by the developed eEUP population had first formed the impressive site distribution and outstanding obsidian use in the Lake Nojiri site group.

5 – Conclusions

The first discovery of obsidian sources and the trial use of obsidian in the initial eEUP indicate that, when modern humans migrate into an unfamiliar land, a comprehensive and wide-ranging exploration of the natural resources was a fundamental adaptive behavior. In particular, the early discovery of the Kozu-Onbase obsidian source implies that modern humans had conventionally exploited marine resources as a subsistence activity before reaching the Japanese Islands. However, the dispersal routes from the continental region to the Japanese Islands have not yet been clarified, whereas several researchers have assumed a possible route via the Korean Peninsula (Sato 2009; Tsutsumi 2012). The eEUP industries are mainly distributed in Kyushu, close to the Korean Peninsula (see the map of the Japanese Islands in Figure 2 for the location) and central Japan. The distribution of the eEUP industries is very sparse in Hokkaido, the northernmost part of the Japanese Islands (see the map in Figure 2). Few lithic industries comparable to the eEUP industries in the Japanese Islands have been discovered so far on the continental side. Thus, it is highly possible that the eEUP industries were independently developed by adapting to the landscape of the Japanese Islands, which was a *cul-de-sac* for modern human dispersals at the eastern tip of the continental Asia. The author estimates that the developed eEUP period was a settling-in phase following initial exploration and colonization, and that at least the developed eEUP populations in central Japan who coped with both regional adaptation and the far-reaching mobility strategy inevitably shared the information of natural resource environment all over central Japan. This type of information sharing across a broad area can be explained by the "corridor-territory" hypothesis, as follows.

Kunitake (2008) first presented the "corridor-territory" hypothesis on the basis of the work of Tamura et al. (2004b) (Fig. 2). The hypothesis states that the groups that inhabited the Kanto Plain had established mobility corridors between the residential areas and procurement zones for lithic raw materials that had been arranged in concentric circles around the Kanto Plain. The different residential areas were connected via the specific procurement zones that played the role of focal points, as for example the Central Highlands. He also pointed out that the corridors continued to provide the Upper Palaeolithic hunter-gatherers with territories along the corridors in which subsistence activities were undertaken and information was extensively exchanged. Thus, the establishment of obsidian procurement system and mobility strategy based on far-reaching land use adopted by the eEUP populations represent the first emergence of the Upper Palaeolithic corridors that ensured the survival of the population by effective food procurement and information exchanges.

The mobility strategy of the eEUP hunter-gatherers this paper discussed on the basis of the analysis of obsidian use represents the structure of the mobility strategy on the largest possible macroscale, that of central Japan, because of the nature of obsidian procurement. The macroscale mobility strategy functions as a system by interacting with the middle-distance (inter-residential area) and short-distance (intra-residential area) mobility. Thus, further analysis based on the archaeological evidence reflecting the mobility of inter- and intra-residential areas is required. For example, details of the reduction of complementary obsidian in the lithic assemblages may be useful as an indicator of middle-distance mobility. The regional inter-site analysis on the *chaînes opératoires* of non-obsidian materials may be effective for an examination of short-distance mobility.

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Initial eEUP sites	Number of artifacts	Obsidian artifacts	Ratio of obsidian	Region	Circular settlements
Seta, Level 8	437	0	0.0%	Western Kanto	-
Tamaranzaka 8-A, Level 1	398	0	0.0%	Western Kanto	-
Shimoyama, Level 4	364	0	0.0%	Western Kanto	-
Tamaranzaka 5, Level 1	274	18	6.6%	Western Kanto	-
Takaidohigashi, Level X	204	0	0.0%	Western Kanto	-
Musashidai, Level Xa	170	170	100.0%	Western Kanto	-
Tamaranzaka 1, Level 1	165	0	0.0%	Western Kanto	-
Hakeue, Level X	142	1	0.7%	Western Kanto	-
Suzuki-miyuki, Loc 1, Level IV	137	0	0.0%	Western Kanto	-
Nishidai-gotoda, Loc 1, Level Xa	123	8	6.5%	Western Kanto	-
Yoshioka, Loc D	100	1	1.0%	Western Kanto	-
Musashi-kokubunji-kanren-musashidai, Loc A, Level 1	88	0	0.0%	Western Kanto	-
Tamaranzaka 8, Loc B, level 1	79	0	0.0%	Western Kanto	-
Musashidai-nishi-chiku, Level 1, SX 50	48	0	0.0%	Western Kanto	-
Tamaranzaka 4, Level 1	32	0	0.0%	Western Kanto	-
Nogawa-nakasu-kita	32	0	0.0%	Western Kanto	-
Higashi-hayabuchi	23	0	0.0%	Western Kanto	-
Shimayashiki, Level IV	22	2	9.1%	Western Kanto	-
Minamiaono, Loc. 1	434	1	0.2%	Eastern Kanto	-
Boyama, Level 6, S48	259	178	68.7%	Eastern Kanto	-
Nishinodai B, Level X-U	227	0	0.0%	Eastern Kanto	-
Kusakari, Loc D, Level 2, C77-D	200	9	4.5%	Eastern Kanto	-
Kusakari-rokunodai, Level 1, N	173	16	9.2%	Eastern Kanto	-
Nishi-ono 1, Loc. C, 6-11	169	1	0.6%	Eastern Kanto	-
Nakayama-shinden II, Level 11	101	0	0.0%	Eastern Kanto	-
Kusakari-rokunodai, Level 1, J	90	2	2.2%	Eastern Kanto	-
Kusakari, Loc C, Level 1, C13-B	28	0	0.0%	Eastern Kanto	-
Mukoyama-yatsu	27	0	0.0%	Eastern Kanto	-
Fukuda-tonozawa 1	27	0	0.0%	Eastern Kanto	-
Wosaru-yama, Level 4, 21	22	1	4.5%	Eastern Kanto	-
Hitokuwada-jinbei-yama 1	22	0	0.0%	Eastern Kanto	-
Takaido-higashi, Level X	21	0	0.0%	Eastern Kanto	-
Obayashi, Level VII, 42	20	0	0.0%	Eastern Kanto	-
Ide-maruyama, Level SC-IV	1,329	37	2.8%	Ashitaka	-
Fujiishi, Level BB-VII	491	189	38.5%	Ashitaka	-

Appendix Table 1 – Obsidian artifacts in the initial eEUP industries in central Japan.

Appendix Table 2 (p. 192) – Obsidian artifacts in the developed eEUP industries in central Japan.

Appendix Table 3 (p. 193-194) – List of obsidian provenance data in central Japan.

Developed eEUP sites	Number of artifacts	Obsidian artifacts	Ratio of obsidian	Region	Circular settlements
Nomizu, Level IV	6,003	11	0.2%	Western Kanto	Grade 3
Seiganji-maehara, Loc.2	1,472	1293	87.8%	Western Kanto	Grade 3
Tsukuijo-magome-chiku, Level 6	1,384	50	3.6%	Western Kanto	Grade 3
Nakahigashi, Loc.2 and 3, Level IX	820	814	99.3%	Western Kanto	-
Kamibayashi, Level 2	3,480	382	11.0%	Northern Kanto	Grade 4
Shimohure-ushibuse, Level II	2,037	4	0.2%	Northern Kanto	Grade 4
Sanwa-kogyodanchi I, Level 4	1,340	622	46.4%	Northern Kanto	Grade 4
Imaisankido, Level IV, Loc. C	823	6	0.7%	Northern Kanto	Grade 4
Shirakawa-kasamatsu	599	5	0.8%	Northern Kanto	Grade 2
Amabiki-kitsunezaki, Unit 1	532	0	0.0%	Northern Kanto	Grade 2
Mitsugo-sawanaka	531	0	0.0%	Northern Kanto	Grade 2
Kojo, Loc. 1C	523	283	54.1%	Northern Kanto	Grade 2
Ogami, Level 4	457	218	47.7%	Northern Kanto	Not available*
Amagatsutsumi, Loc. II-III, Level 3	451	24	5.3%	Northern Kanto	Grade 2
Tairaoppeno	442	199	45.0%	Northern Kanto	Grade 2
Imaisankido, Level IV, Loc B	414	2	0.5%	Northern Kanto	Grade 2
Sirakura-shimohara, Loc. A	403	0	0.0%	Northern Kanto	Grade 2
Hashie-nishijuku, Loc. A-1, 2, Level II	391	1	0.3%	Northern Kanto	Grade 2
Amabiki-mukaihara, Loc. A	268	3	1.1%	Northern Kanto	Grade 1
Bungo-hassaki, Loc.1	257	9	3.5%	Northern Kanto	Grade 1
Shirakura-shimohara Loc. B	102	86	84.3%	Northern Kanto	Grade 1
Yotsuzuka, Unit 14-30	1,433	12	0.8%	Eastern Kanto	Grade 3
Toho-miyukibata-nishi, Level 1, area 1	1,075	2	0.2%	Eastern Kanto	Grade 4
Toho-miyukibata-nishi, Level I, area 2	869	1	0.1%	Eastern Kanto	Grade 2
Higashi-ono 2	819	127	15.5%	Eastern Kanto	Grade 4
Sekihata, Level 1a, Unit A	760	5	0.7%	Eastern Kanto	Grade 2
Boyama, Level 5	750	23	3.1%	Eastern Kanto	Grade 2
Ikehana-minami, Level 1	733	12	1.6%	Eastern Kanto	Grade 2
Koyanouchi, Level I	649	75	11.6%	Eastern Kanto	Grade 4
Minami-sanrizuka-miyahara 1, Loc. 1, CS 1	633	117	18.5%	Eastern Kanto	Grade 4
Sekihata, Level 1a, Unit B	547	41	7.5%	Eastern Kanto	Not available
Ryusuiji-ura, south CS	544	1	0.2%	Eastern Kanto	Grade 2
Oyama, Level II, Unit 2	478	2	0.4%	Eastern Kanto	Grade 2
Nakayama-shinden I, Unit 4	452	12	2.7%	Eastern Kanto	Grade 2
Yotsuzuka, Unit 1-13	356	4	1.1%	Eastern Kanto	Grade 2
Minami-sanrizuka-miyahara 1, Loc. 2, CS 3	299	112	37.5%	Eastern Kanto	Grade 1
Toho-miyukibata-nish,i Level I, area 3	240	1	0.4%	Eastern Kanto	Grade 1
Shibayama, Level 1, Unit 1	194	1	0.5%	Eastern Kanto	Grade 1
Minami-sanrizuka-miyahara 1, Loc 2, CS 2	135	0	0.0%	Eastern Kanto	Grade 1
Ryusuiji-ura, North CS	48	1	2.1%	Eastern Kanto	Grade 1
Doteue, I	2,223	1475	66.4%	Ashitaka	Not available
Nakamiyo I, Level 5	1,856	1606	86.5%	Ashitaka	Grade 3
Doteue, Loc. III	1,172	928	79.2%	Ashitaka	Not available
Doteue, Loc. II	995	635	63.8%	Ashitaka	-
Oidaira-B, Level 2	773	119	15.4%	Ashitaka	-
Matoba	729	8	1.1%	Ashitaka	-
Umenokizawa, Level 2	474	345	72.8%	Ashitaka	-
Nishibora b	434	144	33.2%	Ashitaka	Grade 2
Shimizuyanagi-kita-higashi-one	400	118	29.5%	Ashitaka	-
Fijiishi, Level BB-VI	33	32	97.0%	Ashitaka	-
Hinatabayashi B	9,001	6489	72.1%	Lake Nojiri	Grade 3
Kannoki, Loc. H3, Lebel I, Layer V	8,795	2819	32.1%	Lake Nojiri	Grade 3
Kannoki, H4, Level I, Layer V	7,897	1733	21.9%	Lake Nojiri	-
Nakamachi, Loc. BP 2	6,337	1044	16.5%	Lake Nojiri	-
Nakamachi, Loc. JS	5,708	368	6.4%	Lake Nojiri	Grade 3**
Nakamachi, Loc. BP3	4,567	177	3.9%	Lake Nojiri	-
Shogetsudai, Loc. BP	3,835	1504	39.2%	Lake Nojiri	-
Kannoki, Loc. H2, Level I, Layer V	2,195	184	8.4%	Lake Nojiri	-
Nakamachi, Loc. BP 1	1,886	1107	58.7%	Lake Nojiri	-
Uenohara, Loc. H, Layer 5	1,874	403	21.5%	Lake Nojiri	-
Okubo-minami, Loc. H, Level Ia and Ib	1,224	616	50.3%	Lake Nojiri	-
Kannoki, Loc. H1, Level I, Later V	961	142	14.8%	Lake Nojiri	-
Higashi-ura, H1, Level I	461	406	88.1%	Lake Nojiri	-
Higashi-ura, H1, Level II	332	59	17.8%	Lake Nojiri	-

* circular settlements but not fully excavated. ** composed of two circular settlements.

Appendix Table 3. List of obsidian provenance data in central Japan

Northern Kanto	Mt. Takahara	Central Highlands	Kozu-Onbase	Hakone	Amagi	Total	Num. of obsidian	(%)	Num. of lithics	Method	References (obsidian analysis)
Kamibayashi,Level 2	17	345	10	2	1	375	382	98.2%	3,480	EDXRF	Idei (2004)
Nakane	29				1	30	-	-	-	EDXRF	Tateishi et al. (2011)
Teranohigashi A, level 1	3					3	8	37.5%	8	EDXRF	Morishima (2003)
Mineyama, Level 2		14	1			15	18	83.3%	646	EDXRF	Takehara (2009)
Imai-sankido, level 4	1	97				98	531	18.5%	2,108	EDXRF	Inoue (2004)
Ogami, level 4	216	2				218	218	100.0%	470	EDFRX	Takehara (2008a)
Shirakura-shimohara Loc. B		20				20	86	23.3%	120	EDXRF	Warashina et al. (1994)
Amabiki-mukaihara, Loc. A		3				3	3	100.0%	268	EDXRF	Warashina et al. (1994)
Shikashimizu	4	99				103	>100	-	-	EDXRF	Sugihara et al. (2009a)
Yamagamijo-ato IX	10					10	66	15.2%	180	EDXRF	Tateishi et al. (2010)
Yamauchide B		8				8	55	14.5%	94	EDXRF	Tateishi et al. (2010)
Orimo III, Loc. B		7				7	~70	-	257	EDXRF	Tateishi et al. (2010)
Kakiage, Level 4		1				1	1	100.0%	2	EDXRF	Takehara (2008b)
Shiraiwa-minbu, cultural layer 2		21				21	37	56.8%	722	EDXRF	Tateishi et al. (2010)
Total of northern Kanto (%)	**280 (30.7)**	**617 (67.7)**	**11 (1.2)**	**2 (0.2)**	**2 (0.2)**	**912**					
Eastern Kanto	**Mt. Takahara**	**Central Highlands**	**Kozu-Onbase**	**Hakone**	**Amagi**	**Total**	**Num. of obsidian**	**(%)**	**Num. of lithics**	**Method**	**References (obsidian analysis)**
Nakayama-shinden I	5	1	1			7	354	2.0%	1,434	NAA, WDXRF	Ninomiya (1988), Oya et al. (2008)
Kusakari-rokunodai, Level 3	11	551	4			566	1031	54.9%	1,750	EDXRF	Ninomiya et al. (1994)
Kusakari-rokunodai, Level 2	7	1	4	1		13	25	52.0%	145	EDXRF	Ninomiya et al. (1994)
Harayama, Level 1	2					2	4	50.0%	76	WDXRF	Nitta (2009)
Harayama, Level 2a		2				2	132	1.5%	452	WDXRF	Nitta (2009)
Harayama, Level 2b	25	1				26	837	3.1%	989	WDXRF	Nitta (2009)
Minamisanrizuka-miyahara 1, Loc. 1	2		64			66	117	56.4%	633	EDXRF	Sugihara et al. (2005)
Minamisanrizuka-miyahara 1, Loc. 2			91			91	112	81.3%	434	EDXRF	Sugihara et al. (2005)
Kusakari-rokunodai, level 1*	5		1			6	18	33.3%	262	EDXRF	Ninomiya (1994)
Total of eastern Kanto (%)	**57 (7.3)**	**556 (71.4)**	**165 (21.2)**	**1 (0.1)**	**0 (0.0)**	**779**					
Western Kanto	**Mt. Takahara**	**Central Highlands**	**Kozu-Onbase**	**Hakone**	**Amagi**	**Total**	**Num. of obsidian**	**(%)**	**Num. of lithics**	**Method**	**References (obsidian analysis)**
Fujikubo-higashi, Level IX	1	8	2	2	61	74	635	11.7%	765	EDXRF	Sugihara et al. (2009b)
Fujikubo-higashi, Level X*					1	1	1	100.0%	32	EDXRF	Sugihara et al. (2009b)
Nakahigashi 2, Level IX		2		5	48	55	458	12.0%	820	EDXRF	Sugihara et al. (2011)
Shimosato-honmura, Level IX		2				2	30	6.7%	282	EDXRF	Kadouchi (2001)
kamagaya, Level IXa		14				14	35	40.0%	225	EDXRF	Hitai et al. (2012)
Shimosato-honmura, Level VII	1					1	3	33.3%	32	EDXRF	Kadouchi (2001)
Tanashi-minamicho, phase 1		79		37	34	150	158	94.9%	1,056	EDXRF	Ninomiya et al. (1992)
Nishidai-gotoda, Level Xa*		2				2	8	25.0%	123	WDXRF	Palynosurvey (1999)
Tamonji-mae, Level IX		4		12	2	18	57	31.6%	589	EDXRF	Kadouchi (2001)
Musashidai, Level Xa		136	1			137	~170	-	~170	EDXRF	Hitai et al. (2012)
Tamaranzaka 5, Level X, IX	9	1	3		1	14	174	8.0%	450	EDXRF	Hitai et al. (2012)
Tsukuijo-ato-magome-chiku, Level 6		22	20		2	44	50	88.0%	1,384	EDXRF	Sugihara et al. (2010)

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Yoshioka D, Level BB-5		1				1	1	100.0%	100	EDXRF	Warashina et al. (1999)
Yoshioka D, Level BB-4 lower				4		4	49	8.2%	54	EDXRF	Warashina et al. (1999)
Total of western Kanto (%)	**11 (2.1)**	**271 (52.4)**	**26 (5.0)**	**60 (11.6)**	**149 (28.8)**	**517**					
Ashitaka	**Mt. Takahara**	**Central Highlands**	**Kozu-Onbase**	**Hakone**	**Amagi**	**Total**	**Num. of obsidian**	**(%)**	**Num. of lithics**	**Method**	**References (obsidian analysis)**
Fujiishi, Level BB-IV*				1	4	5	5	100.0%	7	EDXRF	Mochizuki (2010a)
Sakurabatake-ue, Level I*			4			4	4	100.0%	4	EDXRF	Mochizuki (2009a)
Shimizu-yanagi-kita-higashi-one, Level BB-V		59			5	64	118	54.2%	400	EDXRF	Ikeya et al. 1998
Doteue-I, Level BB-V		72	125	407	281	885	1472	60.1%	2,203	EDXRF	Ikeya (1998): 22-138
Doteue-II, layer BB-V		7	41	276	32	356	635	56.1%	995	EDXRF	Ikeya (1998): 139-196
Doteue-III, Level BB-V		11	323	255	15	604	928	65.1%	1,117	EDXRF	Ikeya (1998): 197-268
Oidaira, Level 2		87	1	1	31	120	121	99.2%	773	EDXRF	Nakamura (2011)
Fujiishi, Level BB-VI*			28		2	30	32	93.8%	33	EDXRF	Mochizuki (2010a)
Nishibora b , Level BB-VI*			84		34	118	144	81.9%	434	EDXRF	Sasahara (1999): 14-125
Umenokizawa, Level 2		29	1	252	7	289	345	83.8%	474	EDXRF	Mochizuki (2009b)
Hosoo, Level 1*				11		11	13	84.6%	14	EDXRF	Mochizuki (2010b)
Fujiishi, Level BB-VII*		115	1		51	167	189	88.4%	491	EDXRF	Mochizuki (2010a)
Mukaida-A, Level SC-IV*		1			2	3	3	100.0%	6	EDXRF	Togashi et al. (2007): 203-206
Motono, Level SC-IV*		1				1	1	100.0%	3	EDXRF	Mochizuki (2008)
Ide-maruyama, Level SC-IV*		3	21			24	37	64.9%	1,329	EDXRF	Ikeya (2011)
Total of Ashitaka (%)	**0 (0)**	**385 (14.4)**	**629 (23.5)**	**1,203 (44.9)**	**464 (17.3)**	**2,681**					
Lake Nojiri site group	**Mt. Takahara**	**Central Highlands**	**Kozu-Onbase**	**Hakone**	**Amagi**	**Total**	**Num. of obsidian**	**(%)**	**Num. of lithics**	**Method**	**References (obsidian analysis)**
Uenohara Loc. H		289				289	403	71.7%	1874	EDXRF	Mochizuki (2000)
Uranoyama H Level1		5				5	5	100.0%	16	EDXRF	Mochizuki (2000)
Nakamachi Loc. JS		321				321	368	87.2%	5706	EDXRF	Mochizuki (2004a)
Nakamachi Loc.BP1		836				836	1107	75.5%	1886	EDXRF	Mochizuki (2004a)
Nakamachi Loc. BP2		857				857	1044	82.1%	6337	EDXRF	Mochizuki (2004a)
Nakamachi Loc.BP3		137				137	177	77.4%	4567	EDXRF	Mochizuki (2004a)
Kannoki H1 Level 1		97				97	142	68.3%	961	EDXRF	Mochizuki et al. (2000)
Kannoki H2 Level 1		142				142	184	77.2%	1178	EDXRF	Mochizuki et al. (2000)
Kannoki H3 Level 1		1,909				1909	2819	67.7%	8795	EDXRF	Mochizuki et al. (2000)
Kannoki H4 Level 1		998				998	1733	57.6%	7897	EDXRF	Mochizuki et al. (2000)
Higashiura H1 Lebel 1		303				303	406	74.6%	461	EDXRF	Mochizuki (2000)
Higashiura H1 Lebel 2		49				49	59	83.1%	332	EDXRF	Mochizuki (2000)
Hinatabayashi		3,495				3495	6489	53.9%	9001	EDXRF	Mochizuki (2000)
Okubo-minami Loc. H		492				492	616	79.9%	1224	EDXRF	Mochizuki (2000)
Shogetsudai Loc. BP		1230				1230	1504	81.8%	3835	EDXRF	Mochizuki (2004b)
Total of Lake Nojiri (%)	**0 (0)**	**11,160 (100)**	**0 (0)**	**0 (0)**	**0 (0)**	**11,160**					

* The initial eEUP industries. EDXRF: energy dispersive X-ray fluorescence. WDXRF: wavelength dispersive X-ray fluorescence. NAA: neutron activation analysis.

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2.7. Acquisition and consumption of obsidian in the Upper Palaeolithic on Kyushu, Japan

Résumé
Dans cet article nous examinons des modèles d'exploitation d'obsidienne en divisant la période comprise entre le Paléolithique supérieur et l'ère de la naissance de Jomon, en 10 phases distinctes. Cette périodisation est basée sur les préférences des matières premières et les techno-morphologies dans les ensembles lithiques de l'île de Kyushu, au Sud du Japon. En conséquence trois périodes importantes peuvent être distinguées comme suit. La période 1, correspond au début de l'utilisation de l'obsidienne durant la phase 2 (approximativement 30 000 B.P.) ; c'est le moment où l'homme préhistorique a commencé à utiliser toutes les sources d'obsidienne actuellement connues dans le Sud de l'île de Kyushu. Pendant la période 2, qui correspond à la phase 5 (approximativement 24 000 – 22 000 B.P.), nous constatons l'utilisation d'obsidienne provenant du Nord-Ouest de Kyushu pour la fabrication des couteaux du type de Tanukidai et d'Imagata taillés en pointe. Enfin, la période 3 qui correspond à l'industrie lithique à micro-lames, phase 8 (approximativement 15 000 B.P.), et qui représente l'apogée de l'exploitation de l'obsidienne au Paléolithique supérieur.

Abstract
In this paper we examine obsidian exploitation patterns by dividing the time between the Upper Palaeolithic and the Incipient Jomon periods into 10 distinct phases. This periodization is based on techno-morphological and raw material preference in the lithic assemblages from southern Kyushu, Japan. As a result, threemajor periods are configured as follows. Period 1 constitutes the beginning of obsidian use during phase 2 (approximately30,000 BP); it is the time when all of the currently known obsidian sources in southern Kyushu start being used. During period 2, which corresponds with phase 5 (approximately24,000-–22,000 BP), we see the use of obsidian in northwestern Kyushu for the manufacture of Tanukidani and Imatoge-type knife shaped point. Finally, period 3 coincides with the micro blade industry, phase 8 (approximately 15,000 BP), and represents the peak of obsidian exploitation during the Upper Palaeolithic. Obsidian use predominates in almost all areas of southern Kyushu. With regard to the reasons behind these changes in obsidian use, it seems that they are related to lithic technology, behavioral patterns, and territorial boundaries of the groups that inhabited the area.

Keywords: Kyushu, Japan, Upper Paleolithic, obsidian use, intermittent change

1 – Introduction

Obsidian sources are almost ubiquitous on Kyushu Island as well as throughout the Japanese archipelago. In particular, a large number of obsidian sources, which were highly exploited, are located in southern Kyushu. Moreover, the evidence suggests that obsidian from northwestern (NW) Kyushu was carried more than 100 km away. Therefore, we can obtain some valuable insight into group interaction and the regions in which people circulated. In addition, I attempt a diachronic investigation of the lithic assemblages and a periodization based on them. In this paper, I examine obsidian use and procurement patterns from the late Palaeolithic to the Incipient Jomon period during which obsidian was used and their respective backgrounds.

2 – Problems with previous studies in Kyushu

Archaeological obsidian research in Kyushu starts with the description of obsidian and a comprehensive survey of the sources by Sakata (1982). Following this, several studies focused on the relationship between the population and obsidian of the Upper Palaeolithic (Watanuki 1992; Ogi 1998). Watanuki (1992) examined the lithic raw material proportions at sites from the Upper Palaeolithic and showed the overall trends for each region. His work showed that despite the low quality of obsidian, the utilization ratio was high; obsidian, however, was never used for blades, a development unique to southern Kyushu. Although Ogi's (1998) research has many problems regarding the proposed interpretations, (such as drawing direct associations between the movement of lithic raw materials with exchange and trade), it was useful in terms of examining the lithic raw materials at each site and mapping the circulation of obsidian. However, in southern Kyushu, the amount of specialized studies increase exponentially since the

2000s and as a result, a significant number of regions need to be added or modified. In the late 2000s, Magome (2008) studied the obsidian exploitation in the Kagoshima Prefecture region, while Kuwahata (2003) summarized the usage of all lithic raw materials also in the Kagoshima region, and Fujiki (2002) studied the transition of obsidian use in the Miyazaki Prefecture region. These studies can be summarized as follows: in the Kagoshima Prefecture region, obsidian was not used for tanged points dated in the early part of the late Upper Palaeolithic, but it was used extensively for bilaterally backed tools (Magome, ibid). It has been shown that some types of obsidian were associated with a particular tool type (Magome, ibid). Furthermore, it has been demonstrated that in the Miyazaki region the obsidian used varies depending on the time period. Moreover, generally speaking, the frequency of obsidian exploitation seems to occasionally increase during the microblade industry period and it is evident that in NW Kyushu obsidian was also used. However, since raw materials from southern Kyushu increased, a detailed study on diachronic changes in obsidian usage, including the activities in these two regions, has not yet been conducted.

3 – Obsidian Sources in Kyushu

Since Sakata's study (1982), more obsidian sources have been found in about 30 locations on Kyushu (fig. 1). However, some of these are geologically similar (Nagaoka *et al.,* 2003). The primary obsidian sources on Kyushu are divided into the following four categories: obsidian contained in the talus sediment or rhyolitic lava flows and pyroclastic in NW Kyushu; those derived from the pyroclastic flow of the Aso volcano; those derived from the Shiroyama volcano in the Himeshima Island off the Kunisaki Peninsula coast; and obsidian from southern Kyushu. The frequency of obsidian use was determined by its output, quality, and size.

NW Kyushu: In this area there is a dense concentration of sources that produce large quantities of high quality obsidian (fig. 3). X-ray fluorescence analysis has shown that the distribution point of obsidian nodules and the primary sources don't correspond, and types of obsidian with different elemental composition may be present at the same primary source (Nagaoka *et al.,*2003). Although this becomes a significant problem when discussing the finer aspects of the raw material's appearance, the main external features can be classified as follows: **Koshidake obsidian** (including Muta obsidian), mainly breccias with high quality in a jet-black color, is derived from Arita rhyolite, which constitutes the peak of Mt. Koshidake located in Imari city, Saga Prefecture. In addition, as will be described later, some obsidian from southern Kyushu is a very similar to Koshidake obsidian. **Hario obsidian** (including Yodohime-jinjya, Futrusato, and Kamidoigyo obsidian), mainly from sub-conglomerate to sub-breccia with high quality blue-gray color, is derived from multiple formation points such as the gravel and rhyolite near Sasebo city, Nagasaki Prefecture. As geochemical analysis has not yet been undertaken for this type of obsidian, for its identification we rely on criteria such as color and quality. In the remainder of the paper I will refer to Koshidake and Hario obsidian collectively as "NW Kyushu obsidian".

Central Kyushu: Oguni obsidian, which is transparent black with a lot of phenocrysts, is derived from the Yamanokogawa rhyolite in the Chikugo River basin and upstream of the Yamanoko River. This obsidian comes in the form of riverbed pebbles or slope deposits. **Zogabana tuff** has been described as "glassy welded tuff" by a recent survey (Obata *et al.,* 2001, p.68). It is derived from the special unit of 2 Aso and is usually referred to as "Aso obsidian"; this obsidian is found in pyroclasticflow deposits in the north-eastern part of the Aso caldera at an altitude of about 700 masl. The flaking surface is opaque with impurities and jet-black in color. When exposed to the elements it tends to form a brownish layer on its surface.

Southern Kyushu: Nitto obsidian can be found along the river from Nitto to Arahira in the Yamano region, Kagoshima Prefecture. It is easy to collect and ranges in size from human head-sized to fist-sized nodules, but in many cases it contains impurities. The supply source of **Kuwanokizuru obsidian** is unknown. It is usually found in the form of nodules deposited along riverbeds or in clay layers. This obsidian is of

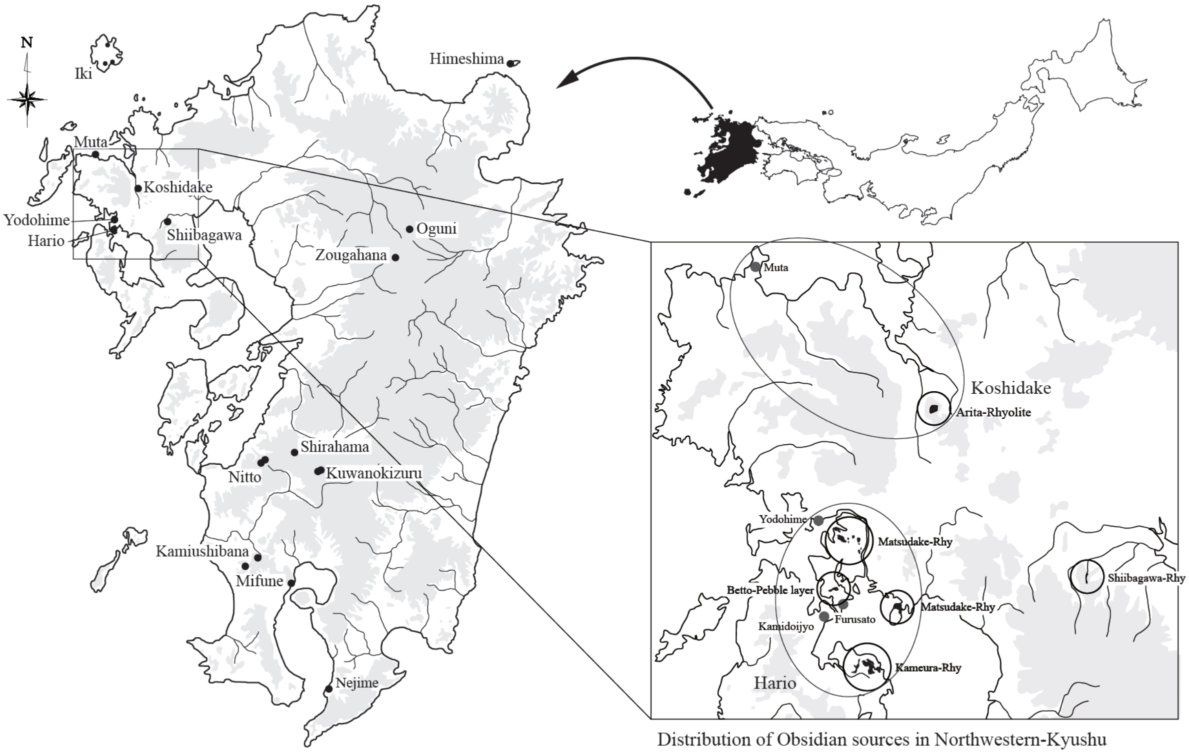
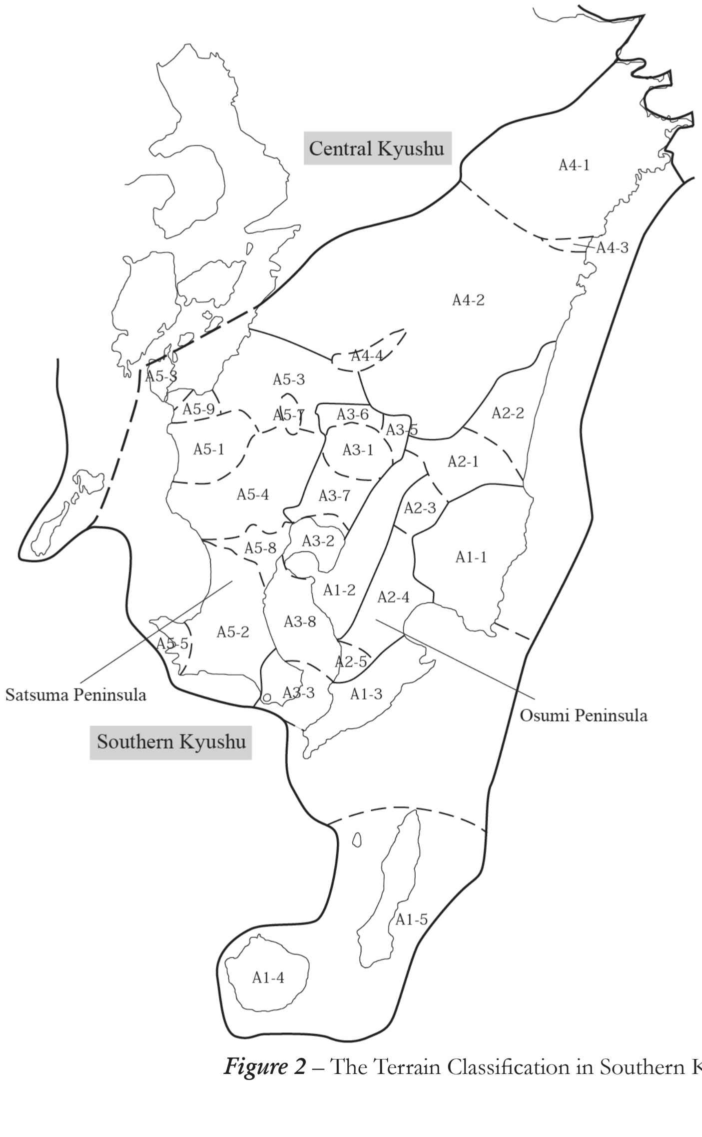


Figure 1 – Distribution of obsidian sources in Kyushu



Section		Subsetion	
A1	Southeastern Kyushu Mountains		
	[Mts.]	A1-1	Wanitsuka Mts.
		A1-2	Takakuma Mts.
		A1-3	Kimotsuki Mts.
		A1-4	Yakushima Isl.
	[Plateau]	A1-5	Tanegashima Isl.
A2	Eastern Plain of Southern Kyushu		
	[Plateau]	A2-1	Morokata Plateau
	[Plateau・Lowland]	A2-2	Miyazaki Plain
		A2-3	Miyakonojyo Basin
		A2-4	Kimotsuki Plain
		A2-5	Kanoya Plateau
A3	Volcanic Mountains in Southern Kyushu		
	[Vol]	A3-1	Kirishima Volcainc Mts.
	[Vol Caldera]	A3-2	Aira Caldera and Sakurajima
		A3-3	Ata Caldera
	[Basin]	A3-5	Kobayashi Basin
		A3-6	Kakuto Basin
		A3-7	Plateau and Lowland of Kagoshima northern Coast
	[Bay]	A3-8	Kagoshima Bay
A4	Kyushu Mountains		
	[Mts]	A4-1	Northern Kyushu Mts.
		A4-2	Southern Kyushu Mts.
	[Valley]	A4-3	Gokase River Valley
	[Basin]	A4-4	Hitoyoshi Basin
A5	Western Mountains in Southen Kyushu		
	[Mts.]	A5-1	Izumi Mts.
		A5-2	Ibusuki Mts.
	[Vol]	A5-3	Hisatsu Volcanic Mts.
		A5-4	Hokusatsu Volcanic Mts.
		A5-5	Nansatsu Volcanic Mts.
		A5-6	Kuroshima Isl.
		A5-7	Oguchi Basin
		A5-8	Plateau and Lowland of Kagoshima Western Coast
		A5-9	Izumi Plain

Figure 2 – The Terrain Classification in Southern Kyushu after Machida *et al.,* 2001

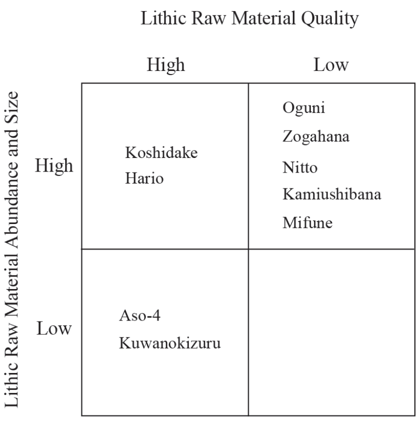


Figure 3 – The Relation between quality and abundance of lithic raw material in each obsidian resources in Kyushu

high quality, its color is amber, and it usually does not have any impurities. Thumb-sized pebbles are most common, even though some large hand-sized ones can be sometimes found. The newly discovered **Hishikari obsidian** seems to be very similar to Kuwanokizuru obsidian (Nagai *et al.,* 2010). Although the relationship between the two is currently unknown, it is possible that secondary sources of Hishikari obsidian are widely spread. **Mifune obsidian** is derived from Mifune rhyolite in Ryugamizu, Kagoshima Prefecture. Fist-sized or bigger pebbles can be found just under the outcrop. This obsidian is highly transparent, black or amber in color with many impurities. **Kamiushibana obsidian** may be derived from Okoba rhyolite or Ichiki acidic rocks in the cityof Satsumasendai, Kagoshima Prefecture. There is no clarity in this jet-black obsidian, and the impurities it contains are less than those in Mifune obsidian. When exposed to the elements, a dark brown or brown layer forms on the surface.

Apart from these known sources there are also types of obsidian whose provenance is still unknown. These types are found at sites in south-eastern Kyushu, which include the so-called Uchiyashiki UT lithic group (Warashina 2001), the Odate OX lithic group (Kishida 2008), etc. It may be difficult to distinguish Koshidake obsidian because in many cases this obsidian has small breccia inclusions and is highly transparent. In fact, it has often been mistaken for Koshidake obsidian. However, when looked at carefully, its pebble surface, texture, and impurities, makes its identification possible with the naked eye.

Figure 3 provides a schematic representation of the relationship between size, quality and abundance of obsidian in Kyushu. Obsidian from the northwest areas tends to occupy the upper left corner of the diagram, i.e., Koshidake and Hario, while other types of obsidian cluster in the upper right corner, i.e., Nitto, Kamiushibana, Mifune. This correlation has a significant effect on the frequency of use and the distribution range of the stone tools in the Upper Palaeolithic.

4 – Obsidian use from the Upper Palaeolithic to the beginning of the Jômon in Southern Kyushu

A – Chronology

The Upper Palaeolithic of Kyushu is typically divided into the early and late Upper Palaeolithic, which occur before and after the Aira-Tn tefra (AT). The early and late periods can be further subdivided into three and five phases respectively, based on the stratigraphy of archaeological sites and the morpho-typological characteristics of the stone tool assemblages, which are as follows (Miyazaki Palaeolithic Association 2005; Miyata 2006; Morisaki 2010; 2011) (fig. 4). The absolute dates presented here have been obtained through C14 uncalibrated data; we have included estimates because of the limited number of dating samples.

Phase 1: Stone tool industry including
denticulates and pebble tools (33,000-30,000 BP)
Phase 2: Stone tool industry including
edge-ground axes (30,000-28,000 BP)
Phase 3: Stone tool industry including small backed blades (Kyushu type)
(28,000-25,000 BP)
Aira-Tn volcanic ash fall (25,000 BP)
Phase 4: Stone tool industry including backed blades similar to those of phase 3
(25,000-24,000 BP)
Phase 5: Stone tool industry including stemmed points (Phase5a)Stonetool industry including Tanukidani type bitruncated points and Imadoge type points(Phase5b)
(25,000-21,000BP)
Phase6: Stone tool industry including bilaterally backed tools and Kou-type points
(22,000-18,000BP)
Phase 7: Stonetool industry including small backed blade and small trapezes
(18,000-15,500BP)
Phase 8:The first half of the Microblade Industry (15,500-13,000BP)

Phase9: The second half of the Microblade Industry (13,000-12,000BP)
Phase 10: Stone tool industry including arrow heads accompanied by pottery production (12,000-11,000 BP)

In the following section, I present my analysis for the purposes of which I divided southern Kyushu into the eastern and the western region while taking into account the distribution of the obsidian sources. Thedetailed geomorphic is conformed to Machida *et al.,* (2001) (fig. 2).

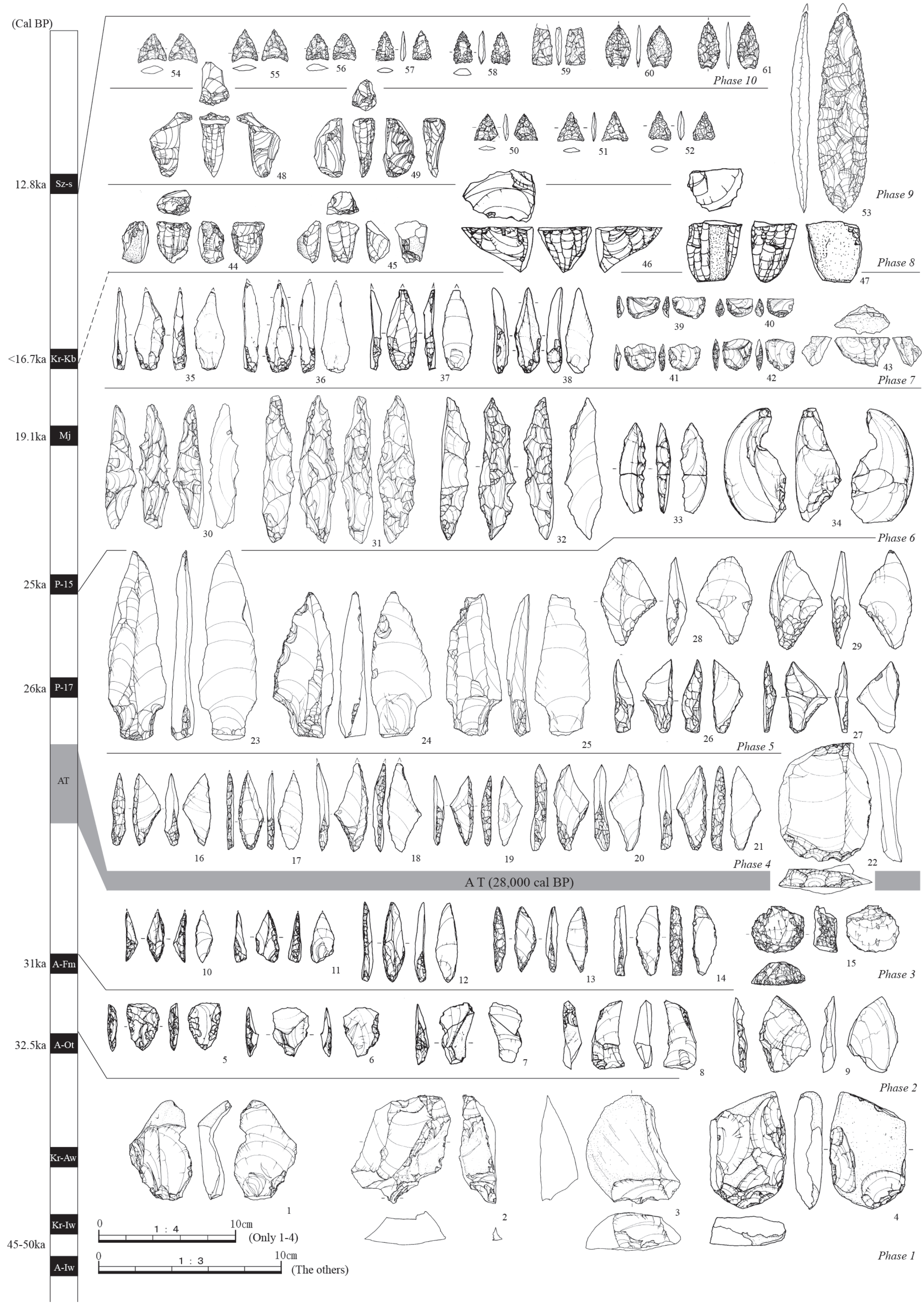
B – The first half of the Upper Palaeolithic (Phase1-3)

Since the Ito pyroclastic flow covers the majority of southern Kyushu, at archaeological sites dated before AT, the ash fall is unevenly distributed in what is now the region of Kumamoto and Miyazaki Prefectures (fig. 5, below).

Western Region: The stone tool industry of phase 1 can be found only in layer 1 of the Chikegamine site, excavated underneath a brown soil layer (the so-called 'ansyokutai') of the Hitoyoshi basin, Kumamoto Prefecture. The exploitation of obsidian during this phase is not certain. During phase 2, the Chikegamine (cultural layer 2) and Ushioyama sites are established on the Hitoyoshi basin. The former consists of an assemblage with edge-grounded axes and trapezes. Although we do not have a complete picture of the stonetool industry, it is worth mentioning the two trapezes made of Nitto obsidian that have been found (Wada and Shiga 2000). At Ushioyama, 12 from the total number of 81 are stone tools made of obsidian. Informal tools, retouched tools and used flakes are among them (Furumori 1999). The bottom of the 6 layer at the Uwaba site located in the vicinity of the Nitto obsidian source also dates to this phase. Even though the total number of tools is unknown, we do know that 43 are made of obsidian, 39 of which are made of Nitto obsidian (Iwasaki 2007). At this site Kuwanokizuru and Kamiushibana obsidian were used in small amounts. On the Satsuma Peninsula, the Maeyama site (cultural layer 1) is the only example. Sangawa and his colleagues (2007) who published the site, divided cultural layer 1 into two phases, 1a and 1b, based on lithic raw material use and the technological characteristics. The obsidian tools are present only in culture layer 1b, which corresponds to phase 2 of the technological features, with features such as the flat flaking adjustment seen in the trapezes. In this assemblage, stone tools made of Kamiushibana and Mifune obsidian comprised 20% of the whole.The stone tools were produced using both types of obsidian because both trapezes and cores have been found.

In phase 3, there are also several sites on the Satsuma Peninsula as well as the Hitoyoshi basin (fig. 5). The lithic raw material used is different at each site, such as the Tanukidani site (cultural layer 1), the Kubo site (cultural layer 1) and the Kunobaru site on the Hitoyoshi basin. At the Tanukidani site, chert was used for the majority of stone tools imitating, as we think, the stone tool production of Kuwanokizuru or Nitto obsidian. Although obsidian was not the typical raw material in stone tool production, formal tools such as knife-shaped points and scrapers were also produced using it (Kizaki 1987). The proportion of obsidian and chert is almost the same as that at Kubo (Kizaki 1993). At Kunobaru, Nitto or Shirahama obsidian account for the majority of lit hic raw materials. The large amount of knife-shaped tools, scrapers, bladecores and flakes excavated point to on-site production (Furumori1999). At the Chochi site (layer 17.18), located in the Ata Caldera area of southern Satsuma Peninsula, the knife-shaped points and scrapers made mainly of shale and agate which can be found in the vicinity of the site; tools made of Kamiushibana and Nitto obsidian have also been found (Nagano 2000). It is believed that they had been produced on-site, because of the dozens of flakes that were excavated, even though no cores were found. Although stone tools made of obsidian were excavated at the Mizusako site (12.13 layers), the location of the source remains unknown.

As mentioned above, it is possible to map obsidian exploitation during phase 2 in the southwestern Kyushu. The formation of sites in the vicinity of the Nitto obsidian source, such as the Uwaba site, indicates that this is the point when its full-scale use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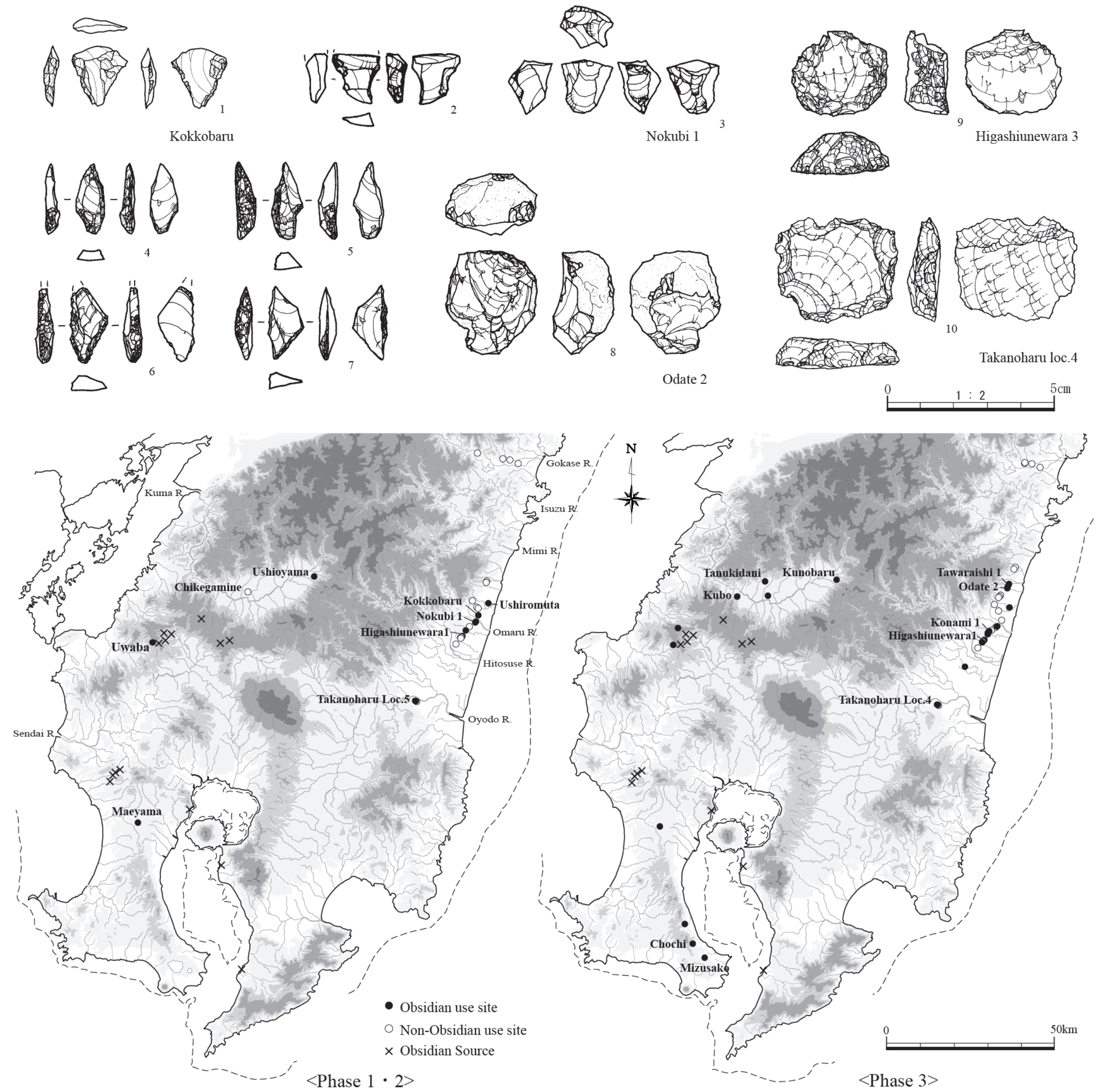


Figure 4 (Left page)
The Chronology of Upper Paleolithic in Southern Kyushu (modified from Miyata 2006)

1, 7-8: Retouched Flake, 2: Drill, 3: Pebble tool, 4: Chipped Axe, 5-7: Trapizoid, 10-14, 16-21, 35-38: Khife Shaped Point, 15,22: End Scraper, 23-25: Stemmed Point, 26-27: Tanukidani-type Bitruncated Point, 28-29: Imatoge-type Point, 30-32: Bilaterally Backed tool, 33: Kou-type Point, 34: Kou-type Point Core, 39-42: Trapeze, 43 Core for Trapeze, 44-49: Microblade-Core, 50-53, 54-61 Arrowhead, 53: Bifacial Point, 1-4, 6-9: Ushiromuta site, 5,10-12: Takanoharu site locality 5, 13- 15: Higashiunewara 3 site, 16-22: Kasugachiku site locality 2, 23-25, 39-43, 54-56, 59: Kirikimimitori site, 26-27: Mitsukuri site, 28-29: Kitaushimaki 5 site, 30-32: Jyogao site, 33-34: Nakanosako 1 site, 35-38: Nokubi 2 s ite, 44: Imazato site, 45: Nishimaruo site, 46: Ikemasu site, 47: Tsukabaru site, 48-49: Tateyama site, 50-52: Yokoitakenoyama site, 53: Asoharaue site, 57-58: Soujiyama site, 60-61:Fukiagekonakabaru site

Figure 5 (Above)
Lithics made of obsidian (above) and Site distribution (below) of Early Upper Palaeolithic on Southern Kyushu

began. It is also important to note that at the Uwaba and Maeyama sites, stone tools made of Kuwanokizuru, Kamiushibana, Mifune Obsidian are also present. Therefore, it is clear that all obsidian sources in southern Kyushu have been found and were developed during phase 2.

Eastern Region: For the first period, we can confirm 1 laminar flake found at Uhiromuta (cultural layer 3) (Tachinaba *et al.,* 2002). Although the details are not known because it was not included in the publication, it may be one of the oldest uses of obsidian in southern Kyushu.

During phase 2, obsidian was used at several sites on the Miyazaki Plain; for example: Kokkobaru site cultural layer 1, Ushiromuta site cultural layer 2, Nokubi 1 site phase 1 industry, Higashiunewara 1 site phase 1 industry and Takanogharu site locality 5 cultural layer 2 etc. One trapeze made of Kuwanokizuru obsidian in Kokkobaru (Ando 2007), 4 stone tools (including a retouched flake) in Nokubi 1 site (Tanaka *et al.,*2004) (fig. 5: 1-3), 1 trapeze and a few flakes made of Nitto obsidian at the Higashiunewara 1 site were also found (Oyama 2006). It must be noted, however, that obsidian during this period was used in very small amounts. At the Takanoharu site locality 5, trapezes, with flat flaking adjustment, flakes and cores made of blue-gray obsidian have been recovered (Hidaka *et al.,* 2004). Even though the color of these types of obsidian is similar to Hario obsidian, there are differences in terms of texture and presence of impurities, and as a result it is thought that these do not come from the Hario source but perhaps from somewhere nearby.

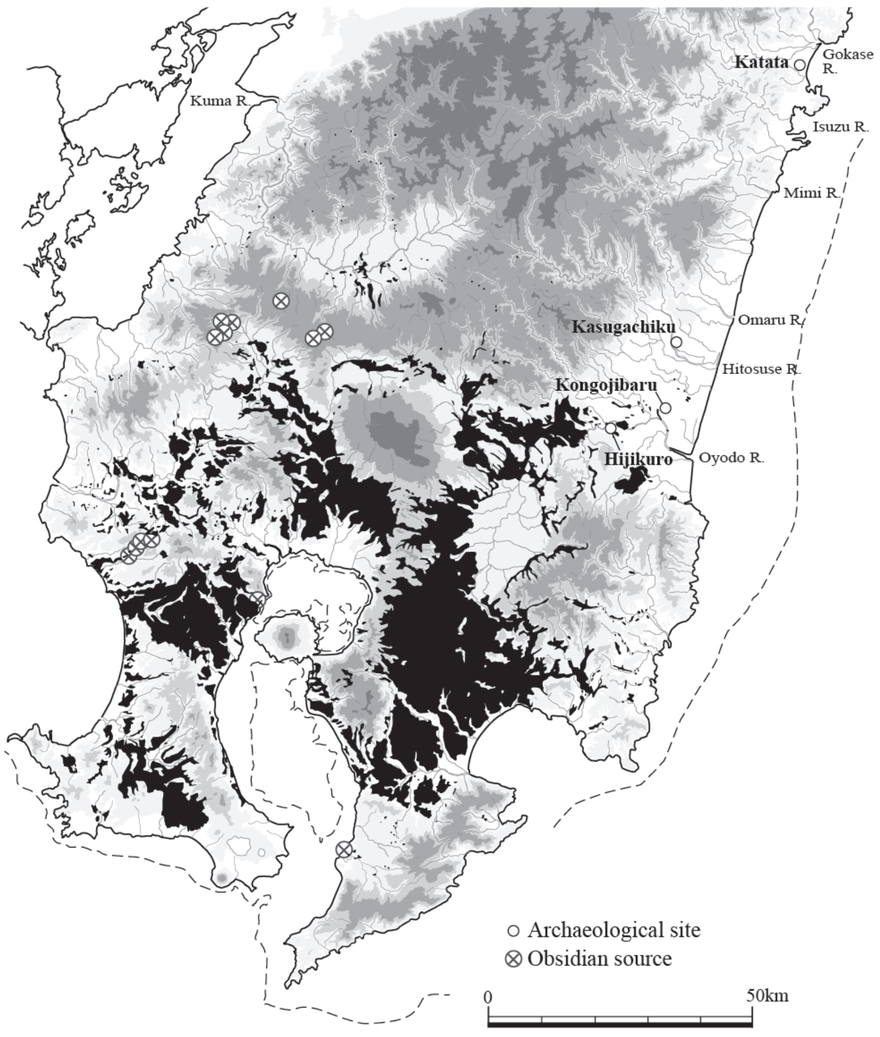


Figure 6 – Relaton between Ito pyroclastic frow (black part) and distribution of archaeological sites in phase 4

The lithic industries of phase 3 include Tawaraishi 1 site, Odate 2 site phase 2, Konami 1 site cultural layer 1, Onmyoji 2 site cultural layer 2, Kandaiji site cultural layer 1, Higashiunewara 3 site cultural layer 2, Nagasako 1 site locality 2 layer 9 etc. The Odate 2 site lithic concentration A comprises of stone tools of the Odate OX group almost all of which are made of obsidian from an unknown source (Kishida 2008) (fig. 5: 4-8). Stone tool production was most certainly taking place on site because firstly, all stagesof the *chaîne opératoire* are present (small knife blade, cores and flakes), and secondly, because several tool shave been successfully refitted. On other sites, however, lithic concentrations are quite rare, and the amount of stone tools or even flakes is usually quite small. A broken knife-shaped tool and several flakes were found at the Konami 1 site (Kuriyama and Nagatsu 2007) and the Onmyo ji 2 site (Yamaguchi 2003) discarded after having been consumed beyond repair. We should also mention the characteristic circular scrapers made of Nitto obsidian such as the ones found at the Takanoharu site 4 (Hirota 2002) and Higashiunewara 3 site (Fukumatsu *et al.,*2004) (fig.5: 9-10). These are also finished tools carried from a different site. Besides these, about 30 flakes made of Zogahana tuff have been excavated at the Tawaraishi 1 site (Yokoyama and Imashioya 2011), which constitutes the earliest exploitation of lit hic raw material from central Kyushu on the Miyazaki Plain. There are several flakes of what has been described in the publication as NW Kyushu obsidian, such as Koshidake and Hario, found at the Higashiunewara 1 site cultural layer 1 and one small knife-shaped tool found at the Konami 1 site. However, this hypothesis has not yet been confirmed through physicochemical analysis.

Even though the use of obsidian in southern Kyushu cannot be completely verified during phase 1, its use is attested with certainty during phase 2 by the small flake tools. It must be noted that in phase 2 almost all of the currently known obsidian sources were in use. Later, in phase 3, Nitto, Kamiushibana and Mifune obsidian were carried in southwestern Kyushu, whereas Nitto and Kuwanokizuru obsidian were carried in the southeastern region. Lithic raw materials of central Kyushu were used on the Miyazaki Plain. In addition, the quantity of obsidian used on sites increased. The proportion of obsidian used in phase 2 is not so high in these areas; during phase 3, however, the situation changed in both regions. In southwestern Kyushu there are industries in which obsidian is used mainly on the Hitoyoshi basin, and on-site production is evidenced on the Satsuma Peninsula. The overall quantities of obsidian however were still small, as was the scale of stone tool production using obsidian in southeastern Kyushu. In addition, reliable examples of stone tools made of NW Kyushu obsidian cannot be confirmed at present.

C – The second half of the Upper Palaeolithic

Phase 4

The following industries can be dated to phase 4 after the AT ash fall: the Katata site, Kasugachiku site locality 2, Kongojibaru 1 site, and the Hijikuro site on Miyazaki Prefecture (fig. 6). At present the sites in the region of the Miyazaki Prefecture are the only one for which we can be fairly sure they belongs to phase 4. Obsidian was used to make one scraper at Kongojibaru 1 (Miyashita1990) and four flakes at Hijikuro (Fujiki 2005). Techno-morpho logically there areknife-shaped points similar to those from phase 3, but the characteristic obsidian tool cannot be seen in these sites. Regarding this issue, Fujiki (2011) proposed that the Aira caldera where obsidian sources are located is no longer available, possibly. Because the recovery of the vegetation from damage of Ito pyroclastic flow was very slow. However, obsidian is not completely absent: the small quantities present at sites need to be carefully evaluated.

Phase 5

126 sites with tanged points have been excavated (JPRA2010); the number of sites increases to more than 130 if we add to this the excavated sites where Tanukidani type bitruncated points and Imadoge type points were found. Compared to phase 4, the number of sites increases dramatically (fig. 7, below left).

Western Region: In the Hitoyoshi basin, obsidian was not used for tanged points, but it was used for other tools found in the same assemblages. Trapezes made of Kuwanokizuru obsidian have been found at Tendogao (Nisjizumi 1990). In addition, obsidian was used for the knife-shaped points and trapezes at Daimaru-fujinosako (Kizaki 1986), Kogamine (Nishizumi 1986), and at Shiratoribira A (Miyazaka 1993). However, since bilaterally backed tools have been found at all of the sites, the possibility cannot be denied.

At Dozonobira on Kagoshima Bay West Coast Hills on the Satsuma Peninsula, Imatoge knife-shaped points made of obsidian were found in addition to tanged points (Sangawa 2006) (fig. 7: 1-6). Thirty-four out of fifty knife-shaped points that were excavated were made of obsidian, primarily Kamiushibana obsidian and secondarily Mifune obsidian. Furthermore, four knife-shaped tools made of NW Kyushu obsidian were presumably found on this site as well. Of these, knife-shaped blades and Tanukidani type bitruncated points were made of Hario obsidian, while the Imatoge type point was made of Koshidake obsidian. Both tools must have been discarded as either defective or overused. In this region, there is a tendency for obsidian to be used for the manufacture of bitruncated points. For example, at the Shimotsukiden site in

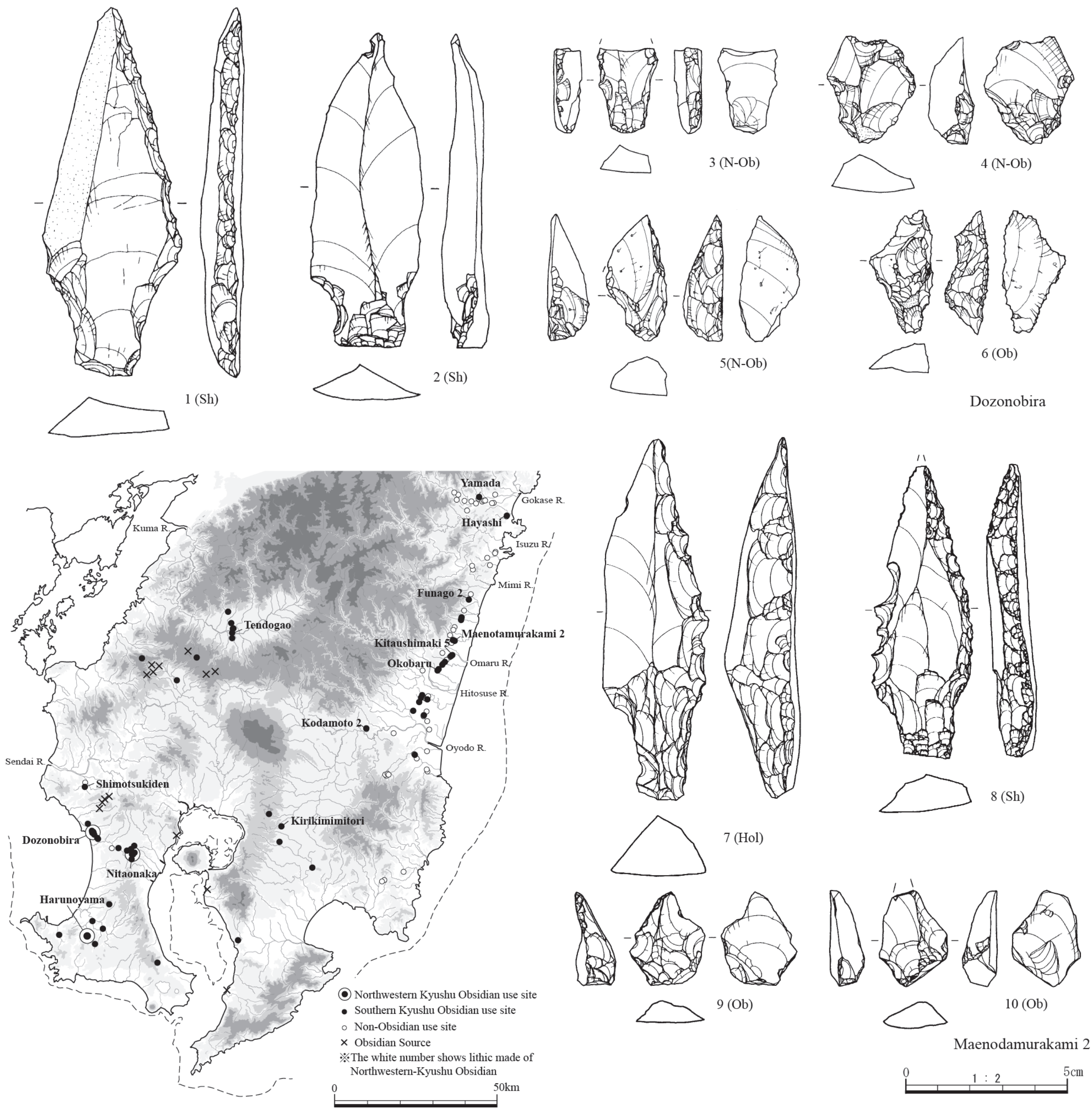


Figure 7 – Lithics (above and below right) and Site distribution (below left) of phase 5 in Late Upper Palaeolithic on Southern Kyushu

the region downstream of Sendai river (Iwaya *et al.,* 2008), four out of five are made of this type of obsidian and at the Okariya-ato site locality B four out of eight were made of one type (Konohara and Minei 2006). At Nitao a large amount of knife-shaped points was excavated made of Mifune and Kamiushibana obsidian (Miyata 2008). In rare cases, some of them were made of Nitto and Kuwanokizuru obsidian, and in one case a knife-shaped point was made of Hario obsidian. The use of NW Kyushu obsidian for Tanukidani type bitruncated points is also attested at the Harunoyama site on the Ibusuki Mountains. Knife-shaped tools and scrapers made of Hario obsidian have been excavated in the eastern part of this site (Uehigashi *et al.,* 2002).

There are two characteristic traits of obsidian use in phase 5 in the western part. Firstly, obsidian is not used for tanged points. However, southern Kyushu obsidian is consistently used for other tool types. Secondly, a small amount of NW Kyushu obsidian was used for bitruncated points and Imatoge type points. The latter trait is particularly important, as it constitutes a major change in obsidian use patterns in southern Kyushu.

Eastern Region: Obsidian stone tools have been found at the Yamada and Hayashi sites of Gokase River valley. In the Gokase River valley, the use of southern Kyushu obsidian had not been recognized at all prior to this making this the first occurrence of obsidian use. These are either knife-shaped tools or retouched tools. The quantity of obsidian used was very limited. At Yamada only one scraper made of Kuwanokizuru obsidian has been found (Akasaki 2007), at the Hayashi site, however, in addition to the knife-shaped point, stone tools made of obsidian such as Nitto and Kamiushibana obsidian were excavated (Higashi *et al.,*2008). However, it is possible that the obsidian bilaterally backed tools may be later in time in that case.

The secure examples at the Miyazaki Plain, including the Gokase River valley, are one bitruncated point at Funago and Okobaru, four knife-shaped points including an Imatoge type point at Maenotamurakami 2, four trapezes at Kitaushimaki 5, and one tanged point at Kodamoto 2. Outside of this area, flake-dominated industries have been found at a dozen of sites on the south of the Omaru River on the Miyazaki Plain.

At Menotamurakami 2 knife-shaped points made of Kuwanokizuru and Nitto obsidian have also been found (Shimada 2007) (fig. 7: 7-10). Both the large tanged point industry and the bilaterally backed tool industry have been recovered from different stratigraphic layers at this site; small flake tools are associated with the former industry. The knife-shaped points produced small oblique flakes, similar to the Imatoge type points. Since in both cases damage or macro-flaking is observed, it is clear that they were used and discarded. There are also trapezes made of Kuwanokizuru obsidian at the Kitaushimaki 5 site, in which Imatoge type points are the majorit y (Kusanag i and Yamada 2003). It is hard to fit them in any of the existing trapeze types; their main characteristic is that they are sharpened at the base. What is referred to as a tanged point made of obsidian from Kodamoto 2 is also problematic with regard to its morphology, because the notch adjustment is weak and does not look like typical microblade material (Shimada 2003). However, X-ray fluorescence analysis had determined that the tool was made of Mifune obsidian, providing therefore solid evidence of the transportation of Mifune obsidian to the Miyazaki Plain.

At the Kirikimimitori site (cultural layer 1) at the 15tharea on the Takakuma Mountains, knife-shaped points using the oblique flakes were excavated (Nagano *et al.,*2005). These are round and more than 5 cm long; they have not been found on the Miyazaki Plain described above. They were most likely produced on site because they are made of Nitto and Mifune obsidian and we have also found cores and flakes from the same raw materials.

As mentioned above, in general, obsidian is not used fortanged points in the eastern region. However, obsidian is used for Tanukidani type bitruncated points and Imatoge type points that may be found alongside tanged points. In order to understand this, we would need to research both the Miyazaki Plain and the Takakuma Mountains. Obsidian use in the former region is limited and no traces of on site production have been found at present. In addition, stone tool size is also generally small. This tendency is similar to that in phase 3. On the other hand, in the latter region, there is evidence of on site production, and the tool size is larger.

Phase 6

There are 126 sites in total where bilaterally backed tools have been found (JPRA 2010) (fig. 8, below). It is thought that the appearance of bilaterally backed tools goes back to the phase 5. What follows is a comprehensive discussion of this.

Western Region: In the Hitoyoshi basin, the use of obsidian for bilaterally backed tools, though not extensive, has been established. Although there is almost no detailed description in the publication (Miyasaka 1993), judging from the photo provided, it seems that Kuwanokizuru and Nitto obsidian were used. It has been noted that

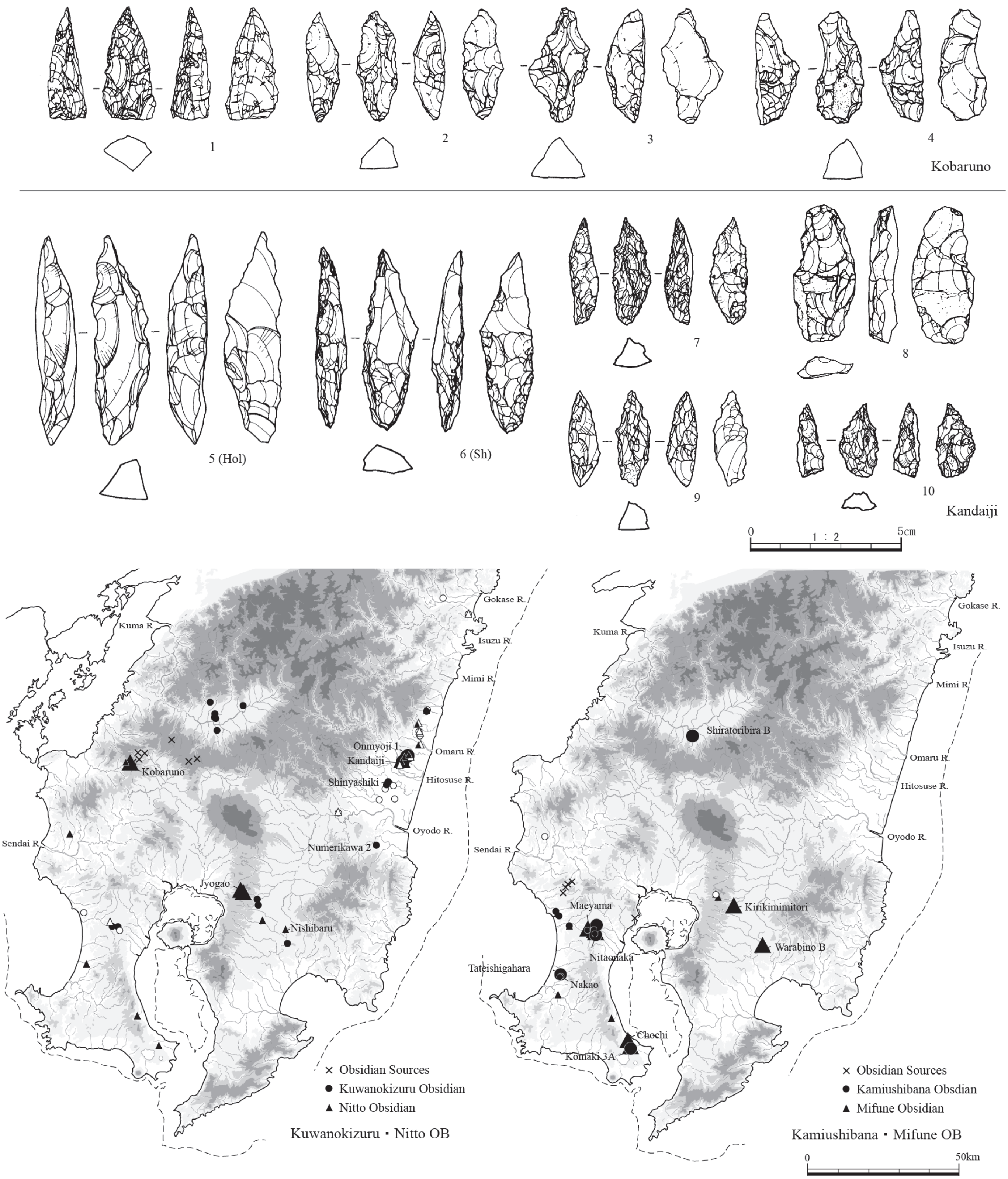


Figure 8 – Lithics (above) and Site distribution (below) of phase 6 in Late Upper Palaeolithic on Southern Kyush

bilaterally backed tools were made of Kamiushibana obsidian at Shiratoribira B site. Eight out of the ten tools were made of this obsidian; flakes and debitage have been also recovered (Miyasaka 1994). It appears that the flakes were brought as raw materials to the site because no cores were found. The case of Shiratoribira B, a highly isolated site with access to Kamiushibana obsidian, has to be carefully studied.

Around the area of the Nitto obsidian source, the production loci of bilaterally backed tools are scattered at such locations as the Kobaruno, Okubo and Asahidake B sites. In particular, stone tools reaching as many as 300,000 have been excavated at the Kobaruno site, which is located at an altitude of 500 masl. Even though not all of these are dated necessarily to phase 6, seventybilaterally backed tools, ranging from medium to small size, were excavated, and it is possible to say with certainty that the production loci must be in the vicinity (Nakamura 1999) (fig. 8: 1-4). At the Okubo site, ten bilaterally backed tools have been excavated in an area of about 80 square meters, eight of which are made of Nitto obsidian (Iwasaki 2007b). The other two were made of Kuwanokizuru obsidian; knife-shaped points have also been recovered at the same site. The site had very dense concentrations of lithic material. The fact that stone tools made of Kuwanokizuru obsidian were also found is important for our understanding of human mobilitypatterns.

The industry including bilaterally backed tools has been distributed abundantly throughout the Kagoshima Bay West Coast Hills. At these sites, bilaterally backed tool made of obsidian are made of either Mifune or Kamiushibana obsidian predominantly. At the Maeyama site culture layer 3 lithic concentration (LC) 12, twelve of thirteen bilaterally backed tools are made of obsidian, seven of which on Kamiushibana and five on Mifune obsidian (Sangawa *et al.,* 2007). A similar situation can be seen at Nitaonaka A and B sites. 122 bilaterally backed tools were excavated in this site, 96 of which are made of obsidian and half of those of Kamishibana obsidian, while the other half is made of obsidian from Mifune, Nitto, and Kuwanokizuru. The lithics made of Nitto obsidian included deficient bilaterally backed tools and scrapers (Nagano *et al.,* 2007). These round scrapers were typical in south-eastern Kyushu during phase 3, but they are also seen during this phase in south-western Kyushu.

While Mifune or Kamiushibana obsidian are predominant, Nitto and Kuwanokizuru obsidian are included in a fixed amount on Ibusuki Mountains and the Ata Caldera region. At the Tateishigahara site, all six bilaterally backed tools are made of Kamiushibana obsidian (Nakamura *et al.,* 2005); the same trend can be observed at the sites Arata, Nakao, Kashiranashisakoda located in the vicinity. There is one bilaterally backed tool made of Nitto obsidian at Nakao and one scraper also made of Nitto obsidian found at the Sakuradani site (Seki *et al.,* 2009). As described above, the fact that Nitto obsidian is often used in this region is remarkable in that it is a phenomenon rarely seen other than in phase 6 (fig.8: below left).

One of the characteristic traits of this phase in the western region is the presence of a Nitto obsidian source site. This site has produced a large amount of bilaterally backed tools in Kobaruno, and there is also a similar situation at a nearby site. This has not been observed in the previous phase. The other characteristic is that the consumption of Kamiushibana and Mifune obsidian seems relatively increased and the lithic industries in which obsidian is the preferred raw material have also increased (fig. 8).

Eastern Region : Although examples from the Yamada and Hayashi sites on the Gokase River valley of phase 5 could actually belong to phase 6, the obsidian used for the bilaterally backed tool industry was found on the Omaru River basin. At the Odate 2 site phase 3 industry, bilaterally backed tools made of Nitto and Kuwanokizuru obsidian were excavated (Kishida 2008). In particular, Nitto obsidian has been also used to produce scrapers and flakes, which form large lithic concentrations. At present, this is the northernmost site with evidence for on-site production. In addition to this, several knife-shaped points trapezes made of obsidian have been excavated at Tawaraishi 1 located on the Omaru River basin (Yokoyama and Imashioya 2011).

In the sites between the Omaru and Hitotsuse rivers, the use of obsidian is common but quantities vary (fig. 8: below left). It should be noted that the existence of industries with a largeamount of stone tools made of obsidian were found. For example, 65 bilaterally backed tools made of obsidian out of 186 have been excavated at the Kandaiji site (Tategami 2007). Jet-black color obsidian from Hishikari, similar to the Kuwanokizuru variety, is the primary raw material, alongside Nitto obsidian. Small tabular nodules of Hishikari obsidian constitute the raw material for the bilaterally backed tools (fig. 8: 5-10). On-site production most probably took place there as suggested by the unfinished tools that were also found. At Onmyoji 1, twenty-six bilaterally backed tools have been excavated, seven of which made of obsidian (Yamaguchi2003). The large amount of flakes excavated, clearly suggests on-site production, even though at a smaller scale than at Kandaiji. In addition, the sites also produced 1-5 bilaterally backed tools made of obsidian is evident and there are many industries such as the ones at Nakanosako 1 (2 of 8), Konami 1 (1 of 9), Makiuchi 2 (3 of 13), Higashiunewara 1 (2 of 16), Uenoharu (6 of 57), Shinyashiki (4 of 22) etc. Nitto and Kuwnaokizuru obsidian, including Hishikari, is often used, but north-western obsidian is never used. The proportion of each type of obsidian at these sites is equally low.

On the Takakuma Mountains obsidian exploitation patterns are completely different from those on the Miyazaki Plain. In this area the type of lithic raw material used for the bilaterally backed tools is obsidian. Moreover, obsidian from all the sources in southern Kyushu has been used. At the Nishibaru site, large bilaterally backed tools, more than 5 cm long, have been found (Maesako and Yokote 2008): 6 of 15 are made of obsidian and it is possible that most of them are Nitto obsidian based on macroscopic observations. At the Jyogao and Tateyama sites, small to medium-sized bilaterally backed tools predominate, the majority of which was made of Nitto obsidian. At Jyogao, 60 of 104 bilaterally backed tools are those made of obsidian and it is believed that 42 of these were made of Nitto obsidian (Arima *et al.,* 2003); some were also made of Kamiushibana and Kuwankizuru obsidian. This situation can be also seen at Warabino B, where many preparation flakes and blanks have been found (Kubota *et al.,* 2007).

As explained above, in the eastern part, the appearance of the obsidian used is notably different from that found on the Takakuma Mountains and the Miyazaki Plain. However, the exploitation of obsidian has increased significantly in both areas compared to the previous phase, which is undoubtedly one of the most important traits of these industries. At sites on the Miyazaki Plain large amounts of Kuwanokizuru and Nitto obsidian have been found, along with evidence for on-site production. Moreover, it is important for our understanding of the mobility of the population that such industries were distributed intensively from Omaru River all the way to Hitotsuse River. Bilaterally backed tool industries were distributed in many regions of the Miyazaki Plain, attesting to the intensive consumption of obsidian in the region. The concentrated distribution of obsidian consuming sites can be seen in the micro-blade industries below. It is not clear whether Kamiushibana and Mifune obsidian were used, but if they were, only a very small amount of them was used. On the other hand, the lithic industries on the Takakuma Mountains are characterized by the large number of bilaterally backed tools made of Nitto obsidian (fig. 8, below right). This is considered to be a temporary phenomenon as this is a pattern observed primarily after phase 7 (see below). However, this is important, as is the problem of the formation of Nitto obsidian source site described above, since they pertain to issues of interaction and mobility patterns.

Phase 7

These industries include both small knife-shaped points and trapezes in the second half of phase 7, with bilaterally backed tools included in the first half. The number of sites decreases compared to the phase before and the one after; there are currently approximately 40 sites (Matsumoto 2005; Shiba 2011).

***Western Region*:** The number of sites is quite low, however, there is a large amount of stone tool production sites that exist on the Satsuma Peninsula. Setogashira A and B, Okariya-ato B, Nishino hara B, Maeyama cultural layer 3, Nitao cultural layer 2, Nitaonaka A-B cultural layer 2 correspond to these industries. As a general trend, Kamiushibana and Mifune obsidian accounted for the overwhelming majority, with shale, chert, chalcedony, agate, and iron quartz following. These lithic raw material proportions are the same for every tool type. It is important to note that NW Kyushu obsidian was found in small amounts in the industries of this region. In Maeyama andNitaonaka A-B site,the trapezes and detached flakes made of Hario obsidian were included. On the Ibusuki Mountains, the ratio of obsidian is low, with shale, agate, and chalcedony taking the lead. The Miyanoue site is the shale source site of this phase, butthere are also small amounts of Kamiushibana and Mifune obsidian tools (Magome 2010). This combination of lithic raw materials is thought to reflect the history of the mobility route.

As shown above, large quantities of Kamiushibana and Mifune obsidian were consumed in this region. This situation remains much the same as in phase 6; it was noted, however, that several stone tools made of NW Kyushu obsidian were also found in the assemblages.

***Eastern Region*:** The most important sites of this phase are the following: Obana A, Nokubi 2, Kodamoto2, Jyogao cultural layer 3-4, Kirikimimitori cultural layer 2. While the raw material preference is as diverse as that of the western region, there is a significant difference based on a detailed terrain classificat ion. On the Miyazaki Plain, the frequency of obsidian use is extremely low. At Nokubi 2 located in the Omaru River basin, the raw material for knife-shaped points is mainly siliceous shale, although a certain amount of rhyolite, chert and obsidian are also utilized (Ozono *et al.,* 2007). Only 3 of the 85 are made of Kuwanokizuru obsidian; 2 of the 3 are fragmented. In small trapezes, chert is preferred with only 2 of the 58 made of obsidian. At Obana A, siliceous shale is the main rock, and hornfels, rhyolite and Kuwanokizuru obsidian is also used (Deyama *et al.,* 2009). The obsidian tools are finished products. At Kodamoto 2, eight small knife-shaped points have been excavated, one of which is made of Kuwanokizuru obsidian (Shimada 2003).

At Jyogao, knife-shaped tools were manufactured using various materials such as obsidian, shale, chert, chalcedony etc. (Arima *et al.,* 2003); however, more than 90% of the knife-shaped tools were made of obsidian at the Kirikimimitori site, cultural layer 2, LC12. Obsidian is often used for small trapezes, with the preferred raw material beingKuwanokizuru obsidian (Nagano *et al.,*2005). At Jyogao, many knife-shaped tools made of Kuwanokizuru obsidian have been excavated with two of them made of Hario obsidian.

It is necessary to consider separately the eastern region of the Miyazaki Plain and the Takakuma Moutains during this phase. In the former, the frequency of obsidian use is reduced compare to that of phase 6. Although the number of sites is low, the industries' formal tools are abundant, such as those found at Nokubi 2; only a few obsidian tools are found and on-site production is not taking place. On the other hand, in the Takakuma Mountains, Nitto obsidian is consumed in large quantities during phase 6. However, while in phase 7 obsidian is consumed in large quantities, evidence of stone tool production has also been found. In both regions the size and shape of the tools are also slightly different, which should be the focus of future studies.

D – From the final phase of the Upper Palaeolithic to thebeginning of the Jômon Period Phase 8-9

Microblade industries have been found at 311 sites (JPRA 2010). In the phase characterized by the microblade industries, the number of sites with obsidian increased dramatically, and obsidian is found in all regions except for one part of the Miyazaki Prefecture (fig. 10). This is a new trend that develops during this phase.

***Western Region*:** In the Hitoyoshi basin, Kuwanokizuru obsidian is the main raw material used. At Jyobaba 2 and Shiratoribira A, all macroblades and macroblade cores are made of this obsidian. At Uwaba layer 3, twenty-three microblade cores were excavated eight of which were made of Koshidake, two of Hario, and seven of Kuwanokizuru obsidian. Micro-blades made of Koshidake obsidian comprised 67% (104 of 155) (Iwasaki 2007a). Fifty-eight of the seventy-two micro-blades and the majority of microblade cores collected were made of NW Kyushu obsidian at the Shirinashibira site on the Nagashima Island (Ikezaki and Yoshidome 1979). A similar situation is also attested for the microblade industries located on the Izumi Plain.

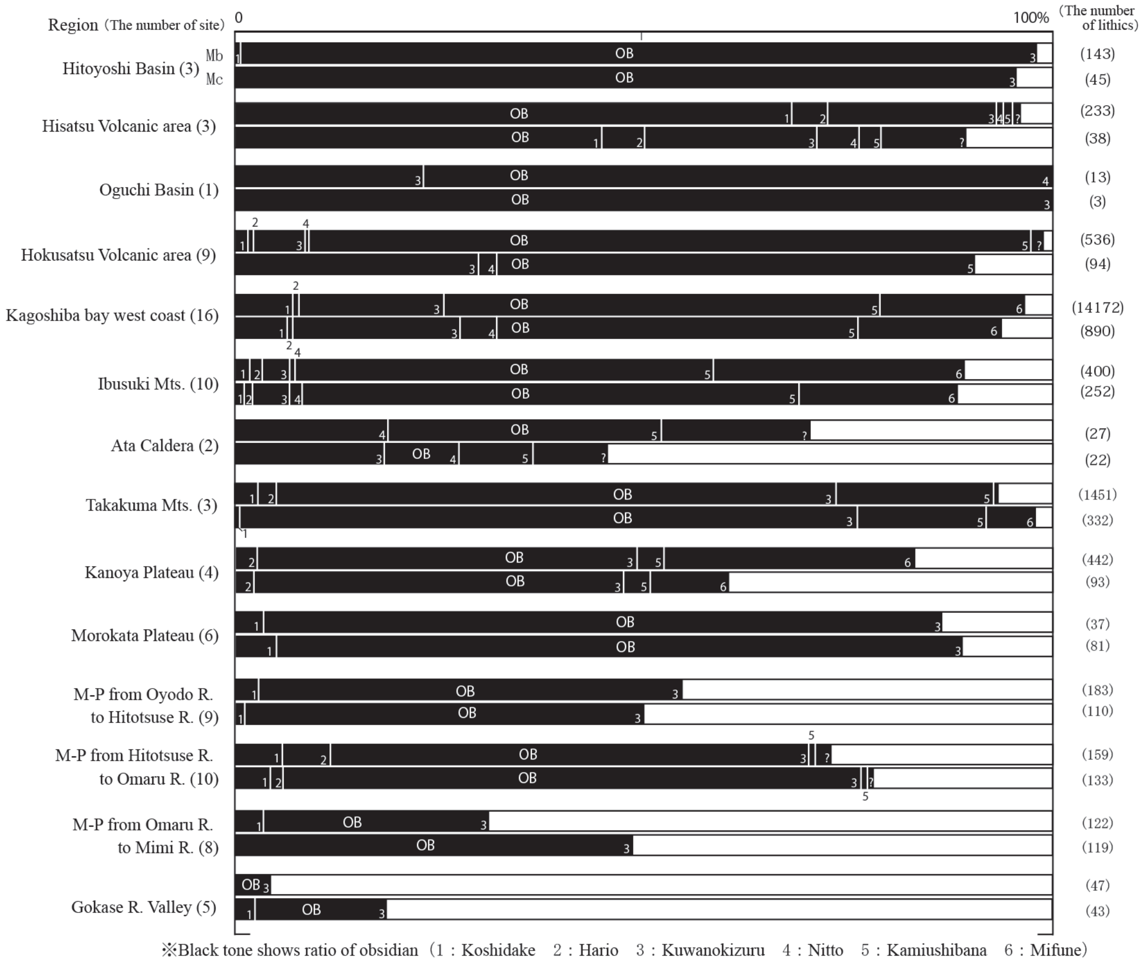
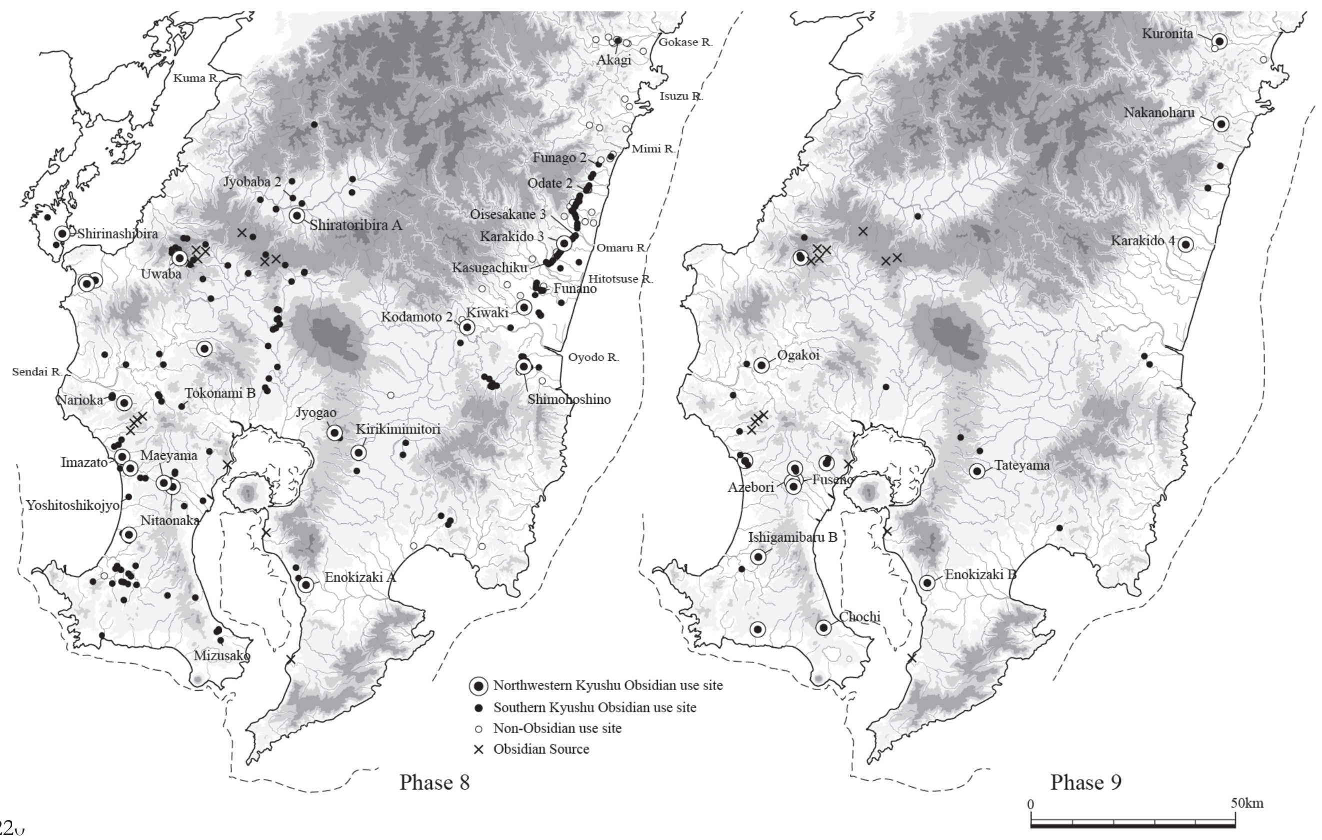


Figure 9 (Above) – The Ratio of Obsidian use in Microblade Industries on Southern Kyushu (Modified from Shiba 2011)

Figure 10 (Below) – The Site Distribution of Microblade Industries on Southern Kyushu



However, the situation is different south of the Okuchi Basin and in the Hokusatsu volcanic area. The amount of NW Kyushu obsidian circulating among the sites sharply decreased; on the contrary, the frequency of use of southern Kyushu obsidian increased. At the sites in upstream the Sendai river, the lithics made of Kuwanokizuru obsidian are the main ones and Kamiushibana obsidian is also included. On the other hand, at the sites in the middle of and downstream of the Sendai, the sites, located behind the Kamiushibana source, show an intensive consumption of this type of obsidian. Tokonami B, Kamuragasako, Narioka B-C and Oharano are the most important of these sites. At Tokonami B site 408 microblades and 27 microblade cores were found, all made of Kamiushibana obsidian except for one of the cores (Dokome 1993). At Narioka site LC B lithics made ofKuwanoizuru obsidian constitute the majority of the assemblage (Ushinohama and Miyata 1985).

On the Kagoshima Bay West Coast Hills, Kamiushibana and Mifune obsidian are the main raw materials. One of the traits of obsidian use in this region is that o only a few microblade cores made of NW obsidian were found on site. However, even in sites where they are present they are very few; such is the case at Imazato, Dozonobira, Maeyama, Nitaonaka A-B and Okariya-ato B etc. At Imazato and Nitaonaka A-B in particular, lithics made of Kamiushibana obsidian are the majority. At Imazato, 73 of the 101 macroblade cores were made of this obsidian, similar to what is happening downstream of the Sendai River described above (Hashiguchi 2002). Nitaonaka A-B yielded a very large assemblage of 667 macroblade cores and 12,782 macroblades in total. The proportions of different types of obsidian used for the manufacture ofmacroblades are the following: 55% (n=7166) made ofKamiushibana obsidian, 18% (n=2330) of Kuwanokizuru and 15% (n=1931) Mifune obsidian. The macroblade Miyagasako (Yagisawa *et al.,* 2000) and Setogashira A (Dokome *et al.,* 2005), Mifune obsidian dominates theassemblages. The fact that either Mifune or Kamiushibana cores have almost the same ratios (Nagano *et al.,* 2007). Dozens of the macroblade core are thought to have been made of Koshidake obsidian. On the other hand, at obsidian is dominant is an important development for this phase, as it shows the distance travelled between the obsidian source and the sites where it was found.

The most common routes of population mobility most likely involved the procurement of the type of obsidian mostly used. However, there are sites, such as Maeyama (Sangawa *et al.,* 2007) and Yoshitoshikojyo (Tsuneta *et al.,*2007) where Kuwanokizuru obsidian predominates. We believe thatKuwanokizuru obsidian was procured and used only for macroblades knapped using the Funano technique for which almost no other type ofobsidian was ever used. The situation at the Ibusuki Mountains area is similar to that in the western coast of the Kagoshima plateau. However, there is no site where microblades are made using Kuwnaokizuru and NW Kyushu obsidian in the region, which is quite different from what is found in the northern region. Komaki 3A and Mizusako are located in the southern Kyushu volcanic area.

In the former, microblade production on crystal quartz is predominant, with obsidian being secondary (Nagano 1996). On the other hand, in the latter, obsidian is the main raw material, among the 7 microblade-cores, 2 Kuwanokizuru, 2 Mifune and 1 Kamishibana obsidian (Shimoyama *et al.,* 2002). However, both microblades and microblade cores are also very small; the length is on average 2 cm less. Most likely this indicates that they must have been discarded after being exhausted.

According to the existence of the NW Kyushu obsidian and composition rate of each obsidian source in southern Kyushu, there are delicate differences in obsidian consumption based on a detailed terrain classification (fig.9).

***Eastern part*:** On the Gokase River valley rhyolite seems to be the exclusive raw material. The Akagi site is one such example (Nobeoka city 1987). In this region, the quantity of stone tools made of Kuwanokizuru obsidian is very small, but present nonetheless.

On the Miyazaki Plain a certain degree of unity is observed in the lithic raw material used in the region between the rivers Mimi and Omaru; that is, the component ratio of non-obsidian raw materials and obsidian is approximately the same. In this area rhyolitecan easily be found at the banks of Gokase. In this area, industries using Kuwanokizuru obsidian can be found only at the Kirishima site. The industries in which the proportion of both obsidian and non-obsidian is almost the same are mentioned and they include sites such as Maenotamurakami 2, Tateno 5 site and Odate 2.

In between the Omaru and Hitotsuse rivers, Kuwanokizuru obsidian is used in many cases at sites such as Kasugachiku site 2, Oisesakaue 3, and Onmyoji 1. At Karakido 3, two microblade cores were made of Hario obsidian. Since preparation flakes were also found, on site production of microblade is almost certain.

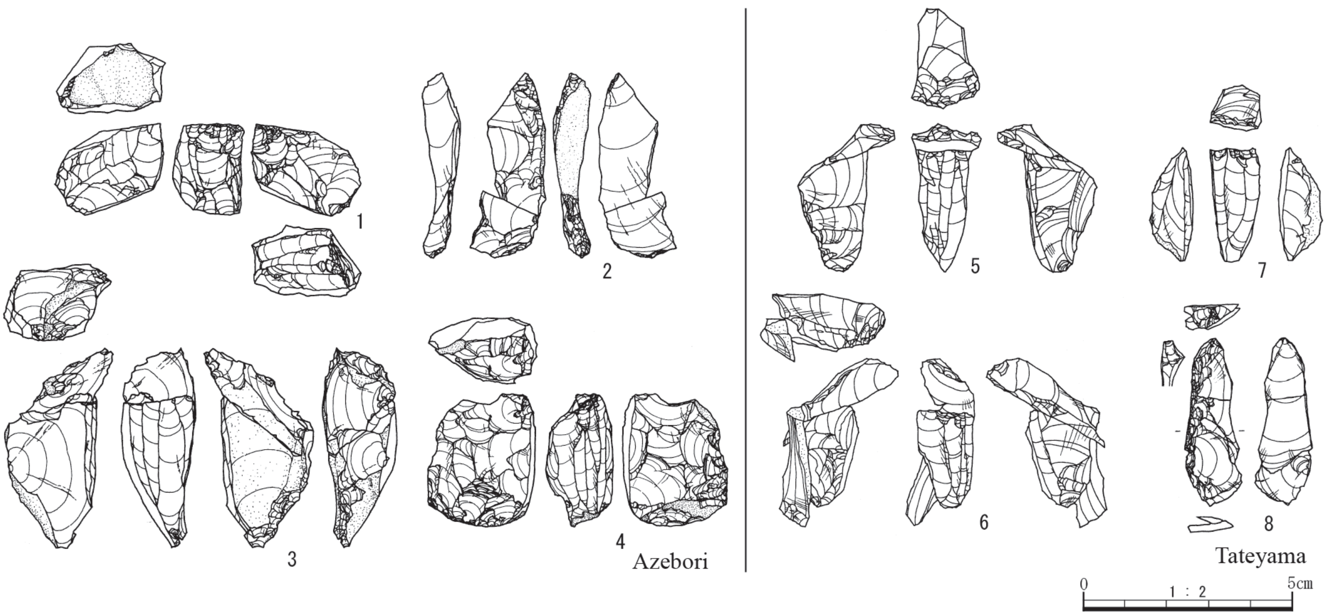
In the assemblages found at sites between the Hitotsuse and Oyodo rivers, both obsidian and non-obsidian raw materials are used. The sites Funano 1 and 2 illustrate this trend (Tachibana 1975). Kuwanokizuru obsidian is the main material used at the former, whereas at the latter, all microblade cores are made of hornfels and shale; Kuwanokizuru obsidian is used only for the microblades.

At the Shimohoshino and Kiwaki sites located in the lower reaches of Oyodo river, microblades are produced using Kuwnaokizuru or Kirishima obsidian. One microblade made of Koshidake obsidian was found at both sites (Torihana 2001); one microblade core made of Kamiushibana obsidian, which is rare in this region, was also found.

On the Takakuma Mountains the main types of obsidian are Kuwanokizuru, Kamiushibana, and Mifune obsidian at different proportions for each site. Lithics made of NW Kyushu obsidian are also found, but there is only small amount in these industries. A lithic concentration consisting of about 20 microblades made of Koshidake obsidian was excavated at the Kirikimimitori site (Nagano *et al.,* 2005); however, there were no indications of om-site production, but rather it seems that the stone tools had been brought in as finished products. At Nishimaruo located south of the Takakuma Mountains, microblade production on Mifune obsidian dominates the assemblage (Miyata 1992). Evidence of production is scarce, but several microblades and microblade cores made of Kamiushibana obsidian have also been found. At Enokizaki A microblade production on Kuwanokizuru obsidian is the main industry, even though there are also two microblades made of Hario obsidian (Aosaki *et al.,* 1992).

One characteristic trait of the southeastern Kyushu area is that Kuwanokizuru obsidian is commonly used along with small amounts of NW Kyushu obsidian, such as Koshidake and Hario. However, there are differences in the use ratio of obsidian and

Figure 11 – Microblade-cores and Spalls made of NW Obisidian of Phase 9 on Southern Kyushu



non-obsidian for each terrain category. The former predominates in the south and the latter is common in the north (fig. 9).

This way obsidian is used in southern Kyushu (east and west regions) is essentially specific to the microblade phase. In phase 9, however, large amounts of NW Kyushu obsidian are also used. This is observed throughout the entire area of southern Kyushu and is particularly prevalent in the western part of the island. The specific industries where this trend is visible come from the following sites: Azebori, Fuseno, Tateyama, Karakido 4, and Kuronita site. In all these sites microblades and microblade cores made of NW Kyushu obsidian have been excavated. Especially at Azebori (Nagano *et al.,*2006) and Tateyama (Yae *et al.,* 2009), a fixed amount of the NK obsidian was introduced to the degree that it formed several lithic concentrations (fig. 11). The microblade technology used is the Fukui technique; biface blank and several large flakes are brought on the sites to make microblade cores and then produce microblades. At Enokizaki B (Inoue *et al.,* 1993) and Kuronita (Hirayama 2009), both typical sites for southeastern Kyushu, a simple technique with no core preparation was used.

Phase 10

The raw material used for the manufacture of arrowheads varies depending on whether or not they were associated with the micro blade industry. Non-obsidian materials, such as black andesite were mainly used at Kakuriyama (Aosaki 1981) and Yokoitakenoyama (Deguchi 1990) accompanied also by microblades (Miyata 1996). However, a large amount of Ryutaimon pottery decorated with clay ridges, was excavated at sites such as the Kakoinohara (Uehigashi *et al.,* 1998) and Sojiyama (Deguchi 1992), where obsidian is the main lithic material used. It is also important that the lithics made of Kuwanokizuru obsidian were transported to Tanegashima Island. However, since no evidence of on-site production have been observed, all of these were likely to have been brought in as finished products. It is worth noting that, while in the 'Ryutaimon', thick liner-relief, pottery phase, the microblade industry changed over completely to the arrowhead industry, inphase 10 obsidian use began to take over once again and, in particular, the use of Kuwanokizuru obsidian. This phenomenon is common in the southeastern and western Kyushu (Shiba 2011). During this phase the two most common types of arrowheads are the flat-based equilateral or isosceles triangular points: the former mainly appears before emergence of Ryutaimon pottery, while the latter is associated with the Ryutaimon pottery phase. However, after this phase, additionallyto these two types, more types appear such as the elongated triangular, the tear drop-shaped and clear convex-based types. It is important to mention that certain types of arrowheads are made on specific raw materials: small points tend to be made of obsidian, in particular Kuwanokizuru, whereas larger ones are made non-obsidian materials, such as andesite and shale.

5 – Obsidian source exploitation patterns

In the previous sections I examined the obsidian usage patterns diachronically, dividing them into two regions, namely south-eastern and western Kyushu. In this section, I look at each obsidian source separately (Fig. 12). The exploitation of NW Kyushu obsidian, Koshidake, and Hario started in approximately phase 5, at sites such as Dozonobira and Harunoyama. In the publication (Nagano 2000), although the potential has been shown in the AT lower, nothing was confirmed by physical and chemical analysis. There is no reliable example from phase 5 in southeastern Kyushu, but it is quite possible that they will be found in the future judging from the situation in the west. A physical and chemical analysis of the lithics in question is deemed necessary. Both Koshidake and Hario obsidian were transported shortly after the AT ash fall. Since a small amount has been found in phase 7, in the future the possibility that it will be found in phase 6 cannot be excluded. Whether these were brought at any opportunity is an important issue; however, it is thought that from the carrying amount of the materials, and not in the context of the population of north and south Kyushu, that they were frequently in contact with each other. In the future, it will be necessary to consider this issue from a multilateral perspective such as lithic technology and an examination that includes other lithic raw materials. Subsequently, it is in phase 9 that the frequency of NW

Northwestern Kyushu Obsidian Sources

Region / Phase	**Koshidake OB**							**Hario OB**							
	HS-V	HK-V	KBW	I-M.	O-P	M-P	G-V	HS-V	HK-V	KBW	I-M.	O-P	M-P	G-V	**epoch**
1					-							-			
2					-							-			**1**
3				?	-						?	-			
4															
5-1							?								**2**
5-2					?	?	?					?			
6				?	?	?	?					?			
7															
8															**3**
9															
10															

Central Kyushu Obsidian Sources

Region / Phase	**Aso (Zogahana Tuff, Oguni OB)**							
	HS-V	HK-V	KBW	I-M.	O-P	M-P	G-V	**epoch**
1					-			
2					-			**1**
3					-			
4								
5-1							?	**2**
5-2							?	
6							?	
7								
8								**3**
9								
10								

Remarks

- in-site produce is majority
- in-site produce is minority
- only tools

? shows materials which have issue of identifing or phase.

HS-V ; Hisatsu Volcanic Region
HK-V ; Hokusatsu Volcanic Region
KBW ; Kagoshima Bay West Coast Hills
I-M. ; Ibusuki Mountains
O-P ; Osumi Peninsula
M-P ; Miyazaki Plain
G-V ; Gokase River Valley

Bold-italic types are regions located obsidian sorces.

Southern Kyushu Obsidian Sources (Hisatsu Region)

Region / Phase	**Nitto OB**							**Kuwanokizuru OB (including Hishikari)**							
	HS-V	HK-V	KBW	I-M.	O-P	M-P	G-V	***HS-V***	HK-V	KBW	I-M.	O-P	M-P	G-V	**epoch**
1					-							-			
2					-							-			**1**
3					-							-			
4						?		?					?		
5-1							?							?	**2**
5-2							?		?					?	
6							?								
7															
8															**3**
9															
10															

Southern Kyushu Obsidian Sources (Satsuma Peninsula Region)

Region / Phase	**Kamiushibana OB**							**Mifune OB**							
	HS-V	***HK-V***	KBW	I-M.	O-P	M-P	G-V	HS-V	HK-V	***KBW***	I-M.	O-P	M-P	G-V	**epoch**
1					-							-			
2					-							-			**1**
3					-							-			
4															
5-1							?								**2**
5-2							?								
6							?								
7															
8															**3**
9												?			
10															

Kyushu obsidian uses in southern Kyushu increases significantly. This phenomenon is essentially different from NW Kyushu(Tachibana 2008; Miyata2011); however, I do not think that is valid for the following reason: the preparation for the elimination of the overhang on the microblade as well as the characteristic microwear on the microblades found in southern Kyushu are not found in northern Kyushu. These are what should be called the unique traits of the southern Kyushu population; the changes in form and amount used should be understood in the context of the lithics exchange network (Shiba 2011).

The nature of central Kyushu's obsidian use trends is still not clear. However, it is no doubt that at the least Zogahana tuff was used in the north of the Miyazaki Plain during phase 3. This suggests that there was a movement of population from around the Aso region to the Miyazaki Plain. Due to the fact that there are cases in which it is difficult to identify Nitto and Oguni obsidian when the pieces of obsidian are small, for the materials in quest ion, it will be necessary to conduct both physical and chemical analyses.

There are extremely complex aspects to the obsidian use in southern Kyushu. However, it is important to note that the use of each obsidian source started in phase 2. This indicates that the development and use already began in the Early Upper Palaeolithic for almost all obsidian sources currently known. Next, I would like to consider the individual aspects diachronically. The Nitto obsidian has been used almost continuously in the region with the exception of the Gokase River valley; however, there is little use of obsidian in these industries. Before phase 6, with the exception of the Kagoshima Bay west coast hills, more than a few flakes made of Nitto obsidian related to lithic production are found in the region, but after phase 7 the frequency of the use is reduced in places not around the source. Kuwanokizuru obsidian is also utilized evenly temporally and spatially. However, there is a change in the quantities used from one time period to the next. It should be noted that its exploitation patterns are opposite to those of Nitto obsidian. In other words, after phase 7 the frequency Nitto obsidian is used is reduced significantly, while by contrast that of Kuwanokizuru obsidian increases. In particular, on the Osumi Peninsula and Hisatsu region, the latter type of obsidian constitutes the main raw material in the assemblages. This may have been a factor in the adoption of pressure flaking technology and the decrease in tool size. In addition, it is possible to indicate that since these two sources are relatively close, they were used interchangeably without changing significantly the mobility routes of the population. The exploitation patterns of Mifune and Kamiushibana obsidian show similarities. There is a slight change through time, but the consumption rate is consistently high in Kagoshima Bay West Coast hills and Hokusatsu region where both sources are located, and it decreases at sites distant from there. The distribution area of stone tools made of Kamiushibana obsidian is slightly larger than those of the Mifune; in the Miyazaki Prefecture, Mifune obsidian use is hardly found.As mentioned above, the temporal and spatial differences related to the use of each type of obsidian are evident when viewed for each obsidian source separately. One of the reasons for these differences is the technique used to define tool form. It cannot however, be explained solely by it. For example, even though Mifune obsidian is not suitable for microblade production, it was used many times for this purpose; similarly, Nitto obsidian was not. As mentioned earlier, I think that it is related not only to the lithic technology but the mobility routes of population and territorial boundaries.

6 – Diachronic overview of obsidian resource use in southern Kyusyu

Period 1 (phase 2) (fig. 13: left): Once obsidian use started, it spread fast. All the obsidian in all southern Kyushu that is currently known started being used during this period. Initially, however, in all areas it was used in small quantities.

Period 2 (phase 5) (fig. 13: center): After the AT ash fall, NW Kyushu obsidian was used for some of Tanukidani and Imatoge type knife-shaped points. Furthermore, during the next period of bilaterally backed tool subsequent to this, namely phase

Figure 12 (Left page) – Use Trend of Obsidian in Upper Paleolithic Southern Kyushu

6, large amounts of lithics appear to have been produced near the obsidian source. Accordingly, obsidian use increased compared to the previous phase. Thus, it is possible that period 2 can be divided into two, but if we also take into account the chronological problem, it seems best to understand this period as it stands now.

Period 3 (phase 8) (fig. 13: right): Obsidian use predominates in almost all areas of southern Kyushu in this phase. It is the time of maximum use in the Upper Palaeolithic. In particular, a large amount of NW Kyushu obsidian was carried in the subsequent phase 9. This was most likely due to the good quality of the raw material exchange network extending over the entire island of Kyushu.

The important thing to remember is, that the trends observed for each period were frequently changing, and that in no way were they continuous or uniform. For example, obsidian use increased considerably in phase 3, but was reduced in phase 4 most likely due to the influence of the AT ash fall. After this there was an increase in use again as sites close to the sources formed in phase 6; the inclination, however, to also use other materials was documented in phase 7 where the frequency of obsidian usage was reduced. Finally, in phase 8 there was a reversal of the pattern and obsidian use was again maximized. Such changes indicate that the use of obsidian has been influenced by a variety of factors and that these factors need to be unravelled through future research.

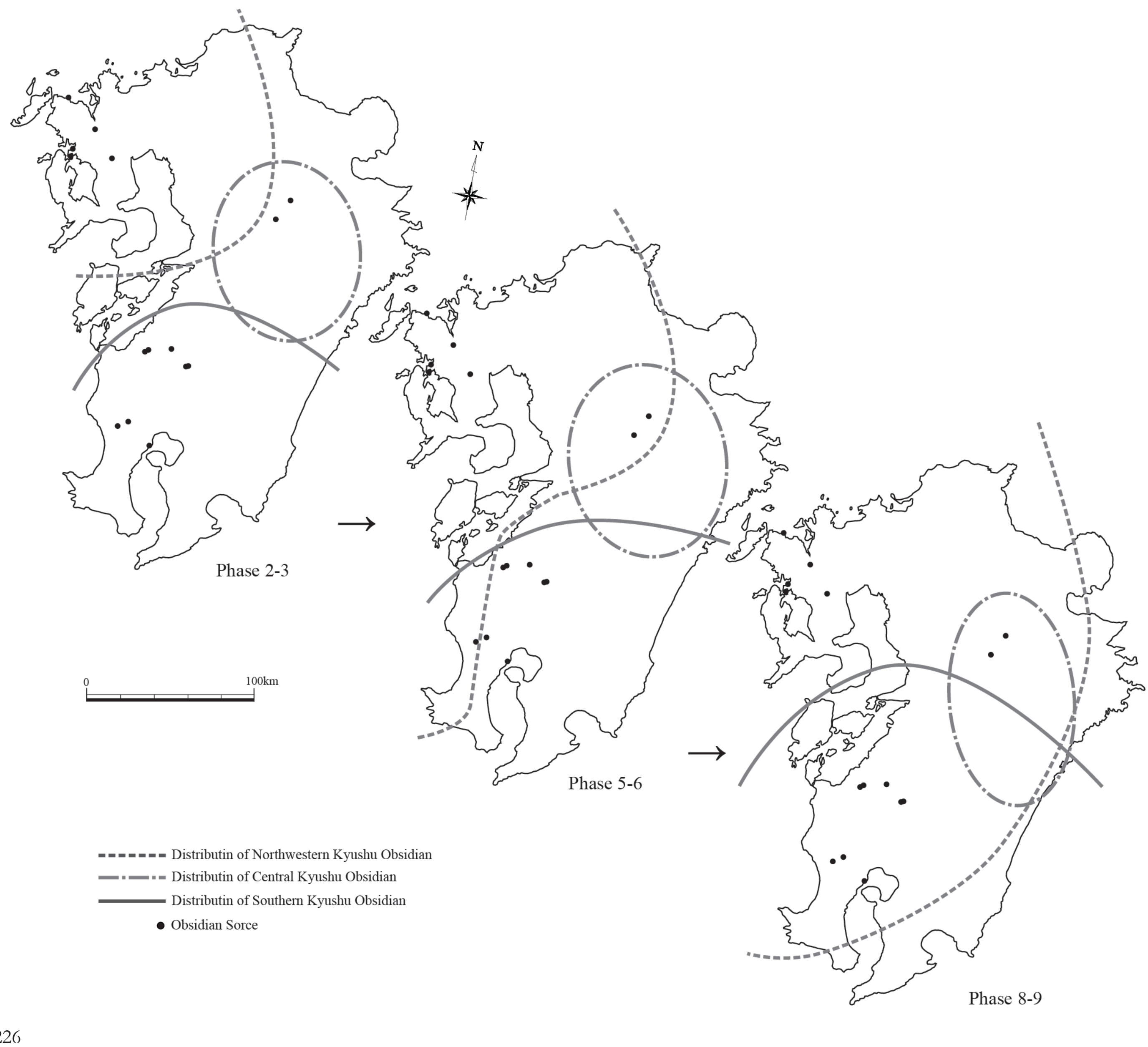


Figure 13 – Circulation of Obsidian use in Paleolithic Kyushu Disitribution of Northwestern and Central Kyushu obsidian are based on Shiba (2010, 2011)

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