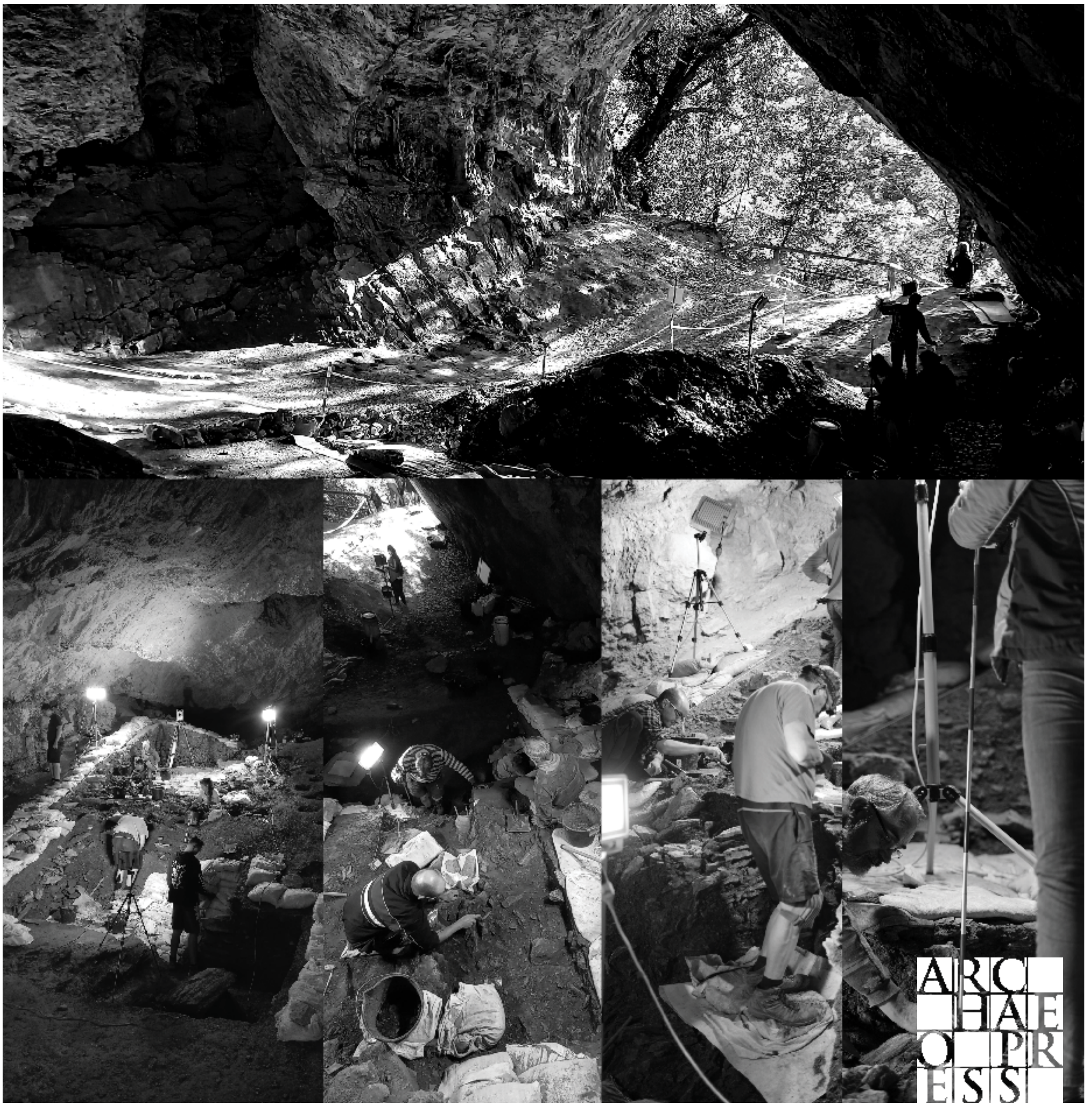
Studies on the Palaeolithic of Western Eurasia

edited by

György Lengyel, Jarosław Wilczyński,
Marta Sánchez de la Torre, Xavier Mangado,
Josep Maria Fullola



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Proceedings of the XVIII UISPP World Congress
(4-9 June 2018, Paris, France)

Volume 14

Session XVII-4

Session XVII-6

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Session XVII-4. The Upper Palaeolithic research in Central and Eastern Europe
Session XVII-6. Lithic raw materials procurement during the upper Palaeolithic from Eurasia. Traditional approaches and contributions from the Archaeometry

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Foreword to the XVIII UISPP Congress Proceedings

UISPP has a long history, originating in 1865 in the International Congress of Prehistoric Anthropology and Archaeology (CIAAP). This organisation ran until 1931 when UISPP was founded in Bern. In 1955, UISPP became a member of the International Council of Philosophy and Human Sciences, a non-governmental organisation within UNESCO.

UISPP has a structure of more than thirty scientific commissions which form a very representative network of worldwide specialists in prehistory and protohistory. The commissions cover all archaeological specialisms: historiography; archaeological methods and theory; material culture by period (Palaeolithic, Neolithic, Bronze Age, Iron Age) and by continents (Europe, Asia, Africa, Pacific, America); palaeoenvironment and palaeoclimatology; archaeology in specific environments (mountain, desert, steppe, tropical); archaeometry; art and culture; technology and economy; biological anthropology; funerary archaeology; archaeology and society.

The UISPP XVIII World Congress of 2018 was hosted in Paris by the University Paris 1 Panthéon-Sorbonne with the strong support of all French institutions related to archaeology. It featured 122 sessions, and over 1800 papers were delivered by scientists from almost 60 countries and from all continents.

The proceedings published in this series, but also in issues of specialised scientific journals, will remain as the most important legacy of the congress.

L'UISPP a une longue histoire, à partir de 1865, avec le Congrès International d'Anthropologie et d'Archéologie Préhistorique (C.I.A.A.P.), jusqu'en 1931, date de la Fondation à Berne de l'UISPP. En 1955, l'UISPP est devenu membre du Conseil International de philosophie et de Sciences humaines, associée à l'UNESCO. L'UISPP repose sur plus de trente commissions scientifiques qui représentent un réseau représentatif des spécialistes mondiaux de la préhistoire et de la protohistoire, couvrant toutes les spécialités de l'archéologie : historiographie, théorie et méthodes de l'archéologie ; Culture matérielle par période (Paléolithique, néolithique, âge du bronze, âge du fer) et par continents (Europe, Asie, Afrique, Pacifique, Amérique), paléoenvironnement et paléoclimatologie ; Archéologie dans des environnements spécifiques (montagne, désert, steppes, zone tropicale), archéométrie ; Art et culture ; Technologie et économie ; anthropologie biologique ; archéologie funéraire ; archéologie et sociétés.

Le XVIII° Congrès mondial de l'UISPP en 2018, accueilli à Paris en France par l'université Paris 1 Panthéon-Sorbonne et avec le soutien de toutes les institutions françaises liées à l'archéologie, comportait 122 sessions, plus de 1800 communications de scientifiques venus de près de 60 pays et de tous les continents.

Les actes du congrès, édités par l'UISPP comme dans des numéros spéciaux de revues scientifiques spécialisées, constitueront un des résultats les plus importants du Congrès.

Marta Azarello
Secretary-General /
Secrétaire général UISPP

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Part I

Session XVII-4

The Upper Palaeolithic research in Central and Eastern Europe

The Upper Palaeolithic research in Central and Eastern Europe

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This volume —The Upper Palaeolithic research in Central and Eastern Europe— presents the papers of a conference session held at the XVIIIth world congress of the International Union of Prehistoric and Protohistoric Sciences (UISPP) in June 2018, Paris. The geographic areas discussed in the session, Central and Eastern Europe, are prehistorically strongly articulated, their cultural successions are highly similar, and share several common archaeological issues to be investigated. We disseminate a wealth of archaeological data from Bavaria to the Russian Plain, which discusses Aurignacian, Gravettian, Epigravettian, and Magdalenian in the perspectives of lithic tool kits and animal remains.

The growing number of research results, especially those from Eastern Europe, presented at international conferences highlights the necessity to discuss the Central European Upper Palaeolithic in the context of the Eastern one and vice versa, otherwise a significant part of the archaeological record of the Late Pleistocene population remains uninvolved and any conclusion drawn upon a fragment of evidences may mislead our understanding of Palaeolithic hunter-gatherer societies. Incorporating the current knowledge of the Upper Palaeolithic archaeological record from each of these parts of Europe may help studying complete hunter-gatherer foraging areas to learn about subsistence strategy, and the organization of society and technology. This knowledge could be a fundamental source to recognize the roots of our behavioural basics, most of which emerged—according to evolutionary psychology—in the Upper Palaeolithic. Although ethnoarchaeology revealed a wide range of knowledge on the behavioural issues of hunter-gatherers, indeed it is difficult to model the human behaviour in glacial conditions applying uniformitarianism, because the Last Glacial Europe was typified by a biome that is absent today. Therefore, the dissemination of the archaeological data and its interpretation from different angles is most welcomed since it allows to incorporate the fragments of knowledge into hypotheses that aim at widening our understanding of human societies subsisting on hunting and gathering, the dominant way of human life practiced over 2.5 million years in Pleistocene conditions, the origins of the human nature. In this regard, we present ten papers that fulfil our approach to sharing archaeological data.

Amira Adaileh, The riddle in the middle – insights into the Bavarian Magdalenian, brings data on the recolonization of Central Europe after the Last Glacial Maximum, studying Magdalenian hunters through a yet hardly known Bavarian examples integrated into the Central European Magdalenian research.

Andrzej Wiśniewski, Bernadeta Kufel-Diakowska, Cyprian Kozyra, Marcin Chłoń, Zofia Różok, and Antonín Přichystal, Epigravettian in the area north of Sudetes: a case study from the site Sowin 7, SW Poland, discuss the activity of post-glacial Epigravettian hunter-gathers north of Sudetes and demonstrate that the main activities at the site are related to the retooling of hunting equipment and food acquisition.

Petr Šída, Upper Gravettian site cluster in Lubná (Czech Republic), presents the most important Gravettian site cluster in Bohemia, Czech Republic, dating to between 24 to 21 ky uncal BP with the oldest art object ever found in the Bohemia.

Alain Tuffreau, Roxana Dobrescu, and Sanda Balescu, Les occupations de plein air du Paléolithique supérieur à la périphérie des Carpates roumaines, review the open-air Upper Palaeolithic record of the Romanian Carpathians on the crossroad of the Danube corridor and provide new chronological data (14C, IRSL, and ESR/U-Th), biostratigraphic and pedostratigraphic evidence, and the re-evaluation of lithic assemblages.

Wei Chu, Adrian Doboș, and Scott D. McLin, So many caves, so little time: a preliminary report from a western Romanian karst survey, the Neanderthal/modern human transition in Europe focusing on Western Romania where the oldest modern human remains of Europe were found. They provide a preliminary assessment of the potential of cave sites for future research.

Philip R. Nigst, Timothée Libois, Tansy Branscombe, Marjolein D. Bosch, Paul Haesaerts, Vasile Chirica, and Pierre Noiret, New fieldwork at Mitoc-Malu Galben (Romania): An overview of the 2013 to 2016 excavations, bring new results of an emblematic Early to Middle Upper Palaeolithic sequence at Mitoc-Malu Galben on river Prut, which yielded a succession from the Aurignacian to the Gravettian over 14 metres of Pleistocene sediment.

Elena-Cristina Nițu, Marin Cârciumaru, Nejma Goutas, Ovidiu Cîrstina, Adrian Nicolae, Florin Ionuț Lupu, and Marian Leu, The cultural dynamics of Upper Palaeolithic to the East of the Carpathians reflected by the characteristics of the Bistrița Valley settlements (Romania) with special focus on the occupations from Poiana Cireșului site, show a sequence of Upper Palaeolithic settlements at Poiana Cireşului–Piatra Neamţ in the Eastern Carpathians, which is composed of multiple occupations of Gravettian-Epigravettian between 20 and 27 ky uncal BP presenting the cultural variability of the European 'Gravettian'.

Laëtitia Demay, Teodor Obadă, Sergei Covalenco, Pierre Noiret, Stéphane Péan, and Marylène Patou-Mathis, Zooarchaeological analyzes of the faunal remains of the upper layer of Climăuţi II (Republic of Moldova), analyse a dense faunal record of the upper layer of Climăuţi II site located on the course of the Middle Dniester dated to the upper Pleniglacial between 20.5 and 20.0 ky uncal BP. They show the remains were accumulated by repeated occupations during a short period of time and quickly covered by sediment as shown by the mammoth remains used to build structures hardly distorted.

Sergey Lisitsyn, The revision of the Gravettian sequence in the Kostenki-Borshchevo locality in the river Don basin (Russia), presents the Kostenki-Borshchevo area site complex and interprets the Gravettian technocomplex succession in the Don basin similarly to the Gravettian periodization in Central Europe.

Liubov V. Golovanova, Vladimir B. Doronichev, Ekaterina V. Doronicheva, and Andrey G. Nedomolkin, Industries of the end of Upper Palaeolithic in the south of Russian plain (northeastern Azov Sea region) and the Northern Caucasus, report sites in Kamennaya Balka, north-eastern Azov Sea region, compared to lithic industries of the north-western Caucasus, which are assigned to the Epipalaeolithic.

The riddle in the middle – insights into the Bavarian Magdalenian

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Abstract

The expansion of the Magdalenian techno complex marks the starting point for the recolonization of Central Europe after the Last Glacial Maximum (LGM). Whereas many regions are well examined in terms of Magdalenian research, south eastern Germany respectively Bavaria is still somehow a blind spot within the Magdalenian map of Europe. Although raw materials in different sites to the East and West indicate a temporal stay in or at least contacts to Bavaria (cf. Maier 2015, Poltowicz 2006), this part of southern Germany is mostly not taken into account if it comes to the big questions within the Magdalenian research. With most of the Bavarian Magdalenian sites located alongside one of the most important Palaeolithic communication axes in Europe – the Danube – this is even more unfortunate, since the Bavarian sites could bear the unique possibility to link the western European Magdalenian sites of the Swabian Jura, Switzerland, France and Spain to the Eastern Central European sites in Bohemia, Moravia and Poland. With regard to the still ongoing debate about a uni- or bidirectional model for the recolonization of Central Europe through the Magdalenian (cf. Maier 2015, Taller 2014), the inclusion of the Bavarian sites into the European Magdalenian research seems even more important.

Keywords: Magdalenian; Upper Palaeolithic; Germany; Typology

Résumé

L'expansion du complexe techno magdalénien marque le point de départ de la recolonisation de l'Europe centrale après le dernier maximum glaciaire (LGM). Alors que de nombreuses régions sont bien étudiées en termes de recherche magdalénienne, le sud-est de l'Allemagne, respectivement, la Bavière est toujours en quelque sorte un angle mort dans la carte magdalénienne de l'Europe. Bien que les matières premières dans différents sites à l'Est et à l'Ouest indiquent des séjours temporaires en Bavière ou au moins des contacts avec la Bavière (cf. Maier 2015, Poltowicz 2006), cette partie du sud de l'Allemagne n'est généralement pas prise en compte dans les grandes questions dans la recherche magdalénienne. Avec la plupart des sites magdaléniens bavarois situés le long de l'un des axes de communication paléolithiques les plus importants en Europe – le Danube – c'est encore plus malheureux, puisque les sites bavarois pouvaient apporter la possibilité unique de relier les sites magdaléniens d'Europe occidentale du Jura souabe, de Suisse, de France et d'Espagne aux sites d'Europe centrale orientale en Bohême, Moravie et Pologne. En ce qui concerne le débat toujours en cours sur un modèle uni ou bidirectionnel pour la recolonisation de l'Europe centrale à travers le Magdalénien (cf. Maier 2015, Taller 2014), l'inclusion des sites bavarois dans la recherche européenne magdalénienne semble encore plus importante.

Mots-clés : Magdalénien ; Paléolithique supérieur ; Allemagne ; typologie

The Bavarian Magdalenian comprises of a total of 18 sites (Table 1) and although this is a considerably high amount of sites, Bavaria is still not considered one of the classical Magdalenian regions. The reason here for might lie in research history on one hand, but on the other hand also in the appearance of the Magdalenian in Bavaria itself. Most of the inventories were excavated in the beginning of the 20th centuries. Therefore many of them are rather of a fragmentary character and published only in form of brief notes. To obtain a better understanding and propose a general idea of the Bavarian Magdalenian it is necessary to briefly describe the sites. The chronological attribution to a Middle or Late Magdalenian is either based on C14 dates or on basis of typology (Table 2).

Barbing, Regensburg

The open air site of Barbing actually marks three different sites or rather concentrations (Barbing A or 1, Barbing 2 and Barbing 3). Barbing A was discovered by Werner in 1971 and excavated by L. Reisch with University of Erlangen-Nürnberg and Werner (cf. Reisch 1974, Geyer 2013). Barbing 2 and 3 are located east of Barbing 1 and were discovered somewhat later (Schönweiß 2000). Those three concentrations may constitute parts of one large site (Geyer 2013, 12). At all of them backed pieces, namely backed bladelets represent the most numerous tool group subsequently followed by burins and end scrapers (Geyer 2013, 30; Schönweiß 2000, 21ff.). The only exception is for pointed blades and borers. These tools seem to be absent in Barbing A or 1 whereas their number increases in Barbing 3 and they occur abundantly in Barbing 2 (Geyer 2013, 30; Schönweiß 2000, 31). If all three Barbing concentrations – namely A or 1, 2 and 3 – represent single sections of one larger site, this could be explained by different functional areas. The typological classification of the material seems complicated since the artefacts yielded nearly no diagnostic tool types and organic material was not preserved. As Schönweiß states the high amount of backed bladelets, together with a relatively abundant occurrence of dihedral burins and end scrapers on blades indicate – at least for southern Germany – a late Magdalenian (Schönweiß 2000, 41). Geyer instead reasons an attribution to the Late Magdalenian on basis of the flying sands which comprised the Barbing artefacts and dates the Barbing A or 1 material subsequently somewhere between the Oldest and the Old Dryas (Geyer 2013, 60).

Eitensheim-Windhöhe, Eichstätt

The open air site was discovered in 1970's by G. Elvers. The surface collection comprises artefacts of different periods including an Upper Palaeolithic complex. Burins prevail clearly next to end scrapers, Zinken and backed bladelets. The occurrence of a scalene triangle led to the conclusion that this site could be dated to the Late Magdalenian (Rieder 1989, 124). Besides the fact, that assemblages with scalene triangles rather indicate an earlier Magdalenian (Maier 2015, 120), it is doubtable that this piece is of Magdalenian age. Maier argues that it cannot be excluded that this triangle is of Mesolithic origin (Maier 2015, 120). Although no Mesolithic artefacts were reported from this site (Rieder 1988, 30; Rieder 1989, 124) an admixture cannot be ruled out. Nevertheless a part of the surface collection might be attributed to the Late Magdalenian, due to the presence of Lacan burins (Maier 2015, 120).

Fürst-Albert-Höhle, Regensburg

The Fürst-Albert cave was excavated in 1905 by A. Langfeld. The excavations yielded medieval, bronze age, Neolithic and Palaeolithic artefacts. Unfortunately the documentation for the excavation does not existent anymore. Among the Palaeolithic artefacts a fragmented barbed point was identified (Kaulich 1995, 20). The lithic artefacts – a burin and an end scraper – were separated from the Neolithic inventory on basis of their different patination and technology (Kaulich 1995, 20). Due to the presence of the barbed point fragment Kaulich concludes that the site must therefore be attributed to a Late Magdalenian (Kaulich 1995, 26).

Heidenstein, Kehlheim

The Heidenstein abri was discovered and excavated by F. Birkner in 1932 (Birkner 1933, 55). It is a relatively small collection of Upper as well as Middle Palaeolithic artefacts. Among the Upper Palaeolithic pieces Birkner reports backed bladelets, burins, end scrapers and borers (Birkner 1933, 55). Unfortunately a closer examination of the Heidenstein lithic and bone collection didn't take place until today. Therefore it has to be classified as generally Upper Palaeolithic material, even if it is quite probable that it is of Magdalenian age as well.

Hohlenstein b. Ederheim, Donau-Ries

The Hohlenstein names two caves located one after another. The front cave was excavated in 1911 by F. Birkner and E. Frickhinger. Under a layer with prehistoric pottery which is not defined in detail a horizon with lithic artefacts, cutmarked bones and perforated shells were found (Narr 1965, 1). Approximately 50 cm beneath and a few meters apart, borers and an awl were found together with diluvial faunal remains. Further excavations in 1912 yielded 'Reste eines Magdalenien' as well as engraved lime stones (Narr 1965, 1). These engravings show three female figurines of the Gönnersdorf style. The lithic artefacts comprise mainly borers, backed bladelets, burins and end scrapers (Narr 1965, 2). Furthermore two single bevelled points were found (Narr 1965, 3). On this basis it seems reasonable to assign the Hohlenstein cave to a Magdalenian, probably to a later phase due to the presence of Gönnersdorf style female engravings (cf. Gaudzinski-Windheuser/Jöris 2015).

Hohler Stein b. Schambach, Eichstätt

The cave site of Hohler Stein was excavated in the early 1920's by F. Birkner. Aside from a mixed Holocene layer and a scarce Middle Palaeolithic horizon, Birkner reported a small concentration of blade material close to the cave wall (Rieder 2016, 24). This very small assemblage was attributed to the Upper Palaeolithic. Rieder reports burins, end scrapers as well as backed points respectively Federmesser and therefore assigns the Late Glacial artefacts from the Hohler Stein rather to the Late Palaeolithic (Rieder 2016, 140). A C14 date on a cutmarked bone however proved an occupation of the cave around 12,410 ± 90 BP, OxA-5752 (Housley *et al.* 1997, 30). The rather small Late Glacial inventory from the Hohler Stein therefore may constitute an admixture of shorter Magdalenian and probably Federmesser occupations.

Kastlhänghöhle, Kehlheim

The Kasthänghöhle was excavated in the end of the 19th century by J. Frauenholz and H. Obermaier and yielded only a single palaeolithic layer that comprised lithic artefacts as well as organic material (Birkner 1936; Freund 1963). Unfortunately a comprehensive examination of the material wasn't carried out to the present day. According to Freund end scrapers of various forms and sizes are represented, as well as borers, backed bladelets and burins, amongst which she describes pieces with an extremely stretched concave truncation (Freund 1963, 101): the so called Lacan burins. The organic artefacts include several points as well as two fragments of a single barbed point (Freund 1963, 102). The lithic raw material is described so far only by Birkner as Jurassic Flint and Jasper (Birkner 1936, 42). Although the inventory from the Kastlhänghöhle is yet only published in form of short paragraphs, it is possible to assign the assemblage to a younger Magdalenian, due to the presence of the single barbed point fragments and the Lacan burin. This assumption is supported by two C14 dates (12,060 ± 90 BP, OxA-5755 and 11,590 ± 90 BP, OxA-5756; Housley *et al.* 1997, 30) that also set the site at the end of the Magdalenian.

Klausenhöhlen, Kehlheim

The Klausenhöhlen cave complex consists of four caves and an abri that were examined since the early 20th century. Since Magdalenian occupation is limited to the Obere and Mittlere Klause, only these two will be described. The Mittlere Klause was excavated 1911-1912 by H. Obermaier and yielded Magdalenian as well as middle Palaeolithic layers. Although the excavators claimed to be able to distinguish two different Magdalenian horizons in niche B of the Mittlere Klause, it is not possible to retrace these observations nowadays. The lithic assemblage consists mainly of burins and end scrapers. Among the bone industry barbed points were found (Kaulich *et al.* 1978, 65). Furthermore art objects in form of engravings on lime stones and a so called baton de commandement with an anthropomorphic face depiction were excavated (Kaulich *et al.* 1978, 65). A C14 date yielded an age of 13.160 ± 130 BP, OxA-5718 (Housley *et al.* 1997, 30) and therefore supports the typological attribution of the material to the Late Magdalenian.

A natural chimney connects the Mittlere Klause to the overlying Obere Klause. Latter was excavated 1905-1908 by Frauenholz and yielded Middle Palaeolithic, two distinct Magdalenian as well as two Neolithic layers. The two Magdalenian horizons were separated through a sterile layer. So far the lithic artefacts from both of the Obere Klause Magdalenian layers can be described as typical for an Upper Palaeolithic inventory (Kaulich *et al.* 1978, 72). Among the organic artefacts awls, needles, points and ivory pendants are mentioned (ibid.). Again, in terms of typology, the site is dated on the basis of the presence of a single barbed point. The lower Magdalenian layer also yielded two C14 dates of 12,350 ± 130 BP, OxA-5719 and 12,440 ± 140 BP, OxA-5720 (Housley *et al.* 1997, 30), which assure the Late Magdalenian dating of the site. A re-evaluation of the material in the course of a PhD thesis at the Friedrich-Alexander University of Erlangen-Nürnberg is in progress.

Kaufertsberg, Donau-Ries

The Hexenküche cave as well as a neighbouring abri (both at the Kaufertsberg) were excavated in 1913 by Birkner. Whereas the cave sediments showed no evidence for a Palaeolithic occupation, the abri instead yielded several cultural horizons. In this context especially layers K1 and K2 are of interest. The lower level K1 comprised a high amount of different types of burins, subsequently followed by backed bladelets, end scrapers and borers (Kaulich 1983, 61). Additionally the inventory yielded a few backed points (Kaulich 1983, 61). Furthermore a baguette demi ronde and a single bevelled point were identified among the organic artefacts of K1 (Kaulich 1983, 66). The presence of Lacan type burins and backed points speak in favour of an attribution of K1 to the Late Magdalenian. Within the upper horizon K2 a somewhat smaller assemblage was found. Here backed bladelets clearly prevail over burins, end scrapers and a comparably high number of backed points (Kaulich 1983, 79). Among the organic industry only a single bevelled point shall be emphasized (Kaulich 1983, 82). For K2 the presence of Lacan burins, a short scraper as well as some backed points suggest a rather Late Magdalenian or even maybe an admixture with younger – possibly Late Palaeolithic – material. This was also discussed by B. Kaulich who considers a short Mesolithic occupation on basis of a geometric artefact, small sized cores and the head burial (Kaulich 1983, 93). A C14 date from the Kaufertsberg level K1 however yielded an age of 12,610 ± 90 BP, OxA-5751 (Housley *et al.* 1997, 30) which ascertains the Magdalenian age of the assemblage.

Metten I and II, Deggendorf

The open air site of Metten consists of two concentrations which are located approximately 250 m apart from each other. Both sites yielded Middle and Upper Palaeolithic material (Weißmüller 1995a). The majority of tools among the Upper Palaeolithic artefacts in Metten I and II consists of end scrapers, burins, truncations and backed pieces (Weißmüller 1995a, 104ff.; Weißmüller 2002, 184). Although the material did not yield discriminating tool types the general composition of the Upper Palaeolithic tools Weißmüller assigns it to a Late Upper Palaeolithic (Weißmüller 1995a, 107). Therefore the classification of the material as Magdalenian can be accepted conditionally, following also Maier's classification of the site as of 'probably Magdalenian' age (Maier 2015, 305).

Oberneder-Höhle, Kehlheim

The Oberneder cave site was initially excavated by A. Oberneder between 1918 and 1923. Further excavations were conducted by L. Zotz and G. Freund in the early 1960's. Both assemblages consist of a total of 382 lithic and eight organic artefacts (Freund 1987, 28), but only 73 lithic and 7 organic artefacts are attributed to the Upper Palaeolithic (Freund 1987, 191). All of the Upper Palaeolithic artefacts derive from one stratigraphic layer, but were distributed in a depth of between 30 up to 70 cm (Freund 1987, 193). On the basis of a bone point Freund attributes the artefacts from the lower part of the Upper Palaeolithic horizon to the Aurignacian (Freund 1987, 193ff.), although she states that the majority of the artefacts only allow an attribution to the Upper Palaeolithic in general (Freund 1987, 195). Anyway a series of Abensberg chert cores and other artefacts are suggested to be of Late Upper Palaeolithic age, due to their similarities in core preparation with the Abensberg chert cores from the Sesselfelsgrotte (Freund 1987, 198). In terms of typology the assemblage comprises end scrapers, burins, borers and backed bladelets. Additionally Freund assigns a bone needle as well as an engraved lime stone fragment to the Late Upper Palaeolithic occupation, although their stratigraphic position was unclear or even – as it is the case with the needle – were found on the very bottom of the Upper Palaeolithic layer (Freund 1987, 198). Eventually the artefact spectre and the emphasized similarities to the Magdalenian from the Sesselfelsgrotte speak in favour of an attribution of the Oberneder-Höhle Late Upper Palaeolithic material to the Magdalenian.

Pollenried, Regensburg

The open-air site was discovered in 1983 by L. Raab, who then started to regularly collect lithic artefacts from the site. In the years 1999/2000 sondages and drillings were undertaken by the University of Erlangen-Nürnberg (Hilgart/Pasda 2002, 13). Surface collection and excavations yielded only a comparably small inventory of lithic artefacts, organic material was not preserved (Hilgert/Pasda 2002, 17). Unfortunately a dihedral burin is the only modified piece within the assemblage, albeit the very high proportion of blades with en éperon platform remnants (Hilgert/Pasda 2002, 23f.) could speak in favour of an attribution of the material to a Late Upper Palaeolithic respectively a Magdalenian (cf. Floss 2012, 382; Maier 2015, 28).

Sesselfelsgrotte, Kehlheim

Excavated in the 1960's and 1980's the site is famous for its very rich Middle Palaeolithic record. Besides, there are also two horizons that can be attributed to the Magdalenian. The lower layer is assigned to the older phase of the central European Magdalenian, whereas the upper Magdalenian layer is described as a Late Magdalenian (Dirian 2003, 199). The lower layer C2 yielded numerous backed bladelets, end scrapers and burins. Besides Dirian lists artefacts he describes as scalene triangles, which could support the dating to an older Magdalenian phase (cf. Dirian 2003, 89). Eventually they could rather represent truncated backed bladelets than scalene triangles (Adaileh 2017, 28). The Upper Magdalenien Level C1 comprises typical Upper Palaeolithc tools like burins, borers, end scrapers and backed bladelets mixed with rather Later Paleaolithc types like short scrapers and backed points. Since Dirians mentions that shape and size of the backed points and burins, as well as the typological diversity and the high amount of backed bladelets speak rather in favour of a Magdalenian (Dirian 2003, 133) and single Late Palaeolithic tool types do regularly occur already in Magdalenian assemblages, it is seen as probable that horizon C1 marks a Late Magdalenian occupation. Two C14 dates gained on bones from Level C2 yielded dates of 12,740 ± 90, OxA-5753 respectively 12,680 ± 100 BP, OxA-5754 (Housley *et al.* 1997, 30) and therefore support an attribution to a later phase for both Magdalenian layers at the Sesselfelsgrotte.

Siegfriedfelsen, Kehlheim

The Siegfriedfelsen, also known as Schellnecker Wänd Abri II, was excavated in 1974 in course of the construction works for the Rhine-Main-Danube canal (Naber 1977, 185). The abri yielded several prehistoric levels including Neolithic, Mesolithic and Palaeolithic material. The Palaeolithic artefacts were restricted to the D-Layers of the site. The uppermost level D1 yielded a small number of artefacts, among which a short end scraper and a fragmented truncated backed bladelet were found (Naber 1977, 191). In D2 only a few flakes as well as a truncated (or maybe pointed) blade were found. D3 and D4 yielded only flakes and blades (ibid.). Due to the lack of discriminating material, this site shall be considered as probably of Magdalenian age.

Speckberg, Eichstätt

The large open air site of the Speckberg was excavated in the 1960's. The artefact concentrations were found in a sedimentary trap, what resulted in a very difficult stratigraphic situation. Therefore the Upper Palaeolithic pieces were separated from the Middle Palaeolithic ones only on basis of typology and technology (Hahn 1989, 87). The artefacts were mostly made of Jurassic flint of local origin (Hahn 1982, 15). Hahn claims that the site was occupied repeatedly during the Magdalenian (Hahn 1989, 90). Although the typological attribution to the Upper Palaeolithic is clear, a classification within a specific Upper Palaeolithic techno-complex seems difficult. Hahn rather excludes an affiliation of the material to the Aurignacian or Gravettian on basis of the lack of specific tool types, than proving the attribution to the Magdalenian by means of typology (Hahn 1989, 90). The high amount of borers and pointed blades in particular within the Speckberg assemblage complicates a comparison with other Magdalenian sites in Bavaria, but meanwhile indicates similarities to Magdalenian sites in France (Hahn 1982, 216).

Tunnelhöhle, Regensburg

The Tunnelhöhle was partly blown up due to railway constructions in the 1860's. In the following years palaeoltihic artefacts from this site were repeatedly collected by J. Fraunholz and M. Moser (Steguweit/Händel 2010, 11). An excavation by the University of Erlangen took place in 2009 after the announcement of the complete blasting of the remaining cave site. Within the typological spectre burins, backed bladelets and end scrapers are dominant (Sauer 2011, 60). Furthermore three single bevelled bone points were discovered (Steguweit/Händel 2010, 13). The composition of the tool types indicates the presence of an Upper Palaeolithic, unfortunately without the possibility to of a more detailed assignment to a specific techno-complex. A C14 date from the Tunnelhöhle however, gained from an organic point, documents an age of 13,335 ± 53 BP, Erl-14,814 (Sauer 2011, 6) which is in perfect accordance to the Magdalenian.

Vilshofen-Kuffing, Passau

The open air site of Vilshofen-Kuffing was discovered in 1996 and ever since several amateurs collected Palaeolithic artefacts from the surface. It is one of only five sites outside France and Spain that yielded scalene triangles in a considerable amount. With an estimated total of about 800 Magdalenian triangles it bears the largest collection of this type in Europe. This tool type proves Vilshofen-Kuffing to be the oldest Bavarian Magdalenian site so far, since Maier dates the occurrence of scalene triangles to the time before 16,000 cal BP (Maier 2015, 59). The examination of the site in course of a PhD project at the Friedrich-Alexander University of Erlangen-Nürnberg is in progress. So far the typological spectre comprises burins, end scrapers, borers and scalene triangles. As far as it can be stated at the moment most of the raw material spectre is represented mainly by different varieties of Jurassic chert, radiolarite and Quarzite.

Weinberghöhlen, Neuburg-Schrobenhausen

This Weinberghöhlen mark a cave system consisting of four caves. The site was excavated in several campaigns in 1938/39, 1947/48, 1967 and 1973 and yielded Middle Palaeolithic as well as Upper Palaeolithic layers (cf. Koenigswald *et al.* 1974). The Upper Palaeolithic occupation comprises two horizons (zone 1 and 2) though zone 2 yielded only a few in terms of chronology not further determinable lithic and bone artefacts (Koenigswald *et al.* 1974, 44). However zone 1 yielded three separated Upper Palaeolithic concentrations (ibid.). All of them comprise of lithic and bone artefacts in different quantities and of general Upper Palaeolithic character. Unfortunately the relation between these three concentrations cannot be retraced (Koenigswald *et al.* 1974, 47). The inventory consists mainly of burins, end scrapers, borers, probably also pointed blades, backed bladelets as well as Gravette points (ibid.). Among the organic artefacts bone points, a possible spear thrower, a proto harpoon and several pieces described as bars and bar fragments of circular or oval shape in cross section (Koenigswald *et al.* 1974, 48) were found. Those bars were also mentioned by Pfeiffer within the Petersfels assemblage and therefore might indicate a Magdalenian (Pfeiffer 2016, 66). Furthermore the presence of a proto harpoon might assure an attribution to the Magdalenian, since Maier dates the occurrence of these pieces around 13,500 BP (Maier 2015, 59). Although it is questionable if this artefact can be addressed as a proto harpoon (cf. Zotz 1955, 85; Koenigswald *et al.* 1974, 48) the general composition of the artefact assemblage points towards a Magdalenian occupation. An admixture with Gravettian material within zone 1 of the Weinberghöhlen however seems highly probable, due to the presence of Gravette points within the assemblage.

The summary of the sites shows clearly how the current state of research varies from site to site. Nevertheless it is possible to propose some general ideas of the Bavarian Magdalenian. These are mainly based on those sites which either provided a C14 date or typologically diagnostic artefacts.

The earliest Magdalenian occupation in Bavaria is represented by the site of Vilshofen-Kuffing. The presence of scalene triangles proves this site to be older than 13,200 BP respectively 16,000 cal BP (Maier 2015, 59). The easternmost site in Bavaria might therefore constitute a first approach towards this region after the LGM, subsequently followed by the sites of Tunnelhöhle and Weinberghöhlen. The Tunnelhöhle yielded – in terms of absolute chronology – the oldest date for a Magdalenian in Bavaria so far (Table 1/Figure 1).

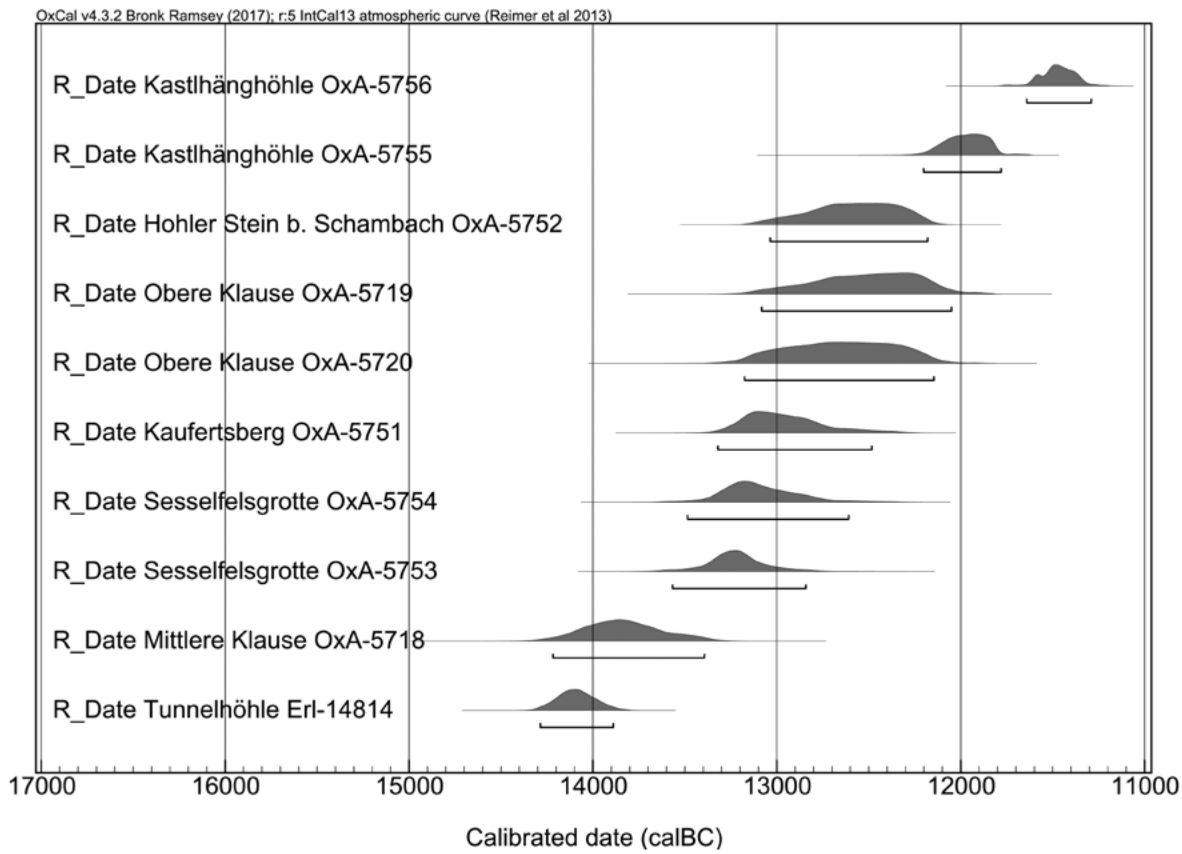

Figure 1. C14 dates for the Bavarian Magdalenian sites
(Housley *et al.* 1997, 30; Sauer 2011, 6).

Name	Longi-tude	Lati-tude	Site type	C14 years BP	Typological dating	Diagnostic feature	Literature
Vilshofen-Kuffing	13.1806	48.5989	open air		Middle Magdalenian	scalene triangles	Weißmüller 1995b, Adaileh 2017
Weinberghöhlen Mauern	11.0361	48.7583	cave		Middle Magdalenian?	proto harpoon?	Zotz 1955, Koenigswald *et al.* 1974
Tunnelhöhle b. Sinzing	11.9789	49.0317	cave	1,3335±53	Late Magdalenian	generally Upper Palaeolithic material	Sauer 2011, Steguweit & Händel 2010
Klausenhöhlen	11.7772	48.9369	cave	13,160±130 12,350±130 12,440±140	Late Magdalenian	single row barbed point	Kaulich *et al.* 1978
Sesselfelsgrotte	11.7894	48.9350	cave	12,740±90 12,680±100	Late Magdalenian	generally Upper Palaeolithic material	Dirian 2003
Kaufertsberg	10.6108	48.8092	abri	12,610±90	Late Magdalenian	Lacan burins	Kaulich 1983
Hohler Stein b. Schambach	11.3669	48.9058	cave	12,410±90	Late Magdalenian	generally Upper Palaeolithic material	Rieder 1992, Floss 2006
Kastlhänghöhle	11.7864	48.9292	cave	12,060±90 11,590±90	Late Magdalenian	single row barbed point	Birkner 1936, Freund 1963
Pollenried	11.9417	49.0315	open air		Late Magdalenian	en éperon platform remnants	Hilgart & Pasda 2002
Eitensheim Windhöhe	11.3203	48.8194	open air		Late Magdalenian	Lacan burins	Rieder 1988, Rieder 1989
Fürst-Albert-Höhle	11.9817	48.9892	cave		Late Magdalenian	single row barbed point	Kaulich 1995
Hohlenstein b. Ederheim	10.4653	48.8089	cave		Late Magdalenian	female depictions of Gönnersdorf type	Freund 1963, Narr 1965
Speckberg Meilenhofen	11.1869	48.8019	open air		Late Magdalenian	generally Upper Palaeolithic material	Hahn 1982, Hahn 1989
Barbing	12.1978	49.0033	open air		Late Magdalenian	generally Upper Palaeolithic material	Geyer 2013, Schönweiß 2000
Metten	12.9156	48.8550	open air		Magdalenien	generally Upper Palaeolithic material	Weißmüller 1995a
Heidenstein	11.7922	48.9256	abri		Magdalenien	generally Upper Palaeolithic material	Birkner 1933, Birkner 1936
Obernederhöhle	11.8375	48.9333	cave		Magdalenien	generally Upper Palaeolithic material	Freund 1987
Siegfriedfelsen	11.8136	48.9231	abri		Magdalenien	generally Upper Palaeolithic material	Naber 1977

Table 1. Magdalenian sites in Bavaria.

The date refers to the end of the Middle Magdalenian (13,335 ± 53 BP, Erl-14,814), but the Tunnelhöhle assemblage provided no typological evidences that would support this classification. Moreover this date falls into a plateau on the calibration curve (Maier 2016, 14) and may accordingly turn out slightly too old. Therefore an attribution of the site to the beginning of the Late Magdalenian shall be proposed. The possible proto harpoon from the Weinberghöhlen however might speak in favour of a chronological position within the Middle Magdalenian. The appearance of proto harpoons is dated to 13,500 BP (Maier 2015, 59). Taking these two sites into account, a second step within the Magdalenian occupation may be marked by a dispersal of the Magdalenian into the south western as well as south eastern periphery of the Franconian Alb shortly after 16,000 cal BP. Another comparably old date derives from the Mittlere Klause (13,160 ± 130 BP, OxA-5718), but the presence of a barbed point ascertains the typological classification of this site as Late Magdalenian. Therefore this date together with the date from the Tunnelhöhle site marks the starting point for the Late Magdalenian occupation of Bavaria. At the latest from 15,000 cal BP on the number of sites increases significantly and an area comprising the southern Nördlinger Ries, the southern Frankonian Alb and the southern Bavarian (Bohemian) Forest (Figure 2). Interestingly all Bavarian Magdalenian sites are located north of the Danube. The only exceptions to this are Barbing and Vilshofen-Kuffing. The youngest Magdalenian date in Bavaria however derives from the Kastlhänghöhle (11,590 ± 90 BP, OxA-5756) and the assemblage comprises typical Late Magdalenian features (Table 2). Single Late Palaeolithic tool types like short scrapers or backed and/or shouldered points as they are described for example at the Sesselfelsgrotte (Dirian 2003, 133) are missing at the Kastlhänghöhle (cf. Birkner 1936; Freund 1963). Given the quite young date of the site, that coincides with the transition from Magdalenian to Late Palaeolithic, this seems even more surprising.

Typological differences within the Bavarian Late Magdalenian sites are barely visible. This may be related to an increasing typological conformity of Central European Magdalenian assemblages between 16,000 and 14,000 cal BP (Maier 2015, 250). Then again the early dates of most excavations as well as differences in preservation between cave and open air sites should not be disregarded as well. The only exception to this is made by sites with very high amounts of borers and pointed blades, like Barbing, Speckberg and Hohlenstein b. Ederheim. As stated by Maier 'pointed blades [...] belong to the least common types of tools among the assemblages of the Central European Magdalenian' (Maier 2015, 119). Nevertheless they show a unique spatial pattern, since they are most abundant along the Danube (ibid.). Borers on the contrary are a very common feature within the Magdalenian, with exception of long borers (Maier 2015, 109ff.). This specific tool type is mostly absent along the Danube (ibid.). The comparably high amount of long borers in the site of Hohlenstein b. Ederheim (Narr 1965, 4f.) therefore seems surprising. Another site which yielded very high proportions of borers is Barbing (Schönweiß 2000, 31), but it has to remain unclear whether long borers are represented among the Barbing borers. Since so far only few sites with such a high percentage of pointed blades and long borers are known, the data base is simply insufficient to be able to assess this pattern in terms of spatial trends or chronology. Moreover the high number of backed points and borers might simply reflect different site functions. As far as statements concerning their number within the different Bavarian assemblages can be made, pointed blades and long borers are by no means restricted to the mentioned sites, but rather infrequent compared to Barbing, Hohlenstein b. Ederheim and Speckberg.

Statements concerning raw material procurement and subsequently land use patterns are equally difficult to make, since only few Bavarian Magdalenian sites yield reliable information about variety and percentages of raw materials. The few in terms of raw material analysed sites however give the impression of a mostly regional based raw material procurement pattern, which was also already observed by Maier for the Magdalenian sites along the Danube (Maier 2015, 94). According to him the range for raw material acquisition does usually not exceed 40 km (ibid.). Even though raw material sources of sufficient quality seemed to be present in the proximity of mostly all Bavarian Magdalenian sites, reverting to river gravels seems to represent a regular behaviour within raw material procurement as proved for example at Barbing (Geyer 2013, 21).

Magdalenian phase	**Absolute dating**	**chronologically significant characteristics in Bavaria**	**Literature**
Middle Magdalenian	18,000-16,.000 cal BP	proto harpoons, scalene triangles	Maier 2015; Langlais *et al.* 2015
Upper/Late Magdalenian	16,000-14,000 cal BP	single- and double-row barbed points, Lacan burins, en éperon platform remnants, female depictions of Gönnersdorf style	Maier 2015; Pasda 2012; Floss 2012; Gaudzinski-Windheuser/Jöris 2015; Langlais *et al.* 2015

Table 2. Magdalenian phases represented in Bavaria and the underlying features.

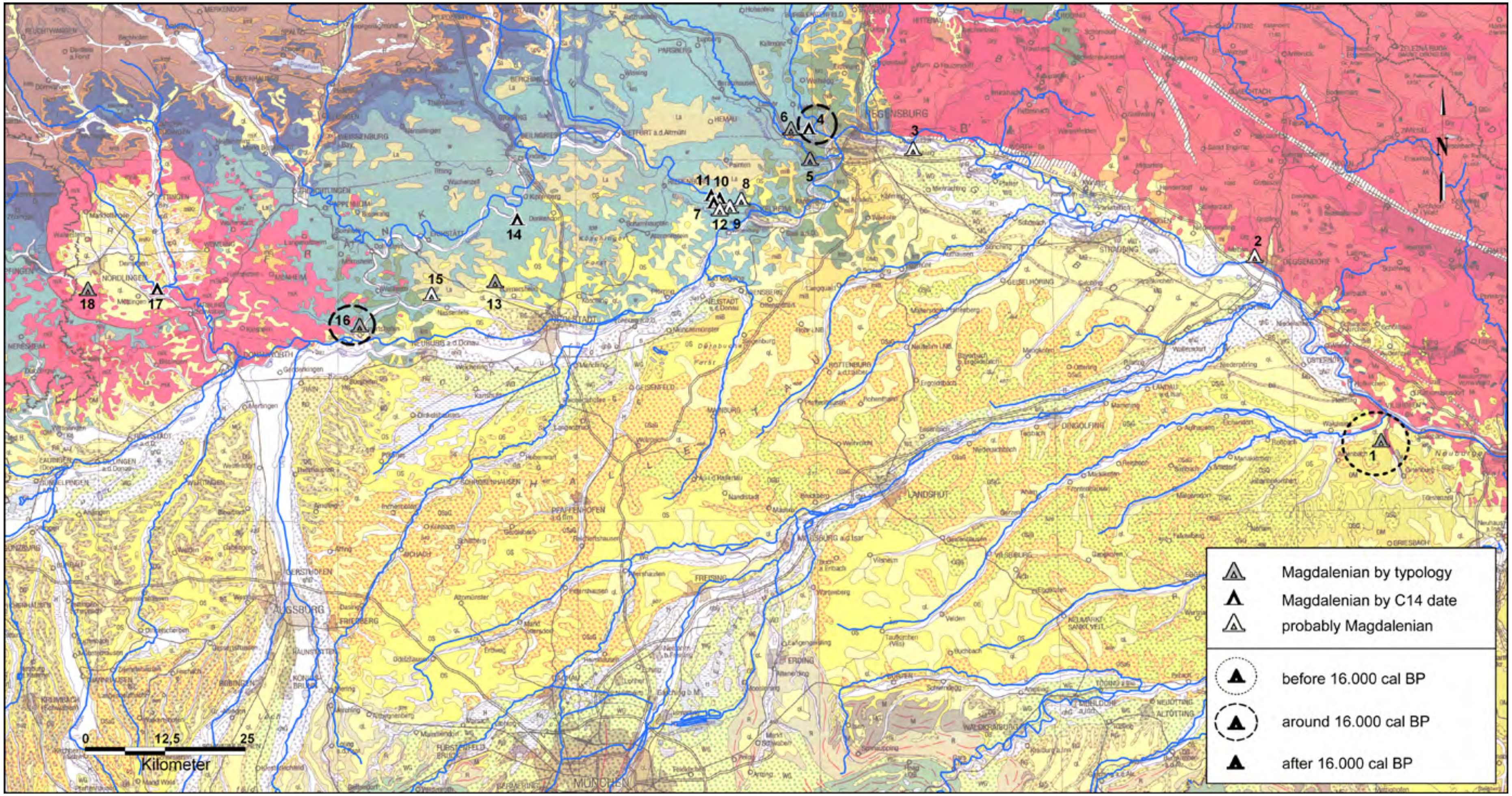

Figure 2. Magdalenian sites in Bavaria. Geologische Karte Bayern 1:25.000, Bayerisches Landesamt für Umwelt, www.lfu.bayern.de (1 Vilshofen-Kuffing, 2 Metten, 3 Barbing, 4 Tunnelhöhle, 5 Fürst-Albert-Höhle, 6 Pollenried, 7 Kastlhänghöhle, 8 Obernederhöhle, 9 Siegfriedfelsen, 10 Sesselfelsgrotte, 11 Klausenhöhlen, 12 Heidenstein, 13 Eitensheim-Windhöhe, 14 Hohler Stein b. Schambach, 15 Speckberg b. Meilenhofen, 16 Weinberghöhlen b. Mauern, 17 Kaufertsberg, 18 Hohlenstein b. Ederheim).

Summing up the collected data for the Bavarian Magdalenian the high potential for future research becomes apparent. As stated initially the Bavarian region could provide necessary information about the recolonization of Central Europe and possible connections between eastern and western Magdalenian site clusters. In opposition to the recolonization model proposed by Maier, which acts on the assumption of Bavaria being repopulated around 16,000 cal BP (Maier 2015, 238ff.), Vilshofen-Kuffing proves an older date for the first Magdalenian occupation in Bavaria. The typological differences to Bavarian Magdalenian sites dated to about 16,000 cal BP (Tunnelhöhle, Mittlere Klause) speak in favour of an older date for Vilshofen-Kuffing. The question whether this first approach towards the Bavarian region represents the result of an eastward or westward expansion might be answered after the complete analysis of Vilshofen-Kuffing. Further questions concerning internal characteristics, land use pattern and possible relations of the Bavarian Magdalenian sites to neighbouring areas are completely depending on a preceding initial respectively re-analysis of the Bavarian assemblages.

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Epigravettian in the area north of Sudetes: a case study from the site Sowin 7, SW Poland

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Abstract

The central issue addressed here is the activity of hunters and gathers related to post-glacial Epigravettian occupation in the areas located north of Sudetes. Using data from open-air site Sowin 7, SW Poland, we would like to demonstrate that the main activities conducted at the site can be related to the retooling of hunting equipment as well as with a whole set of tasks aiming at food acquisition. Comparing the remains from Sowin with other Epigravettian sites in Poland we can conclude that the Epigravettian troops were well-equipped and the visits were indeed extensive. Although it is difficult to explain whether the remains are related to the logistic or residential model of the settlement, current research indicates the presence of systematic exploitation of the environment.

Keywords: Epigravettian; Silesia; technology; tool use; imported rocks; activity

Résumé

La question centrale abordée ici est l'activité des chasseurs et des rassemblements liés à l'occupation épigravettienne post-glaciaire dans les zones situées au nord de Sudetes. En utilisant les données du site en plein air Sowin 7, SW Pologne, nous aimerions démontrer que les principales activités menées sur le site peuvent être liées à la réorganisation de l'équipement de chasse ainsi qu'à un ensemble de tâches visant à l'acquisition de nourriture. En comparant les restes de Sowin avec d'autres sites épigravettiens en Pologne, nous pouvons conclure que les troupes épigravettiennes étaient bien équipées et que les visites étaient effectivement étendues. Bien qu'il soit difficile d'expliquer si les restes sont liés au modèle logistique ou résidentiel de l'établissement, les recherches actuelles indiquent la présence d'une exploitation systématique de l'environnement.

Mots-clés : Epigravettien ; Silésie ; technologie ; usage des outils ; roches importées ; activité

1. Introduction

Regarded as a continuity of the middle phase of Gravettian culture, the Central European Epigravettian (CEE) (Kozłowski 1979, 1986, fig. 3.1; 2007) has been distinguished within loess belt of Central Europe. Unquestionably, core sites of CEE are known from the Middle Danube Valley, Tisa river basin as well as from the Vistula river valley near Kraków (Kozłowski 1986, 1996; Oliva 2007; Kaminská 2015; Wilczyński 2015; Nerudová 2016; Lengyel 2016; Djindjian 2016).

Against this backdrop, our studies suggest that the occupation of CEE hunters and gatherers, being in its form a dynamic one, has covered larger territories than loess uplands. There is evidence from an open-air site Sowin 7 situated in Opole Woivodeship, SW Poland that the foraging zones of CEE humans have also reached a sandy belt of the central European lowlands. In this context, a critical question concerns a type of activity executed within this unique site. Moreover, integration of observations from Sowin 7 with previous knowledge of Epigravettian in Poland has triggered a discussion of the meaning of CEE settlement sites located outside residential territories as well as of its character; whether the CEE sites correspond with opportunistic and isolated visits or maybe with more systematic land use?

During the seven seasons of excavations conducted at site Sowin 7 up to 2017, a significant number of data have been acquired allowing to distinguish lower, the cultural layer corresponding with post-LGM (Late Glacial Maximum). Based on meticulous analysis of the archaeological material, it seems that the main activities conducted at the site can be related to the retooling of hunting equipment as well as with a whole set of tasks aiming at food acquisition.

Petrographical features of stone tools made of imported rocks indicate that CEE group from Sowin 7 operated in the Western Carpathians. The inventory, that represents one of the largest collections in Poland, should be related to the local conditions characterized by the presence of high-quality erratic flints, stimulating probably the direction and range of human activity. We contextualize our results by comparing them with other Epigravettian sites in Poland in terms of settlement dynamics. This leads to the conclusion that records from Poland (Silesia and Lesser Poland) can be related to well-equipped and extensive visits of CEE groups.

The following part of this paper move on to describe the Gravettian briefly in the Oder river valley, then in greater detail an issue of raw material origin as well as the typo-technological structure of assemblage and methods of blank production. However, as the central issue addressed here concerns the human activity; therefore, there is a separate discussion regarding the functional meaning of tools. This part integrates technological and microscopic observations as well as a spatial distribution of finds from site Sowin 7.

2. Gravettian in the Oder river valley and its proximity

Within the catchment area of Oder river, all main phases of development of Gravettian have been recorded (Figure 1). The oldest traces are known from site Henryków 15, dated radiometrically to 28.5-31.5 kyr BP uncal (see Wiśniewski *et al.* 2015). At this site, several clusters of artefacts were distinguished, connected with blade blank production, repairing hunting equipment as well as with the use of lithic tools made of local erratic flints. Lithics were accompanied by remains of hearths and bones of fauna including reindeer.

The middle phase of Gravettian is well represented with the key site Ostrava-Petřkovice I which contained two settlement horizons dated respectively to 23,370 ± 160 BP and 20,790 ± 270 BP (Oliva, Neruda 1999; Svoboda 2008). Within site Ostrava-Petřkovice, numerous hearths, pits and places of ochre use were discerned while among artefacts radiolarite specimens were recorded. The lithic artefacts are represented by products and waste of uni- or bidirectional blade core reduction and numerous retouched tools. Presumably, to the same period belong traces from the site Wójcice B (Dagnan, Ginter 1970) where charcoals and small fragments of mammoth bones were recovered. The latter were dated using AMS to the middle stage of MIS 2 (personal communication of K. Zarzecka-Szubińska 2018). Unfortunately, finds has been deposited in slope sediments.

Possibly, of the same period are remains from the site Rozumice 3, where only lithic artefacts have been discovered (Foltyn 2000). The middle stage of Gravettian is also represented by dozens of artefacts and animal bones from the site Pietraszyn 11 (Kozłowski 1964). Age estimation has been confirmed by radiocarbon dating of a single bone (S. Talamo, personal communication, 2018).

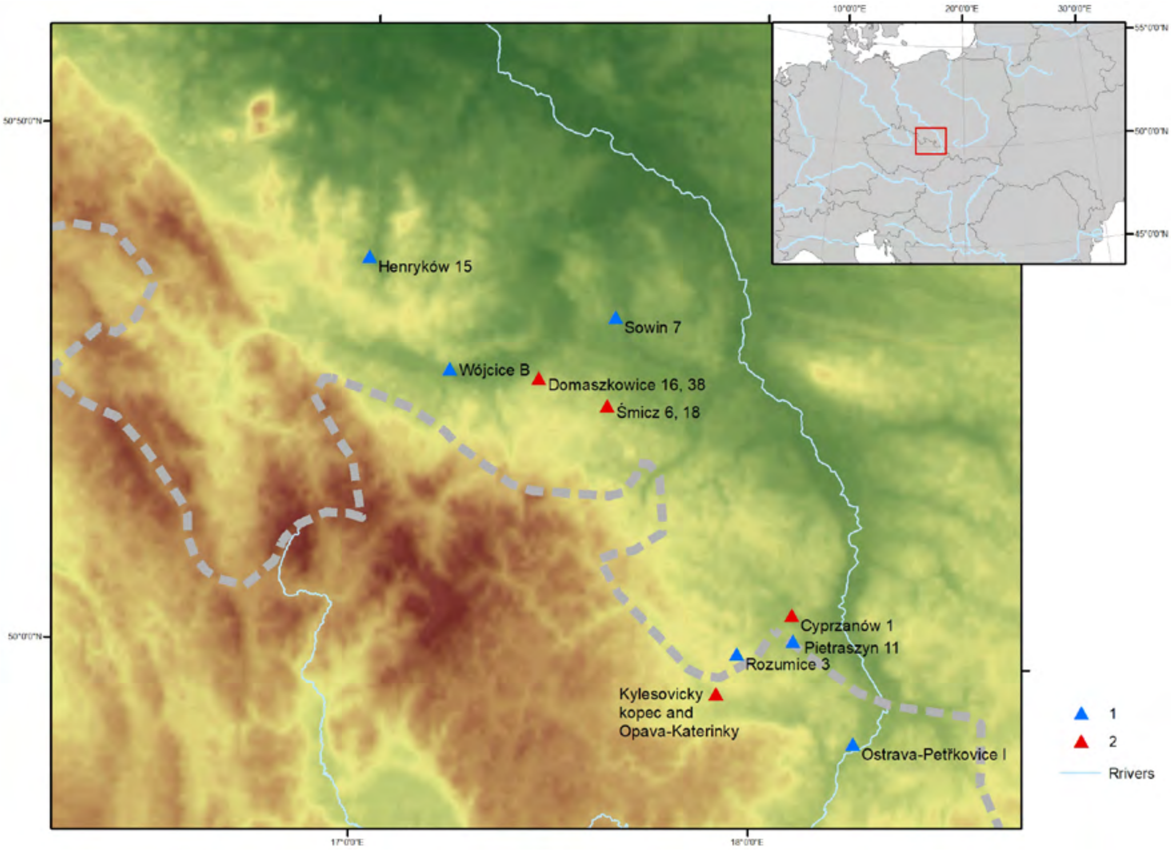

Figure 1. Distribution of Gravettian sites in the Odra river catchment area.
1 – xcavated sites, 2 – sites known only from surface finds.

In this context, it is also worth mentioning that at least six more sites discovered in the first part of 20 century are known: Cyprzanów 1; Debrzyca 1; Domaszkowice 16 and 38; Śmicz 6 and 18 (Kozłowski 1964). The site Cyprzanów 1 provided the largest collection of lithic artefacts including specimens made from radiolarite. The next two sites: Śmicz 6 and 18, known from field survey (Kozłowski 1964), are located in the proximity of Sowin.

The youngest phase of Gravettian is represented by sites in Opava-Kylešovický kopec with its surrounding and Opava-Kateřinky located in the Czech part of Silesia (Svoboda *et al.* 2002, 218; Neruda 2018).

3. Methods

Analysed materials from Sowin 7 site have been obtained through excavations initiated in 2000. During the first seasons of field works covering in total 40 sqm, neither sieving nor exact location of finds was applied (M. Furmanek, personal information). As a result, a total number of finds from the initial seasons is very low and differs considerably from collections obtained during the systematic field campaigns conducted between 2012 and 2017, when in total area of 40 sqm was tested.

In the course of excavations between 2012 and 2017 artefacts larger than 2 cm were located with total station (Leica TC407). In the case of elongated artefacts of length >3 cm, the bearing and plunge of finds were documented. The entire sediment was sieved.

In order to understand technological activity, a meticulous study of all lithic material in respect of features related to core reduction methods and tool manufacture was conducted. Apart from morphometrical analyse of blade blanks and specific waste (i.e., tablets, crested blades, etc.), the project of refitting was carried out. Together, these studies have outlined the direction of manufacture including core reduction as well as tool production.

Taking into account the fact that at Sowin 7 site local and imported raw materials were used, determination of the origin of transported rocks was of great importance. For determination of potential place/places of natural outcrops, X-ray diffraction (XRD) for mineral composition of Fe-ochres, microscopic analyses and energy dispersive x-ray fluorescence analysis (ED-XRF) for chemical composition of radiolarites were applied.

Applied methods of field documentation, with the use of total station for collecting data, has allowed analysing spatial distribution of finds with the use of geographic information system (GIS), namely ArcGIS software by ESRI. This stage of research included, among others testing dispersion of core reduction waste, typological and functional tools and their fragments as well as refits of artefacts.

Discussing the issue of human activity, of high importance were also studies of usewear traces observed at retouched tools, aiming at the determination of their function. Analysis performed at artefacts cleaned in an ultrasonic tank were carried out with the use of Olympus SZX9 stereomicroscope (up to x114) and Nikon ECLIPSE LV100 metallographic microscope (x50-500).

By employing multivariate statistics, it was possible to study differences and similarities between Epigravettian assemblage from Sowin 7 and other Epigravettian and Magdalenian sites in respect of humans' mobility (Parry, Kelly 1987). Sites were compared using the percentage frequency of finds. Classic correspondence analysis was used for two-dimensional cross-tables (Beh 2004; Bølviken *et al.* 1982). Sites were described by four variables related to types of finds: domestic tools, hunting armament, formal cores, and expedient cores. Correspondence analysis decomposes dependence between two categorical variables (site name and the type of find) using singular values decomposition. Dependencies between rows and columns could be presented on the plots in the with low-dimensional space according to the total dependency measure (called 'inertia' in correspondence analysis method) explained. Correspondence analysis aims to visualize similarities of distribution of column categories in rows, and distribution of row categories in columns. That means that i.e. sites with a similar distribution of finds types are close to each other on the chart. Moreover, row categories located on the biplot close to column categories show higher than expected from independency abundance of a given type of find in the given site.

4. Site location, its' chronology and stratigraphy

In this paper, we analyse dataset obtained during excavation of the lower cultural layer of the site Sowin 7, Opole Voivodeship (SW Poland). The site is located in the Niemodlin Wall forming a part of the Niemodlin Plain (Figure 2). Niemodlin Wall is separated from the western and eastern side by Nysa Kłodzka and Ścinawa Niemodlińska river valleys. The site is situated on the ridge of the latter one. The surface of the Niemodlin Wall rises ca. 25-40 meters above the bottom of surrounding valleys (Przybylski and Badura 2001), forming a kind of bridge linking European lowland with Głubczyce Plateau and Moravian Gate.

At site Sowin 7, four layers were identified (Figure 3). Top of the site section is formed by recent plowed layer (1), beneath which, aeolian sands (2) have been recorded. The sandy layer is comprised of periglacial structures represented by cracks and traces of bioturbation, the latter one of Holocene origin. Beneath the aeolian sands, a layer of sands and silts (3) has been documented. This layer contains characteristic laminas connected either with the processes of a relic or contemporary hydrogenic accumulation of iron compounds (L. Lisá, personal communication, 2017). In this layer, we observed continuity of periglacial cracks. Below this layer

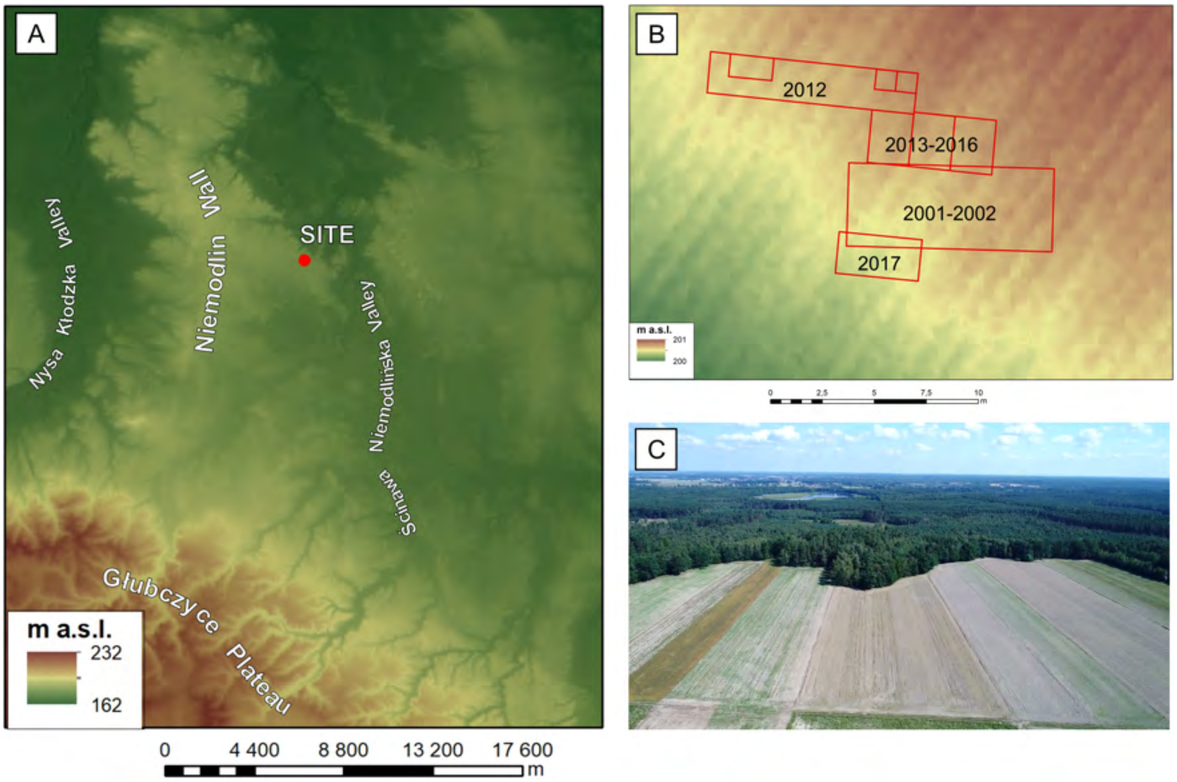

Figure 2. Location of site Sowin 7: A. general map; B. distribution of trenches; C. view from the west to the east on a fragment of Ścinawa Niemodlińska Valley covered in forest.

Figure 3. Site Sowin 7, projection of flint artefacts (white crosses) on the eastern section of the trench from 2017. 1-plouging soil, 2-aeolian sands, 3-sandy-silty sediments.

sands and gravels have been deposited. These sediments correspond with glacial environment dated to MIS 6 (Oder glaciation).

Within the plowed soil (1) and the top of aeolian sands (2) finds of Magdalenian culture were recovered while below, in sandy layer (3) assemblage of Epigravettian culture occurred. In the light of optically luminescence method, the age of aeolian sands (2) can be correlated with Bøling, while the age of sandy layer with Epigravettian artefacts with older Dryas (see more Wiśniewski *et al.* 2017).

Epigravettian finds were recorded in the entire area of 80 sqm. However, a spatial distribution of artefact, could have been more extensive. Considering vertical projection, artefacts form a kind of a band with a thickness of approximately 10-20 cm (Figure 3). In the southern and northern part of the excavated area, two clusters of stone artefacts have been discerned. It is worth mentioning that apart from lithic artefacts, a few lumps of ochre and small particles of charcoals have been discovered. However, the age of charcoals is not consistent with the results of OSL dating and typological estimation of lithic artefacts.

5. Spatial distribution of finds

Site Sowin 7 with a high average density of finds (288 artefacts/ 1 sqm), stands out among other Polish Epigravettian sites in terms of the number of lithic artefacts. The excavated area can be divided into two parts: southern and north-western (Figure 4). In the southern part, an oval structure was recognized, with a maximum length of 10 m and a maximum width of 3 m. Unfortunately, due to incomplete data obtained during the first two seasons, a full reconstruction of the structure is unattainable (see point 3). However, the more meticulous approach adopted between 2012-2017 seasons, has allowed to discern 4-5 small concentrations connected with different types of human activity such as blade core reduction as well as production and use of expedient tools. In this context, it is worth mentioning that, this part of the site is not only representative as per range of used raw materials including flints, quartzite, radiolarite, and ochre but also due to the occurrence of the highest number of backed tools within the whole site. Within the structure, various types of refits were documented: refitting of production sequences, modifications, and breaks (after Cziesla 1990). The highest number of refits in this place resulted from abandonment of waste of core reduction and production of burins.

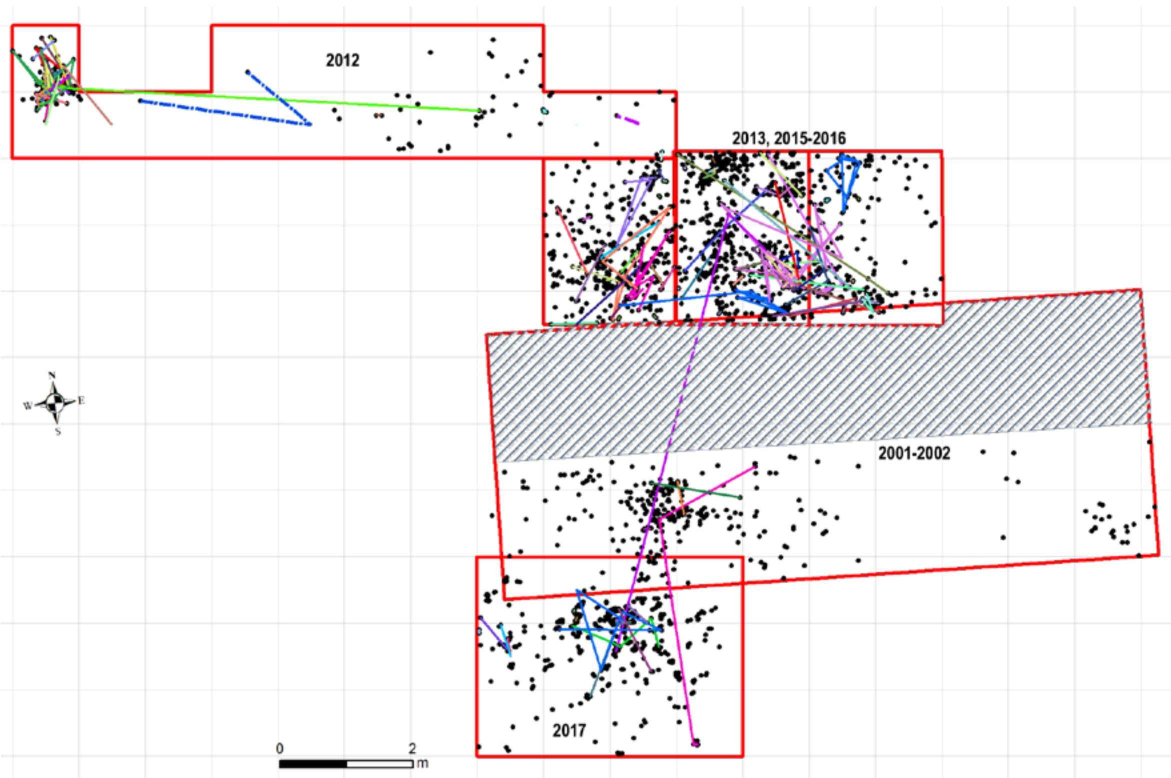

Figure 4. Map of lithic artefact distribution and group of refits (coloured lines) within Epigravettian horizon of site Sowin 7. Signature marks were used to show the northern part of trench from 2002 without data.

In the north-western part of the site, a small cluster was recognised. Despite the small size (1 x 0.8 m), the concentration provided approximately 2000 lithics mostly connected with core reduction and only a dozen or so tools (above ten specimens). The refits are represented by elements of production sequences and breaks.

Although the works related to the study of refits have not been completed yet, no refits connecting both discerned structures has been recognised. It seems that the northern and southern areas were connected with different types of activities. The northern part represents the blank blade workshop, while the southern part contains elements of complex activities including production, use and repair tools as well as the use of ochre.

The most striking aspect of a spatial situation is a lack of combustion areas or even its traces expressed by the grouping of blown flint, accumulation of charcoal or burned ground. Also, none pebbles indicating the presence of such a place have been found (see Stevenson 1985, 1991). Only fragments of radiolarite backed points and selected flint artefacts bear traces of burn suggesting a presence of nearby combustion zone. Having discussed the spatial distribution of finds and the organisation of the space, it is necessary in further section to integrate these results with observations concerning tools' function.

6. Raw material procurement

Epigravettian finds from site Sowin 7 were made mainly of local erratic flints collected from glacial Middle Pleistocene deposits (Badura and Przybylski 2001). They were easily accessible in the proximity of the site (Wiśniewski *et al.* 2012). The biggest nodules reached up to 16 cm in length while most of the chunks and nodules from the area of study are represented by smaller pieces (Wiśniewski *et al.* 2012, fig. 4, 405). By examining the volume and size of erratic flints from the glacial sediments in the vicinity of the site with a method developed by C. Pasda (1996), it can be indicated that collecting of large pieces required some time. In the light of refits, it is possible also to conclude that testing of erratic raw material by Epigravettian people took place at the camp (Figure 5).

Of course, it cannot be excluded that a part of retouched tools made of erratic flints was introduced to the site from other areas of Silesia such as Głubczyce Plateau where high-quality erratic flints occur. During production, humans also used small nodules of quartzite brought from local glacial deposits.

Only radiolarite products indicate distant transport. These artefacts are represented by four fragmented backed pieces, which constitute a part of composite tools probably repaired within the camp. It seems that radiolarite was collected during a stay in the area of its natural occurrence in the Carpathian Mountains (Figure 6). As per ED-XRF analysis, it can be concluded that the most probable outcrops of these radiolarites are located at Vršatské Podhradie, Pieniny Klippen Belt, West Slovakia. Both, radiolarites from Sowin and Vršatské Podhradie contain a similar small amount of strontium (Sr). At the same time, in the vicinity of Brodno-Kusyca Gateway near Žilina (Slovakia), which is believed to be optional place of provisioning, the radiolarites contain higher portion of Sr. Anyway, the distance between Sowin and Vršatské Podhradie as the crow flies is around 170-175 km, while between Sowin and Kusyca-Brodno – 165 km (see Kozłowski 2013; Přichystal 2013).

In both cases, we are dealing with extra-local imports. Because of their conspicuous colour, radiolarites attracted Epigravettian hunters from Sowin. Part of radiolarites is different in colours and chemical composition comparing Jurassic radiolarites from the Pieniny Klippen Belt. This second group could be collected at secondary natural source around Gliwice about 90 km far of Sowin (see Foltyn *et al.* 2009).

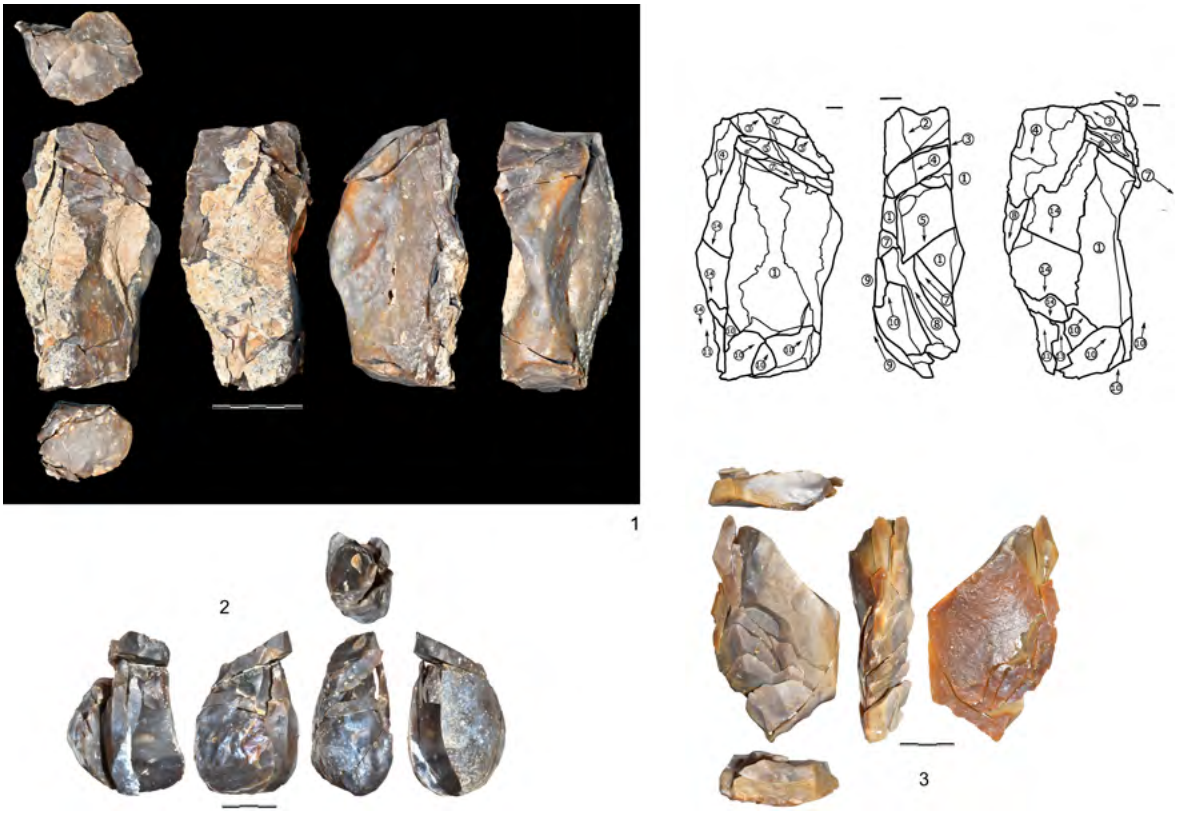

Figure 5. Groups of refits demonstrating the method of core reduction:
1 – bidirectional; 2 and 3 – unidirectional.

Figure 6. Specimens made of radiolarite.

7. Remarks on technological activity connected with raw material transformation

Compiling together the structure of assemblage (Table 1) and results of refitting study it seems that the central part of the human activity at the camp was focused on blade blank manufacture basing on the reduction of unidirectional, and occasionally bidirectional blade cores. The bidirectional strategy was applied only in the case of bigger blocks of raw material (Figure 5: 1). Morphology of cores corresponds to other Epigravettian assemblages from Poland (Wilczyński 2006, 2007, 2009) and neighboring countries (Nerudová 2016). Microscopic study of technological features indicates that during flaking a soft hammer was commonly used. The striking platforms of cores were prepared mainly by single blows providing tablets. The ridge of the striking platform was sometimes strengthened by abrasion, and rarely an active part of the striking platform was retouched.

At the initial stage of core reduction, two approaches were used. The first one, leading to striking a series of cortex blades or elongated flakes directly from the surface which was destined as a

Category	Erratic flint	Quartzite	Radiolarite	Hematite	Other raw material
Flakes and fragments	1551	1			
Blades and fragments	1016				1
Small debitage (<2 cm)	7011	2			
Raw material, chunks	73	10			2
Cores, pre-cores	38				
Retouched tools	192		5		1
Anvils		1			
Special tool waste	128				
Elements from core preparing	210				
Other				10	

Table 1. A general structure of the assemblage and raw material diversity.

Category	N	%
Blade	100	50,51
Chunk	9	4,55
Flake	83	41,92
Undetermined	6	3,03
Total	198	100

Table 2. Type of blank of retouched tools.

Category	N	%
End-scrapers	20	10,10
Burins	83	41,92
Retouched blades and flakes	35	17,68
Backed pieces	48	24,24
Truncated pieces	2	1,01
Sidescrapers	2	1,01
Tool fragments	8	4,04
Total	198	100

Table 3. Retouched tools.

flaking surface. As a result, a rounded flaking surface was created. The second one involved installation of the crest which was mainly unilaterally prepared. In this case, flintknappers obtained narrow, flat or slightly rounded flaking surface. The average length of blade blanks is 55.6 mm varying from 27 to 122 mm (sample from 2012-2013 after G. Michalec 2018). The average width of blades is 17.9, while an average thickness is 4.8 mm. Blades are usually bent in the longitudinal section and occasionally twisted around a vertical axis. These parameters are comparable with blades from other Polish Epigravettian assemblages such as Targowisko, Piekary IIa, and Kraków Spadzista B+B1, layer 5 (Wilczyński 2006; 2007, 2009). Worth mentioning is the fact that rarely, nevertheless, people used unidirectional flake cores.

Remains of retouched tool production illustrate the next stage of transformation of raw material at the camp. The most numerous tools which were prepared on the spot are burins produced from flakes and blades, seldom from chunks (Tables 2, 3). In some cases, from one blade/flake series of two or three burins was produced. Unfragmented and fragmented burins show the diverse location of burin blows, various size and number of burin spalls as well as different treatment of

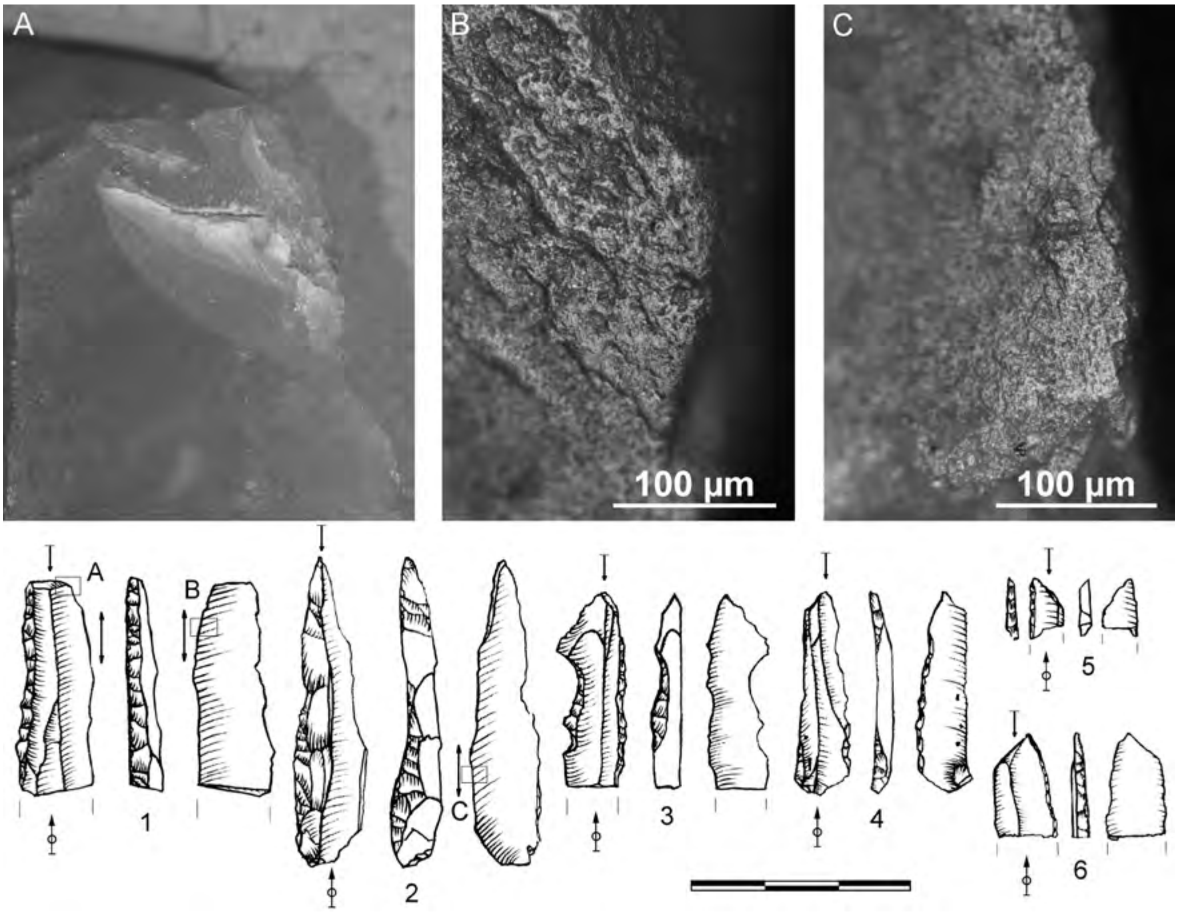

Figure 7. Backed pieces with traces of use (1-6); impact scar (A), traces on longitudinal edges (B-C).a). Specimens made of flint.

burin platform (Figure 7). In the light of traditional classification, we have distinguished truncation burins, dihedral burins, single blow burins and selected burin on the broken blade (see Tomášková 2005).

The predominance of burins over other tools is of course not a unique feature of Epigravettian assemblage. It was also recorded at site Kraków Spadzista, layer 5 (Wilczyński 2007, 73).

Regarding other tools, it is highly probable that most of the end-scrapers, scrapers and retouched flakes were also created on the spot. In turn, only a part of backed pieces may have been produced at the camp while some of them were brought to the site in the form of composite tools and then the pieces were replaced by new ones. This activity is confirmed by the presence of fragmented backed pieces bearing traces of use (see remarks on use-wear traces).

Summing up, the lower layer of site Sowin 7 consists of two technological segments. The first one is connected with the preparation of take-out products and manufacture of tools which were prepared, used and abandoned at the camp. The second one, contain traces of using specimens which were brought into the camp from outside, sometimes from distant locations.

8. Tool use

More than a third of retouched tools from Sowin bear traces of use (Table 4) connected with the following activities: hunting, butchering, working hide and processing of bone and mineral materials.

Category	n	Impact traces	Cutting soft animal tissue	Hide	Bone/antler or mineral material	Other/ undetermin ed	No traces
End-scrapers	20	-	-	8	1	6	5
Burins	53	-	-	1	10	4	38
Retouched blades and flakes	32	1	5	-	2	2	22
Backed pieces	44	6	6	1	2	5	24
Truncated pieces	2	-	-	-	-	-	2
Scrapers	2	-	-	-	-	-	2
Undetermined tool fragments	8	1	-	-	-	1	6
Burin spalls	1				1		
Total	162	8	11	10	16	18	99

Table 4. Tool use.

Hunting practices are confirmed by impact traces such as bending step fractures and burination on eight artefacts made from erratic flint, including six backed pieces (Figure 7). In two cases impact scars are accompanied by longitudinal microtraces on the lateral, sharp edges (Figure 7: 1-2). Tools are broken missing batts or tips.

Artefacts with traces of cutting soft animal tissue can be both linked with hunting and butchering. Among these implement pieces and retouched blades of larger dimensions has occurred (Figure 8: 1-7). One of the backed pieces is made of radiolarite (Figure 8: 7). Traces of use are preserved on lateral or protruding edges that are slightly rounded and polished and are running in longitudinal direction indicting cutting motion. Microchipping is also present. Considering that a composite hunting weapon may have been used by Epigravettian hunters, we cannot exclude that some of the smaller pieces from this group played function as barbs of a projectile weapon and other as knives for butchering and cutting meat. Remains of ochre are recorded on one of the retouched blades. Residues are preserved on the part of the tool opposite to the cutting edge, where we should expect hafting traces. Unfortunately, no hafting scars or polishes in this part of the tool confirming the presence of a haft have been observed.

Next activity reflected in microwear is exemplified by tools used for working hide. These group of tools includes side-scrapers, a burin, and a backed piece, out of which eight artefacts bear traces of scraping fresh hide (Figure 9: 1, 3-5). Hide scrapers do not belong to worn out tools. Working edges are slightly rounded, with bright and greasy polish but without abrasive marks. Tools had been most possibly used in the initial stage of processing hide, which is cleaning hide from fat and meat. Hafting traces are recorded on one of the side scrapers. Working hide is also confirmed by traces of rotary motion on the backed piece tip.

Amongst the group of side scrapers, two implements differ in terms of the development of usewear traces comparing to those described above. Working edges are highly rounded and have abrasive character, with polish texture changing from greasy to bright and reflected (Figure 9: 2, 6). Scars are present, but traces cover ridges of those scars as well. It is difficult to determine the function of these worn out tools. They can be connected with scraping hide with abrasive additives or long-lasting wood scraping, or with performing more than one function. One of these two side scrapers particularly differs from the other tools in terms of morphology and raw material (Figure 9). Moreover, side scraper has distinctive hafting and binding traces – large and flat scars and extensive hafting polish on a ventral surface (Figure 9: 6).

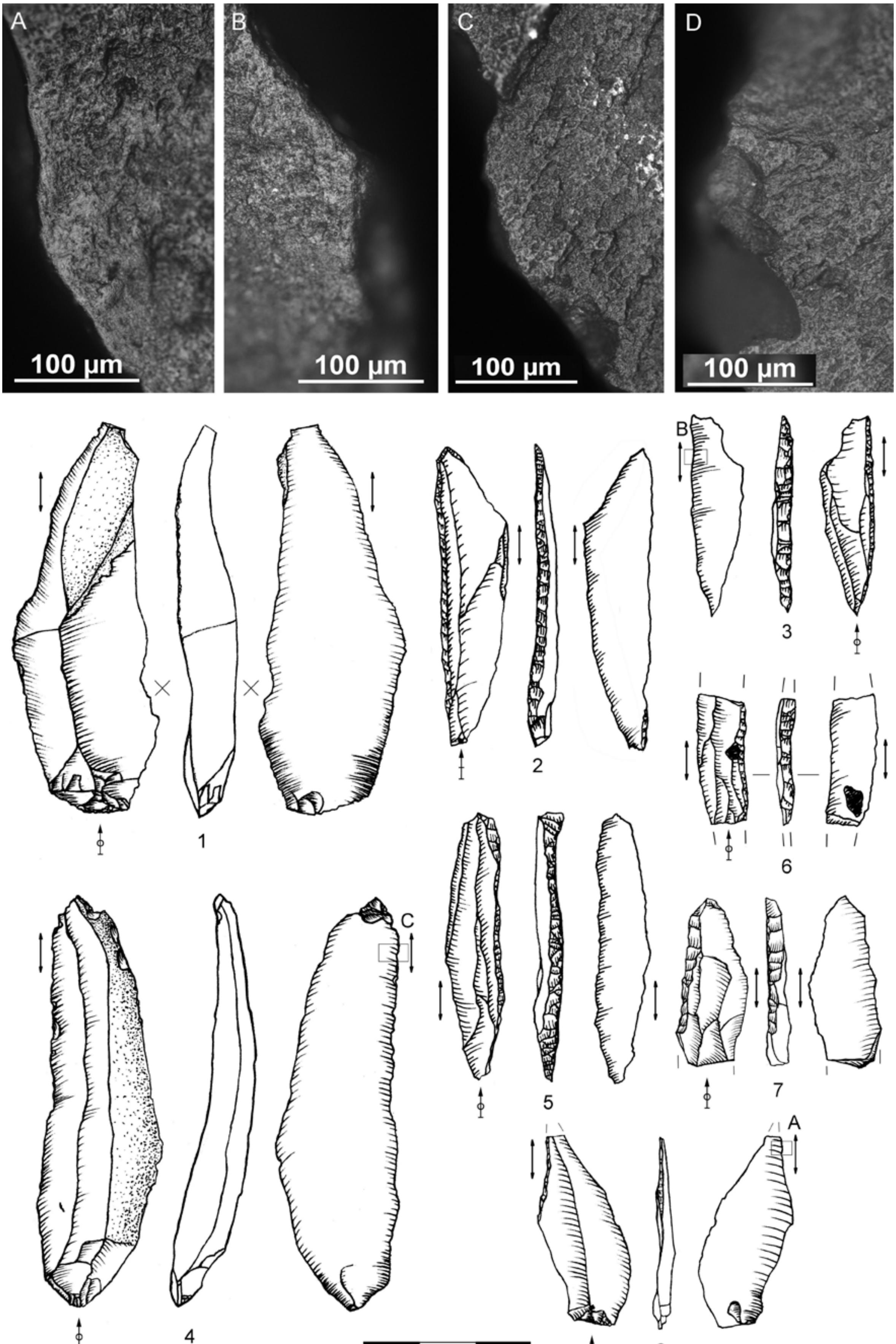

Figure 8. Retouched blades (1, 4, 8) and backed pieces (2-3, 5-7) with traces of use; traces of cutting soft animal tissue (A-D). Raw material: 1-6 and 8 – flint, 7 – radiolarite (see Fig. 6:2).

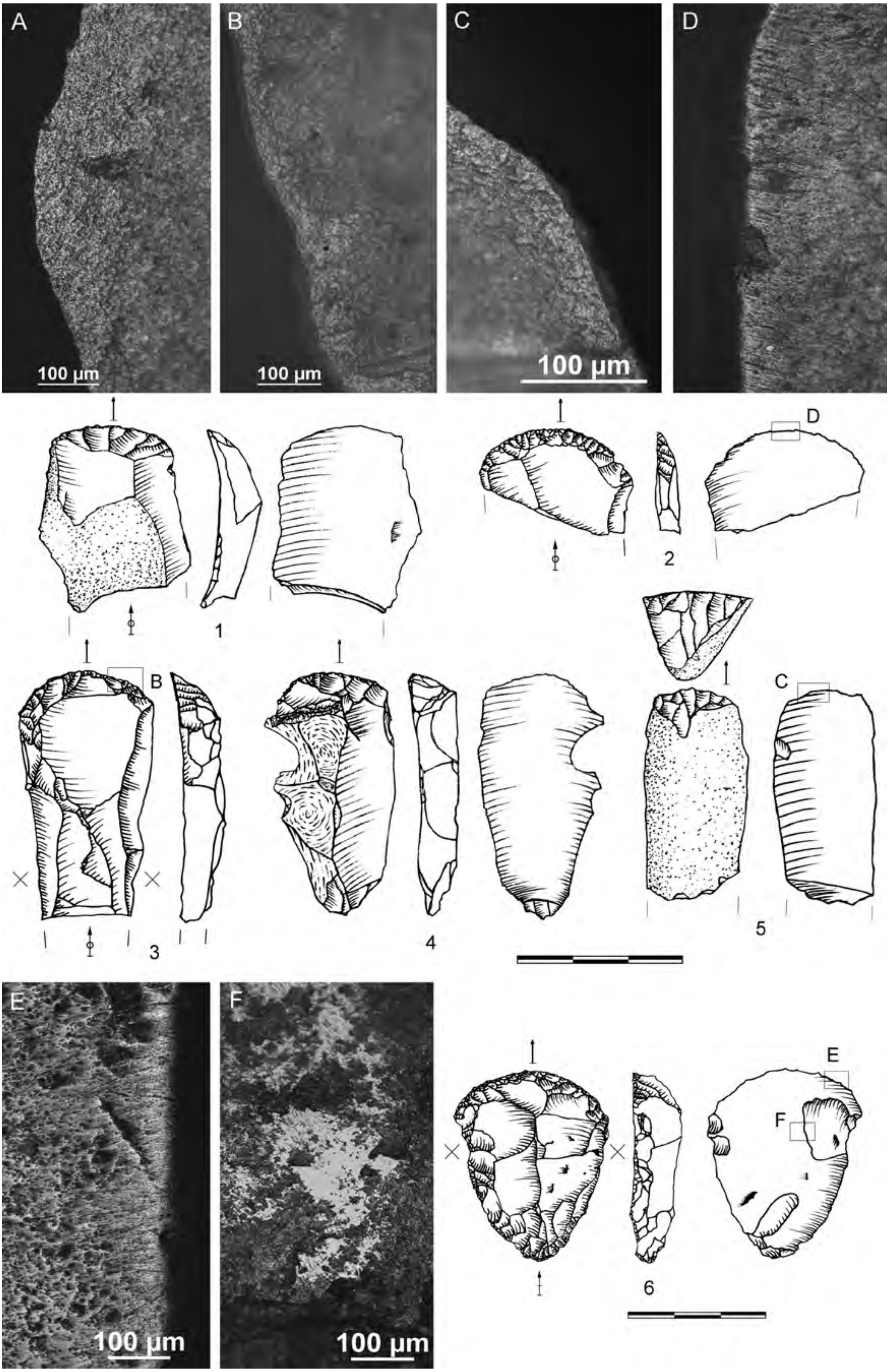

Figure 9. Endscrapers with traces of use (1-6); traces of scraping hide (A-C); traces of scraping hide or wood (D-E), hafting traces (F). Specimens made of flint.

Hard animal and mineral materials had been mainly worked with burins. This type of tool outnumbers other tools in the lithic assemblage from Sowin. Burin tips and edges of burination were used as working edges for engraving, sawing and scraping bone (Figure 10). Bright antler polish indicates working fresh or wet material. Abrasive traces that concentrate on a small area of the very edge suggest working dry, hard material. Burins were very dynamic tools. They had been resharpened, what is confirmed by numerous refitted blocks consisted of burins and burin spalls, as well as traces of use on burin spalls. A few tools with highly developed rounding on tips were used for processing stone. In this group of tools, one burin is differently preserved and bear traces of hafting (Figure 10).

The function of sixteen tools, including scrapers, burins, backed pieces, and other tools with microtraces is difficult to determine. One of the interesting pieces is represented by a backed piece with its tip broken and abrasive traces in the proximal part. We cannot exclude intentional rubbing prior to hafting.

Almost two third of the retouched tools bear no traces of use. The most numerous among this group are burins (that were often resharpened) and retouched blades and flakes that may have been used as ad hoc tools. They are followed by backed pieces, fragmented in most of the cases, but with non-diagnostic snap fractures. Many retouched tools were made on knapped, quartered small flint nodules and these tools in most cases bear no traces of use or traces are not well developed. It suggests the ad hoc use of tools of local production.

Tools can be grouped as follows:

- damaged elements of hunting weapon, including backed pieces with impact traces;
- knives for cutting soft animal tissue and butchering, including a backed piece made from radiolarite;
- slightly worn side scrapers of local production for the initial stage of processing hide;
- completely worn outside scraper and burin, both with hafting traces (possibly brought to the site for the reconstruction of damaged tool kit);
- a high number of tools made locally (mainly burins), used for working bone; made, resharpened, used and discarded at the site.

These observations suggest that the purpose of a short stay of the hunters and gatherers in Sowin was the reconstruction of the hunting weapon, whereas other activities such as processing of animal materials include only necessary actions.

9. Multivariate analysis

Correspondence analysis enables to draw the following conclusions (see Figure 11, Table 5). First, it is not possible to detect any connections between cultural determination and distribution of particular assemblages. The Epigravettian and Magdalenian assemblages are concentrated in three quarters on the diagram. Only one of the Magdalenian sites, Wierzawice 31, diverges from the rest because it includes a high number of hunting tools. The Epigravettian assemblage from Sowin 7 is placed close to the Magdalenian assemblage from Podgrodzie 16. Generally, we can say that the Epigravettian assemblage from Sowin 7 is similar to the assemblages with a high percentage of domestic tools. To sum up, the Epigravettian and Magdalenian assemblages do not form any recognizable cluster.

10. Discussion

Archaeological remains from site 7 at Sowin constitute most probably partially excavated camp that requires further field works. Nevertheless, the current stage of research enables us to answer

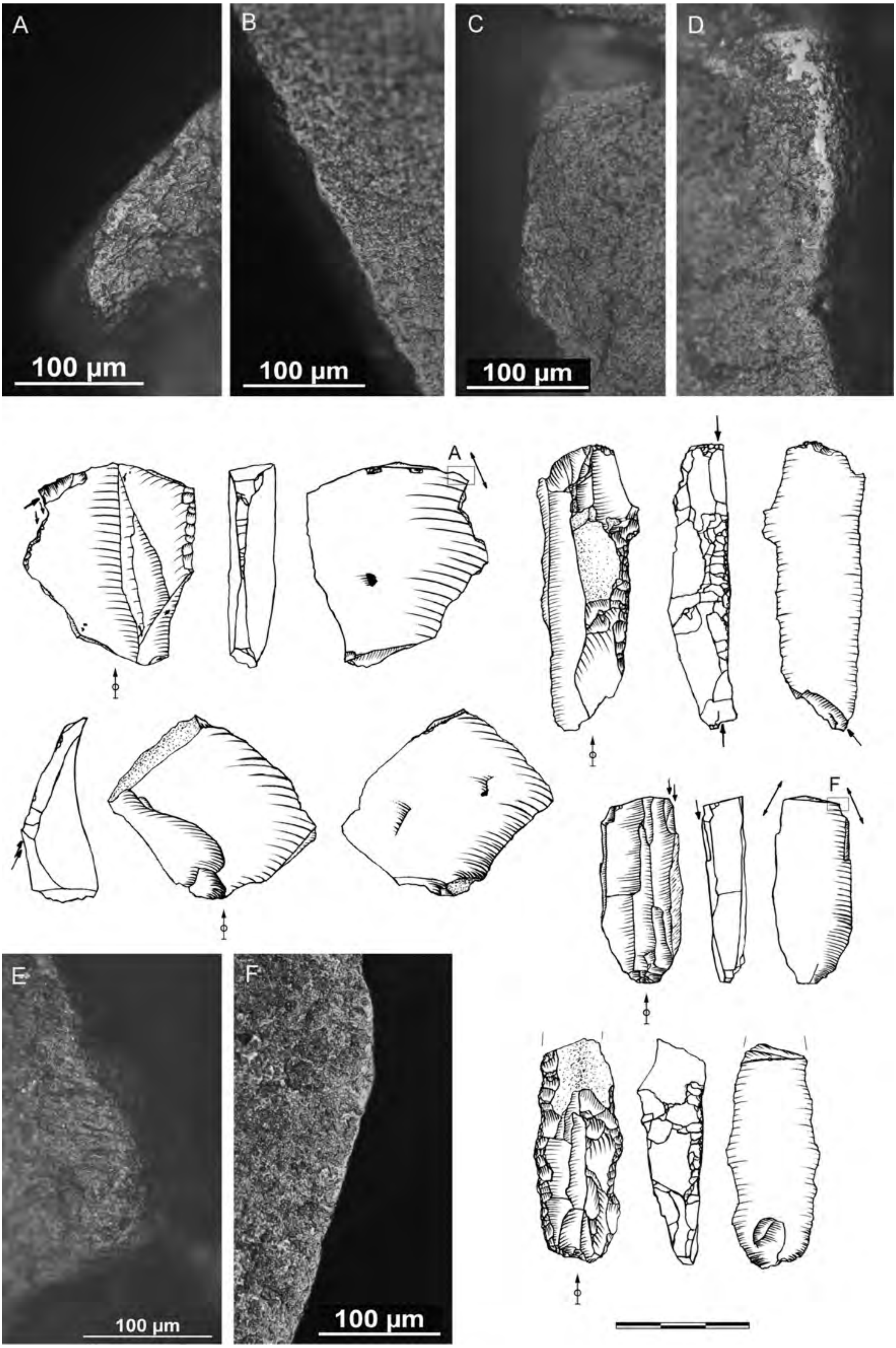

Figure 10. Burins with traces of use (1-5); traces of working bone/antler (A-C, E-F), hafting traces (D). Specimens made of flint.

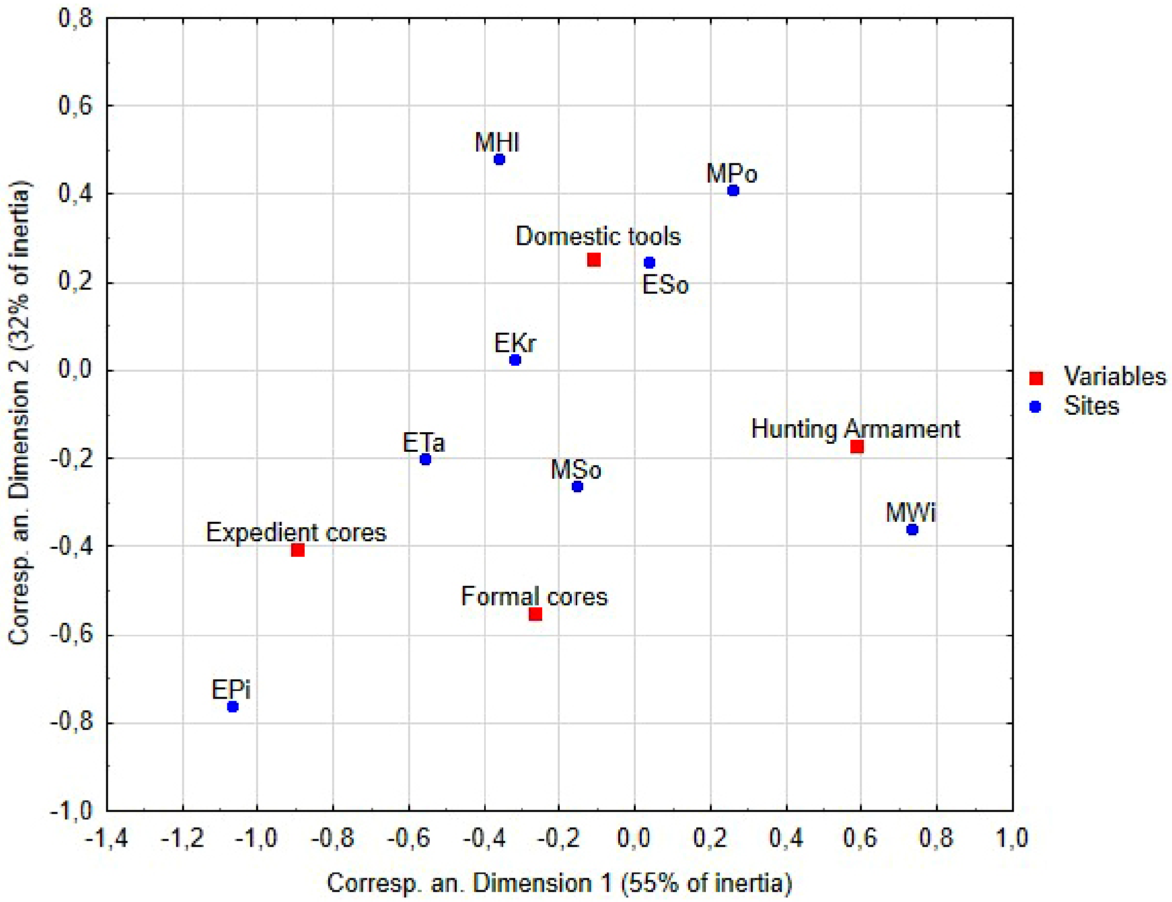

Figure 11. Scatterplot of CA Dimension 1 vs. CA Dimension 2 for Magdalenian and Epigravettian sites.

Cultural unit and site	Categories				
	Domestic tools	Hunting Armament	Formal cores	Expedient cores	Total
EKr	40	8	11	6	65
ETa	52	13	15	23	103
EPi	3	0	3	3	9
ESo	140	50	17	6	213
MSo	81	34	45	10	170
MHl	28	3	0	4	35
MWi	31	78	14	2	125
MPo	75	34	0	0	109
Total	450	220	105	54	829

Table 5. Data for correspondence analysis. Abbreviations: EKr-Kraków-Spadzista B1+B2, ETa- Targowisko 10, EPi- Kraków-Piekary IIa, ESo- Sowin 7, lower level, MSo-Sowin 7, upper level, MHl-Hłomcza, MWi-Wierzawice 31, MPo- Podgrodzie 16.

a question regarding the character of the records and its contribution to the understanding of the Epigravettian settlement on the area located north of the Carpathians and Sudetes.

In the light of the analysis of the assemblage from Sowin, it looks that the finds reflect a schematic pattern of adaptation of hunters and gatherers to the local environmental conditions (Binford

1979, 1980; Kelly 1995). The assemblage includes elements produced through the exploitation of local resources. More to the point, favorable conditions such as easy access to flint nodules (on deflation surface) proximity of water and food resources (river valley) could have been one of the factors affecting the choice of this place. In the immediate vicinity, there are also numerous depressions that might have served as waterholes for animals and plant sources. On the one hand the stay of a group of people in Sowin was aimed at retooling of hunting equipment as well as a production of blanks and retouched tools from good quality flint material; on the other hand, within site usual activities for hunting camp were performed. They are exemplified by traces of cutting soft and hard animal tissue.

Interestingly, no direct records suggesting butchering practices has been found yet. For butchering a considerable space is needed which should be easily readable within the excavated area (see Binford 1983, 169-170). This is an important issue for future research.

As it was mentioned above, various activities were performed at the site. This has been confirmed by the occurrence of distinctive usewear traces that differs in respect of various actions performed. Returning to the question posed at the beginning of this study that is: How exactly did the hunters' activity look like during their stay in Sowin, we may consider the following scenario. A group or groups of hunters and gatherers came to the Niemodlin Plain. They were well prepared and equipped with hunting weapon (including radiolarite backed pieces, one with traces of cutting soft animal tissue), composite tools (knives) with lithic parts made of radiolarite and erratic flint and tools for making and/or repairing tools (including worn out, hafted side scraper and burin).

Microtraces observed on the lithic tools from Sowin suggest rather a short stay of the hunters and gatherers who used their toolsets during one type of activity. Some of the tools were resharpened and discarded most probably in the same place where an activity took place (scrapers, burins). Hafting traces are rare, preserved mostly on tools brought to the site.

Comparison of impact traces and those occurred as a result of cutting found on tools from Sowin with those observed at Magdalenian hunting camps such as Wierzawice (Bobak *et al.* 2017), suggest that they are of moderate nature. It seems that hunting activities were not the main ones and processing of animal carcass was limited to the necessary tasks, such as butchering and cleaning hide from grease and meat. So far, no domestic tools such as worn out hide- or leather- scrapers have been found in the assemblage. Instead, we have a high number of shortly used but resharpened bone processing tools. The evidence presented in this paper suggests that hunters and gatherers from Sowin used highly specialized toolkits. Daily activities were concentrated on the production of tools from the local erratic flint and making hafts and other parts of tools form organic materials. Tools were intended to be used at the site for making composite tools and to 'carry away'. Similar activity model has been observed at other Polish Epigravettian sites: Targowisko 10 and 11 from Lesser Poland (Kufel-Diakowska 2013).

Interestingly, in Sowin a few lumps of ochre were found. They could have played a symbolic role and/or element of utilitarian activity (Wadley 2005) such as tanning the skin (Philibert 1994). Unfortunately, it is impossible to resolve this question.

Within the excavated area no clusters of charcoals or even burnt flints were found, suggesting that no activities requiring the use of fire within this zone took place. However, considering a large amount of knapped flint materials (36 cores) and ad hoc tools, modified and resharpened, such remains with hearths should be expected to be found during future works.

The present study of assemblages from site 7 at Sowin makes several noteworthy contributions to understanding Epigravettian sites located in Poland, north of Carpathians. Recently a few similar sites have been analysed from the chronological, typological and technological perspectives

(Wilczyński 2015; Wiśniewski *et al.* 2017). However, no occupational process and territorial system were discussed.

By juxtaposing Epigravettian sites with proceeding Gravettian and following Magdalenian ones, we see that the former are few, (see Kozłowski 2007; Wilczyński 2015) including even sites without any precise chronological determination. This confirms the opinion expressed earlier by J.K. Kozłowski (1992) that the groups of Epigravettian people did not widely exploit the area of Carpathian and Sudetes foreland. Moreover, the occurrence of non-local raw materials in Sowin such as radiolarite, obsidian, and limnoquartzite indicate that the range of exploitation network was extensive and reached the diameter of 100-300 km. What is interesting, a similar trend was recognised north of Carpathians (Lengyel 2016).

Quantity and density of the Epigravettian assemblages from Poland are not impressive and differ when comparing with Magdalenian collections dated back to Dryas II and Bølling (e.g., Maier 2015; Schild 2014; Wiśniewski, T. 2015). Also, the percentage of retouched tools and the ratio of ad hoc tool to formal one suggests rather a narrow range of activities (hunting weapon retooling and accompanying tasks with the use of burins, rarely endscrapers). However, when correspondence analysis of Magdalenian and Epigravettian sites is considered, it needs to be stressed out that neither strong relations between Magdalenian sites nor between Epigravetian ones have been observed. Same, no apparent differences between Magdalenian and Epigravetian have been demonstrated.

Regarding Polish Epigravettina sites, it should be added that apart from a few cases (i.e., Sowin 7, Deszczowa Cave) there is no evidence for the activities other than manufacture. What is interesting, Epigravettian remains from Poland should not be connected with the notion of the occupation of unknown lands – terra incognita. Recognized sites are represented by blade blank workshops confirming familiarity with local raw resources and performing planned tasks. The appearance of mentioned sites could have been a result of a very mobile settlement strategy with refugial centers located to the south or southeast. Probably, such occupational model was one of the preferable by the epigones of Gravettian, facing possible, a significant decrease in a number of populations occupied central-eastern part of Europe in LGM and subsequent period (see Bocquet-Appel *et al.* 2005; Maier *et al.* 2016).

11. Conclusions

Research on the site no 7 in Sowin (lower layer) enhance our understanding of Epigravettian groups penetrating area north of the Carpathians and Sudetes. The site dated to ca. 16,000-17,000 BP (OSL dating) has provided evidence on the retooling of hunting weapon and processing of hide and bone. Raw materials were gathered prevalently from the vicinity. There is no evidence for longer stay of a group of hunter-gatherers who came from the area of the White Carpathians bringing a few tools made of raw material typical for that area. It seems that in both areas that are: in Sowin and Lesser Poland we obtained evidence of dynamic occupation system developed north of the Carpathians and Sudetes in LGM and subsequent period. Currently, it is difficult to explain, whether it was logistic (see Maier *et al.* 2016) or residential model of the settlement (Wiśniewski *et al.* 2012; Lengyel 2016). However, it is clear that it was systematic exploitation of an immediate surrounding.

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Upper Gravettian site cluster in Lubná (Czech Republic)

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Abstract

Lubná is one of the most important prehistoric sites in Bohemia. With a total of 8 Gravettian sites located in a small area, it represents the greatest concentration of Upper Palaeolithic sites and has no precedent in the area. The closest analogy is the Pavlovian site cluster of Dolní Věstonice II. However, Lubná is younger, dating between 24 to 21 thousand years BP and is not so rich in material culture (Šída *et al.* 2009, 2015; Šída 2016).

Dominating raw material are silicites of glacigenous sediments coming from north (Silesia and Saxony). In small amount we can find quartzites of north western Bohemia and Bavarian plattensilex. All sites have very low amount of cores, and this presence on sites are at high stage of exploitation. Microchips, flakes and burin spalls demonstrate the blades and tools production on sites. Tool composition is typical for gravettian with gravettian points and micro points, domination of burins and with numerous microlits. Kostenki points are missing. Specific is presence of typical pavlovian microliths in Lubná II. Art objects are almost missing – the only one piece is small pendant made of mammoth tusk coming from Lubná II. Reindeer is dominating in all faunal assemblages evaluated until now. This comes together with high elevation of sites coming to more than 350 m a.s.l. Reindeer teeth show us summer period of occupation on site Lubná I. The Lubná sites seems to be summer short time hunting camps specialised on reindeer hunting, but, in contrast, on Lubná VI we have minimum reindeer antlers what shows not summer time of occupation.

Keywords: Gravettian; Central Europe; site cluster; Czech Republic; Lubná

Résumé

Lubná est l'un des sites préhistoriques les plus importants de Bohême. Avec un total de 8 sites gravettiens situés dans une petite zone, il représente la plus grande concentration de sites du Paléolithique supérieur et n'a aucun précédent dans la région. L'analogie la plus proche est l'amas de sites pavloviens de Dolní Věstonice II. Cependant, Lubná est plus jeune, datant entre 24 et 21 mille ans BP et n'est pas si riche en culture matérielle (Šída *et al.* 2009, 2015; Šída 2016).

Les matières premières dominantes sont les silicites des sédiments glacigènes provenant du nord (Silésie et Saxe). En petite quantité, nous pouvons trouver des quartzites du nord-ouest de la Bohême et le silex en plaquettes bavarois ('plattensilex'). Tous les sites ont de très faibles quantités de nucleus, et il sont présents à des stades élevés d'exploitation. Les microéclats, les éclats et les chutes de burin démontrent la production de lames et d'outils sur les sites. Les pointes de Kostenki sont absentes. La présence de microlithes pavloviens est spécifique de Lubná II. Les objets d'art sont presque absents – le seul fragment est un petit pendentif en défense mammouth provenant de Lubná II. Cela est dû à une haute altitude des sites situés à plus de 350 m a.s.l. Les dents de renne nous montrent une période d'occupation estivale sur le site de Lubná I. Les sites de Lubná semblent être de courts camps de chasse spécialisés dans la chasse au renne, mais, en revanche, à Lubná VI nous avons un minimum de bois de renne qui montrent une période d'occupation non estivale.

Mots-clés : Gravettien ; Europe centrale ; grouep de sites ; République tchèque ; Lubná

Lubná is one of the most important prehistoric sites in Bohemia. With a total of 8 Gravettian sites located in a small area, it represents the greatest concentration of Upper Palaeolithic sites and has no precedent in the area (Figure 1). The closest analogy is the Pavlovian site cluster of Dolní

Figure 1. Lubná. Location of areas I to VIII on current orthophotomap.
Orthophoto © ČÚZK.

Věstonice II. However, Lubná is younger, dating between 24 to 21 thousand years BP and is not so rich in material culture. Lubná is notable because it is where the oldest art object ever found in the Bohemia was discovered (Šída *et al.* 2009, 2015; Šída 2016).

Lubná I was the first Paleolithic site excavated in Bohemia. A high school teacher and amateur geologist named Jan Kušta discovered it in 1890. Excavations continued the following year and were completed in 1913 by J. Soukup. The second main location was discovered and excavated in 1933. The site was first located by B. Typolt and J. Renner and the excavation was undertaken by J. Böhm. The excavation of Lubná II can be considered to be the first modern excavation of a Paleolithic site in the country. Even today, after more than 80 years, we can perform advanced planigraphic analysis based on Böhm's field documentation (Figure 2).

In the first phase of research at Lubná, archaeological remains were also discovered in several other locations (IV, V, VII and VIII). Some of these components have preserved archaeological material (IV, VIII), whilst the rest are only reported in the literature. Lubná IV was excavated by S. Vencl in 1961. In the same year, Lubná III was also discovered and explored. Lubná VI was discovered in 2006 and the first trenching was undertaken in 2012. The most recent excavation was hold here last year in cooperation with J. Wilczyński on area of 20 sq meters.

For comparison of Lubná sites we can deal with almost 6000 chipped artefacts. Larges assemblage comes from 2018 excavations at Lubná VI (evaluation is in progres, collection exceeds 2000 pieces, collection of 2012 trench consist of 155 pieces). The second largest one is Lubná III with 1442 artefacts; next largest is assemblage of Lubná II site with 926 artefacts. Lubná IV with 566

Figure 2. Original field photo documentation of J. Böhm, deposited in the archive of the Institute of Archaeology of the CAS in Prague, V.V.I. Overall view of finished area I from northeast.

artefacts and Lubná I with 468 artefacts are following. Smallest assemblages come from site Lubná VIII (64 artefacts). The dominant raw material in the assemblage from Lubná I is erratic flint (94.7%). This may also include the unidentifiable patinaed silicites that make up 2.1% of the assemblage. Raw materials remained undetermined for 12 artifacts (lost pieces, 2.6%). Single examples of Permo-Carbonian limnosilicite, Tušimice quartzite and plattensilex make up 0.2% of the total. Permo-Carbonian limnosilicite is a local raw material. Tušimice quartzite was available in the Northwest Bohemian lignite basin located about 40 km away. Erratic flint would have come from a minimum distance of 120 km, obtained from the area north of the border mountains, and the nearest sources for plattensilex were outcrops located near the Bavarian Arnhofen, about 150 km from the site.

Of the original assemblage from Lubná I, a total of 468 stone artefacts remain. The assemblage was larger; in 1891, J. Kušta noted 750 pieces of worked stone. What happened to the missing artifacts is not known.

Blades make up the largest part of the assemblage, comprising 28.8% of the total. Microblades comprise 3.2% of the assemblage. Flakes comprise 25.2% and burin spalls an additional 13.9%. Cores comprise only 1.5%, microchips only 1.3% and fragments 4.1% of the total collection. Tools represent 30.3% of the assemblage from Lubná I. 1.7% of the collection (8 artifacts) could not be identified because it is temporarily unavailable.

Significantly, the tools from this assemblage are of Gravettian type: predominantly burins (23), end scrapers (9), backed blades and microlithic tools. Seven identifiable La Gravette points are present in this assemblage.

From the osteological material held in the National Museum, A. Verpoorte obtained two radiocarbon dates, both indicating a date of around 22 thousand years BP (Verpoorte 2003).

Again, the dominant raw material from Lubná II is erratic flint. This raw material comes from a minimum distance of 120 km, from the area north of the border mountains. One worked stone artifact was not identifiable due to burning, but it is likely also erratic flint. No other raw material was used at Lubná II.

A total of 926 chipped stone artefacts from Lubná II are held in the collection of the National Museum. The largest group are flakes (36.7%), followed by blades (21.4%) with microblades (3.6%). Fragments make up 10.8% and burin spalls 13.4% of the assemblage. Cores make up only 0.5% of the assemblage. Tools make up 13.4% of the total assemblage.

Significantly, the assemblage was dominated by Gravettian tool types. Burins were the most numerous (51), followed by end scrapers (7), backed blades and microlithic tools. Nine La Gravette points were excavated from Lubná II.

There are two broken bone chisels in the collection. During the excavation a tiny pendant made from mammoth ivory was discovered in square b2. The pendant is 2.5 cm x 1.35 cm and 0.74 cm in height. The terminal part of the artefact is flattened, thinned and pierced. The terminal part is partly damaged and there is a crack running through the hole. The entire surface is finely ground and on the dorsal side are three parallel oblique lines. This tiny pendant is the only art object from the Gravettian period to be found in Bohemia.

The osteological material from Lubná II is very fragmentary, but it was possible to identify five huntable animal species: loess horse (Equus germanicus), reindeer (Rangifer tarandus), wolf (Canis lupus), fox (Vulpes sp. – Alopex sp.), and hare (Lepus sp.), leaving 984 unidentified bone fragments. Where it was impossible to identify by species, the bones were sorted by size – large mammal (the size of a horse or aurochs), medium-sized mammal (the size of a reindeer or wolf) and small mammal (the size of foxes and hares) (Nývltová – Fišáková in Šída (Ed.) 2009).

Stone paving was present on the site, as is common on bohemian sites. In the case of Lubná II, the pavement was made up of fragments of iron sandstone and quartz boulders. There were two separate concentrations of stone pavement. The larger concentration is located around the southern hearth. In this area, the stones are placed very close together. A second, much looser accumulation is located around the north hearth. It seems, therefore, that the pavements are functionally related to hearths and the technological processes that take place in their vicinity. The paving stones were not removed during excavation.

Macroindustry is represented by 25 artifacts, including one flake and 24 fragments of lydite, slate, quartz, quartzite and hematite. The last artifact is a hammer stone made of a diabase boulder.

Thanks to detailed record keeping linking artifacts to the field plan, we are able to undertake planigraphic analysis of the site. The excavated area was divided by a regular grid of squares measuring 0.5 x 0.5 m (1 to 24 x A to V), and all significant features and artifacts were recorded. We can distinguish several major areas with differing artefact concentrations (Figure 3). They are:

a) a possible dwelling space (squares about HP x 12-17) with an inner hearth (south) in square J13, empty space in squares LO x 14-16, and a probable entrance in squares I-N17.
b) a space outside the entrance into the dwelling (south of it, squares IN x 18-20).
c) an outdoor work area in squares KO x 6-8 with a hearth (north) in square M7-8.
d) a waste zone around the outdoor work area with a width of one to two squares (0.5 to 1 m).
e) the main waste zone between the outside working area and dwelling space (in the shade north of the dwelling, squares I-L x 10-11).

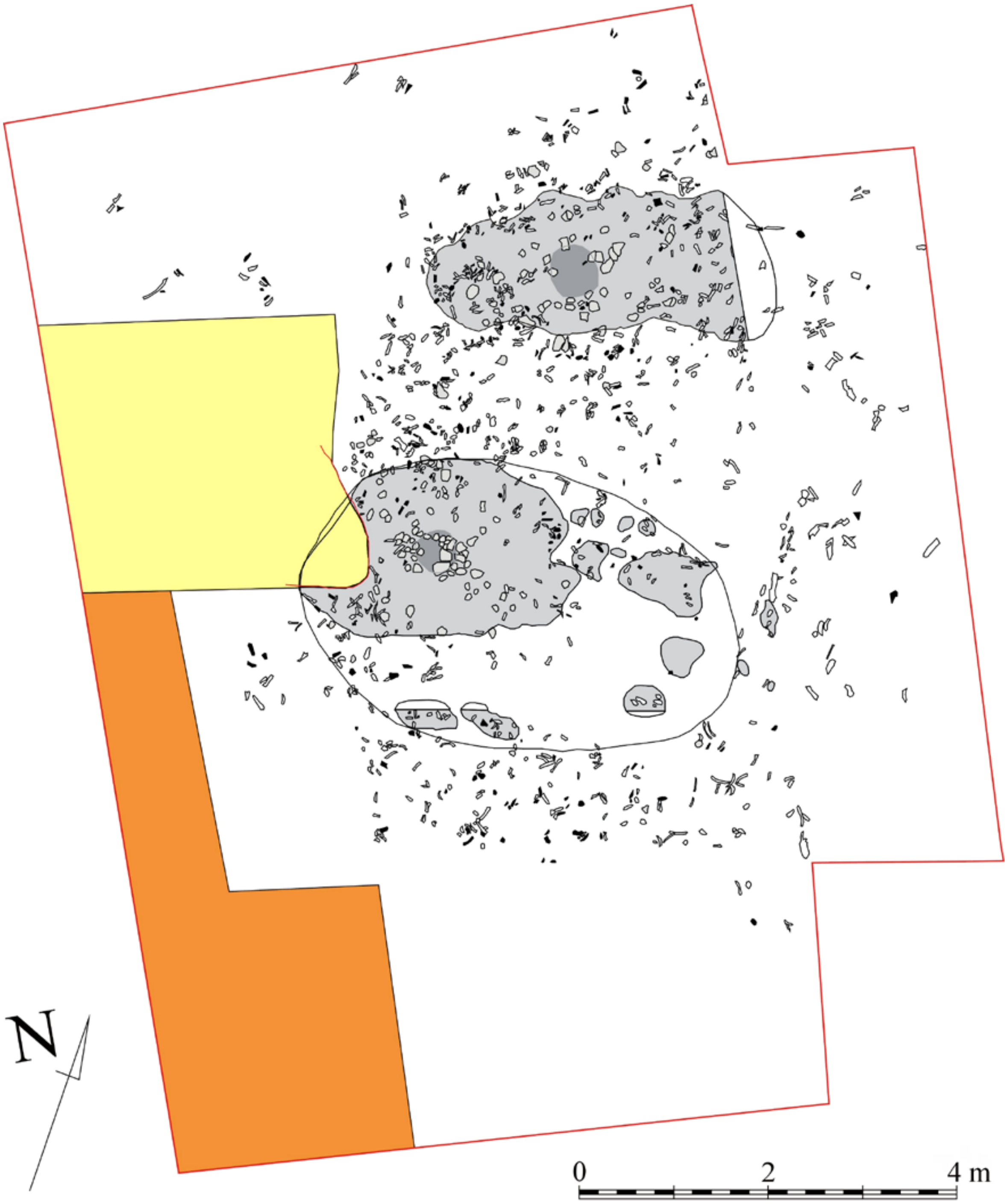

Figure 3. Lubná II. Plan of site according to original by J. Böhm.
Legend: ochre – unexcavated area, yellow – disturbed area, light gray – stone plates, medium gray – black carbon distribution area, dark gray – hearth, black – chipped industry, white – bones, red line – edge of area of excavations.

f) a few isolated accumulations of bones and chipped stone industry outside the main accumulation on the western edge (non-specific working space – work with the hunted animals?)

Two samples of the animal bones were taken for radiocarbon dating during the laboratory treatment of the assemblage in 2005. Relevant results were not obtained due to low collagen content. Lubná III is not accessible for evaluation, therefore we can only work with publication of M. Otte (1981).

It consist of 1442 artefacts, almost all of them are silicites of glacigenous sediments (local raw materials are represented only by 0.3%).

The largest group are fragments (32.2%), followed by flakes (14.4%), blades (6.3%) with microblades (10.5%). Burin spalls make up 5.8% of the assemblage and microchips 22.3%. Cores make up only 1.2% of the assemblage. Tools make up 7.2% of the total assemblage.

The composition of the tools is typically Gravettian, with burins (29 artefacts) prevailing over backed side blades (28). Besides these the assemblage contains 3 La Gravette points and 14 Microgravettes. Endscrapers (1) and borers (2) are only marginal. Three blades are truncated with cross retouching. There are ten retouched blades and six notches. Eight artefacts are combined tools (Otte 1981, 242-247).

As in the case of Lubná III, assemblage of Lubná IV is not accessible for evaluation, therefore we can only work with publication of M. Otte (1981). It consist of 566 artefacts, all of them are silicites of glacigenous sediments.

The largest group are flakes (23.1%), followed by fragments (21.9%), blades (11.8%) with microblades (8.1%). Burin spalls make up 4.4% of the assemblage and microchips 17.1%. Cores make up only 0.9% of the assemblage. Tools make up 12.5% of the total assemblage.

The composition of tools is also typically Gravettian, with burins prevailing (21 artefacts), followed by retouched blades (15) and backed blades (13). Besides these the assemblage contains Microgravettes (5), only marginal are endscrapers (2), borers (1) or retouched flakes (1). Two blades are truncated with oblique cross retouching (pointed blades). Two artefacts are notches. Nine artefacts are combined tools (Otte 1981, 247-251). Lubná V an VII are just mentined in regional literature and no pieces of chipped industry are known.

Only 64 chipped stone artifacts from Lubná VIII are held at the Museum of T.G.M. in Rakovník, located in the 'guard house'. This is a small, but significant assemblage, certainly belonging to the Gravettian period.

The types of raw material used here correspond to the composition of the assemblages from other parts of the site. Erratic flint is predominant, comprising 62 artefacts (96.9%). The remaining two artefacts were made of Skršín quartzite (3.1%) from the eastern edge of the Podkrušnohorská Basin, 40 km away from the site. Erratic flint was brought from a distance of at least 120 kilometers.

The majority of the assemblage is made up of flakes (54.7%), followed by blades (17.2%) and microblades (4.7%). The assemblage also contains fragments (18.8%) and a few types (4.7%). Cores, burins spalls and microchips are not present in this assemblage.

Only three tools are present in this assemblage – a microlithic La Gravette point, a microburin on backed microblade and a straight truncated blade.

Site VI was discovered in 2006 not far from stations I-IV. The station's section was uncovered in a road cut (Šída *et al.* 2009). In 2012 a small trench was excavated. Central fireplace with ash pit, stone industry and huge amount of bones was discovered. Assemblage of 2012 trench consists of 155 artefacts, almost all of them are silicites of glacigenous sediments (only 4.3% are of local origin).

The largest group are flakes (24.7%), followed by blades (16.6%) with microblades (6.8%) and fragments (11.1%). Burin spalls make up 1.2% of the assemblage and microchips 31.5%. Cores make up only 0.6% of the assemblage. Tools make up 7.4% of the total assemblage.

There are only 12 retouched tools in assemblage of 2012 trench. Microlithic tools (two microlithic Gravette points and two microlithic backed blades) and laterally retouched blades are prevailing with 4 pieces. Other types are present only in one piece. These are: diedric burin, fragment of gravettian point, truncated blade and combination of diedric burin and truncated blade.

During 2018 excavations more 20 sq m were excavated and second fireplace was uncovered. Between both fireplaces large cummulation of chipped industry was explored. Dating of station is similar to the station I (Wilczyński *et al.* in pres). Evaluation of all aspects of excavations is now in progres by J. Wilczyński.

As resume we can stretch on the most significant signs of Lubná site cluster. It is the only place in Bohemia, where several stations are located in a such small area. Dating of all fits to the upper gravettian period. Dominating raw material are silicites of glacigenous sediments coming from north (Silesia and Saxony). In small amount we can find quartzites of north western Bohemia and Bavarian plattensilex. All sites have very low amount of cores, and that present on sites are at high stage of exploitation. Microchips, flakes and burin spalls demonstrate the blades and tools production on sites. Tool composition is typical for gravettian with gravettian points and micro points, domination of burins and with numerous microlits. Kostenki points are missing. Specific is presence of typical pavlovian microliths in Lubná II. Art objects are almost missing – the only one piece is small pendant made of mammoth tusk coming from Lubná II. Reindeer is dominating in all faunal assemblages evaluated until now. This comes together with high elevation of sites coming to more than 350 m a.s.l. Reindeer teeth show us summer period of occupation on site Lubná I. The Lubná sites seems to be summer short time hunting camps specialised on reindeer hunting, but, in contrast, on Lubná VI we have minimum reindeer antlers what shows not summer time of occupation.

During more than one hundred years was explored unique concentration of small gravettian camps. In short we can this site present also as example of history of palaeolithical research. As we asumed, there are still archaeological situations hidden in the loess. Last year excavation explored largest situation ever found here. And research will continue during next years.

Acknowledgement

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Les occupations de plein air du Paléolithique supérieur à la périphérie des Carpates roumaines

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Résumé

De nombreuses fouilles ayant livré un abondant matériel paléolithique ont été réalisées tant en grottes qu'en plein air durant la période communiste. Cependant, les publications roumaines demeurent peu connues en dehors du pays jusqu'à la découverte dans la grotte de Pestera cu Oaşe des plus anciens restes d'Hommes anatomiquement modernes en Europe. La position de carrefour de la Roumanie à la croisée du couloir danubien, des plaines orientales et du bassin pannonien est généralement peu prise en compte dans les publications récentes. Les assemblages du paléolithique supérieur ont été attribués à différents techno-complexes et périodes plus sur le modèle des classifications françaises que des données de l'Europe centrale et orientale. A partir de la fin 20e siècle la chronologie de plusieurs sites de plein air en contexte loessique situés à la périphérie des Carpates (Moldavie, Dobroudja, plaine orientale du Danube) a été réévaluée sur base de nouvelles datations (dates 14C, dates IRSL sur loess, dates ESR/U-Th sur dents), d'analyses biostratigraphiques et pédostratigraphiques ainsi que de nouvelles lectures du matériel lithique. L'impact des processus taphomoniques a également été pris en compte dans les régions au faible bilan sédimentaire limoneux (Banat, Oaş, Maramureş).

Mots clés : Paléolithique supérieur ; périphérie des Carpates roumaines ; gisements de plein air

Abstract

During the communist period, the excavations were numerous in caves and open air sites. The palaeolithic record is abundant. The Romanian publications remained poorly known outside Romania until the recent discovery of the oldest European AMH remains at Oase Cave. The location of Romania at the crossroad of the Danube corridor, the Eastern plains and the Pannonian Basin is rarely taken into account in recent publications. The Upper Palaeolithic assemblages were assigned to different techno-complexes and time-periods more inspired by the French classifications than by the results obtained in Central and Eastern Europe.Since the end of the XXth century, the chronology of several intraloessic Upper Palaeolithic sites around the Carpathians, located in Moldova, Dobrogea and Eastern Danube Plain, has been re-examined and better defined on the basis of new chronological data (14C, IRSL ages on loess, ESR/U-Th ages on teeth), biostratigraphic and pedostratigraphic evidence and re-evaluation of lithic assemblages. The impact of taphonomic processes in regions with thin loamy deposits (Banat, Oas, Maramures) is also better known.

Keywords : Upper Palaeolithic; Romanian Moldova; Dobrudjaa; Danube Plain; Oaş; Maramureş; open air sites

1. Introduction

Les sédiments éoliens et les dépôts de versant observables à la périphérie des Carpates roumaines (Moldavie roumaine, Plaine du Danube, Banat, bassins de l'Oaş et de Baia Mare) recèlent de nombreux témoignages d'occupations humaines remontant aux stades isotopiques marins (SIM) 3 et 2. Les pièces lithiques sont attribuables à différents techno-complexes de la fin du Paléolithique moyen et du Paléolithique supérieur. Leur interprétation s'avère parfois délicate, surtout lorsqu'il s'agit de matériaux provenant de fouilles anciennes. Les restes de mammifères ne sont conservés qu'en Moldavie roumaine. Les enregistrements limono-sableux des collines subcarpatiques et les séquences loessiques bordant la vallée du Prut sont particulièrement développés avec des séquences archéologiques comprenant de nombreux niveaux souvent bien individualisés (vallée de la Bistrița et gisements de Mitoc-Malu Galben et Ripceni-Izvor). Dans le sud-ouest (Banat) et le nord-ouest (bassins de l'Oaş et de Baia Mare) de la Roumanie, la faible épaisseur des dépôts du Pléistocène supérieur et des phénomènes taphomiques affectent la distribution verticale du matériel archéologique et, parfois, l'homogénéité des séries lithiques. L'interprétation de la datation des sédiments pour établir l'âge des ensembles lithiques y est souvent délicate.

Les études concernant le Paléolithique, et plus particulièrement le Paléolithique supérieur, s'inscrivent dans une longue tradition de recherches (Cârciumaru 1999). Elles connurent un développement important avant et après la 2e guerre mondiale en contexte karstique dans les Carpates, et aussi à leur périphérie, dans des dépôts de plein air, avec les recherches de N.N. Moroşan (1938), C.S. Nicolăescu Plopşor (Nicolăescu-Plopşor et Bolomey 1961 ; Nicolăescu-Plopşor *et al.* 1966), puis de M. Bitiri (Bitiri 1972 ; Bitiri et Căpitanu 1972), F. Mogoşanu (1978), A. Păunescu (1993), M. Cârciumaru (1989), V. Chirica (1989). Au cours des vingt dernières années, des inventaires (Păunescu 1998, 1999, 2000), des synthèses (Anghelinu et Niţă 2014 ; Anghelinu *et al.* 2018 ; Băltean 2011 ; Cârciumaru *et al.* 2007, 2010 ; Chirica et Borziac 2009 ; Chirica *et al.* 1996 ; Chu 2018 ; Cosac 2008 ; Dobrescu 2008 ; Noiret 2009) et des réévaluations de données et de sites connus (Alexandrescu *et al.* 2004 ; Anghelinu *et al.* 2012 ; Cârciumaru *et al.* 2006 ; Dobrescu et Tuffreau 2013 ; Dobrescu *et al.* 2015 ; Otte *et al.* 2007 ; Sitlivy *et al.* 2014 ; Steguweit *et al.* 2009 ; Tuffreau *et al.* 2009, 2013, 2014, 2018) ont renouvelé et enrichi une documentation qui, pendant longtemps, a été peu prise en compte dans les discussions ayant trait au Paléolithique supérieur européen. Cependant, les fragments crâniens mis au jour dans une grotte, « Peştera cu Oase », localisée dans un massif calcaire du Banat, dans la prolongation des Carpates méridionales, ont attiré l'attention sur le bassin oriental du Danube. Il s'agit des restes d'Homme anatomiquement moderne les plus anciens connus en Europe mais ils demeurent sans lien avec des éléments de culture matérielle (Rougier et Trinkaus 2012 ; Trinkaus *et al.* 2003).

Il convient de souligner qu'en raison du faible développement de l'archéologie préventive en Roumanie, la presque totalité des fouilles réalisées en plein air concernent des gisements du Paléolithique supérieur connus depuis plusieurs décennies.

Des travaux de terrain ont été menés en plein air à la périphérie des Carpates roumaines en Moldavie roumaine (vallées du Prut et de la Bistrița), dans la Plaine du Danube, le bassin de l'Oas et la dépression (Figure 1). Il a été ainsi possible de comparer les contextes stratigraphiques et géomorphologiques ainsi que leurs impacts sur l'interprétation des données archéologiques (Dobrescu *et al.* 2015 ; Dumitrascu et Vasile 2018 ; Tuffreau *et al.* 2009, 2013, 2014, 2018).

2. Contextes sédimentaire et chronologique

La plupart des données concernant le Paléolithique supérieur à la périphérie des Carpates proviennent de dépôts éoliens, des loess, et de formations limono-sableuses en position de versant. Les séquences loessiques les plus importantes, qui peuvent atteindre une vingtaine de mètres d'épaisseur en Dobroudja (Conea 1969), ont une étendue chronologique qui s'étend de la limite paléomagnétique Bruhnes/Matuyama jusqu'à la fin du Pléistocène supérieur (Balescu *et al.* 2003). Leur âge a été précisé au moyen de datations par luminescence (Balescu *et al.* 2003, 2010, 2013, 2018 ; Timar-Gabor *et al.* 2011). Malgré des conditions sédimentaires favorables, le matériel attribuable à du Paléolithique supérieur en Dobroudja demeure peu abondant (Păunescu 1999 ; Tuffreau *et al.* 2013.). Il est mieux représenté dans la Plaine du Danube (Păunescu. 2000 ; Păunescu et Alexandrescu 1997 ; Tuffreau *et al.* 2014) Les industries lithiques attribuables au Paléolithique

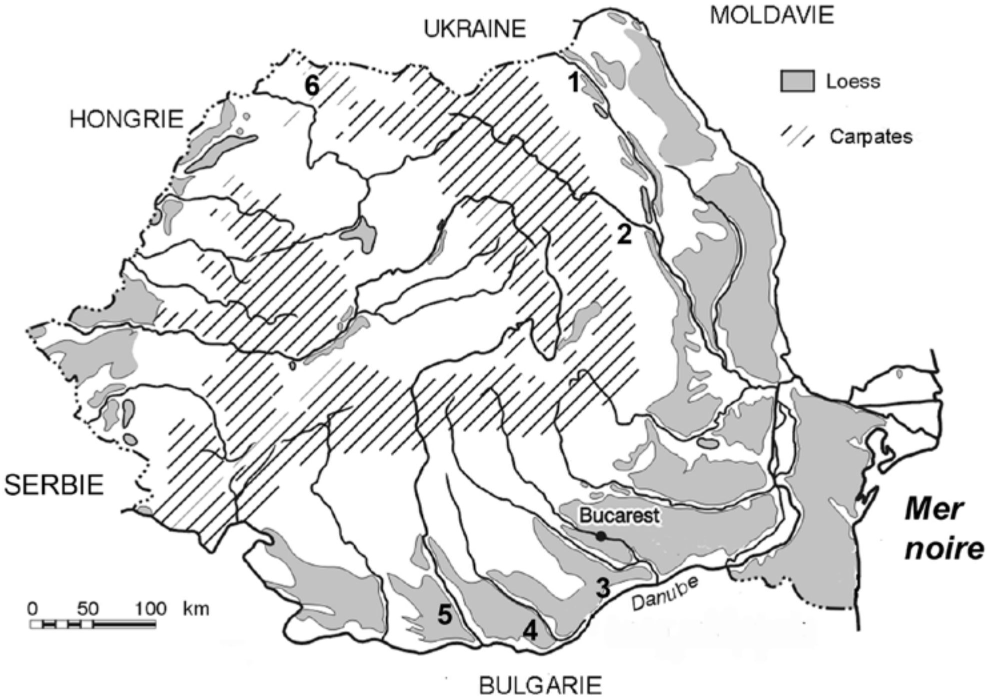

Figure 1. Carte de la Roumanie avec indication de la localisation des gisements cités.
1 : Mitoc. 2 : Buda et Lespezi. 3 : Giurgiu-Malu Roşu. 4 : Ciuperceni-La Vii1.
5 : Vădastra-Măgura Fetelor. 6 : Bassin de l'Oaş.

supérieur sont particulièrement abondantes dans les épaisses séquences de la vallée du Prut avec les gisements de Ripiceni Izvor (Păunescu 1993) et de Mitoc-Malu Galben (Otte *et al.* 2007) dont la séquence a été l'objet de nombreuses analyses pédo-sédimentaires et de datations 14C (Haesaerts *et al.* 2003, 2007a et b). Dans la moyenne et la basse vallée de la Bistrița, qui traverse des collines subcarpatiques, au pied des Carpates orientales jusqu'à sa confluence avec le Siret, le matériel archéologique (industries lithiques et ossements de mammifères) provient de sédiments limono-sableux tapissant les versants de la vallée (Bitiri-Ciortescu *et al.* 1989 ; Căpitanu *et al.* 1962 ; Cârciumaru *et al.* 2006 ; Păunescu 1998 ; Tuffreau *et al.* 2018).

Dans le nord-ouest de la Roumanie, des industries lithiques attribuables à du Paléolithique supérieur sont connues dans les bassins de l'Oaş et de Baia Mare (Bitiri 1972 ; Dobrescu *et al.* 2018) mais le matériel lithique, le seul qui soit préservé en l'absence de conservation des restes osseux, provient de sédiments loessiques peu épais parfois affectés par des remaniements (Tuffreau *et al.* 2013).

3. Moldavie roumaine

3.1. Mitoc-Valea Izvorului

Le gisement paléolithique de Mitoc Valea Izvorului (département de Botoşani) est situé sur la rive droite de la vallée du Prut, un affluent du Danube, à 300 m au nord-ouest du gisement aurignacien et gravettien de Mitoc Malu Galben (Otte *et al.* 2007). Des fouilles ont été réalisées en 1956 par C.S. Nicolăescu et N. Zaharia (Nicolaescu-Plopşor et Zaharia 1959) puis par M. Bitiri (Bitiri 1965 ; Bitiri et Cârciumaru 1978). Le matériel lithique serait, en grande partie, attribuable à une industrie de transition entre le Paléolithique moyen et le Paléolithique supérieur en raison de ses caractéristiques qui associeraient des éléments supposés être attribuables au Paléolithique moyen (débitage Levallois, racloirs et denticulés) et au Paléolithique supérieur (débitage laminaire, grattoirs et burins). Le gisement de Mitoc-Valea Izvorului a été parfois considéré comme étant l'un des sites de référence pour la transition entre le Paléolithique moyen et le Paléolithique supérieur à l'Est des Carpates (Allsworth-Jones 1986 ; Chabai *et al.* 2004). De nouvelles fouilles ont été entreprises en 2003 et 2004 pour tenter de préciser le cadre stratigraphique, l'âge et la nature de l'industrie lithique de ce gisement (Tuffreau *et al.* 2009).

La séquence loessique de Mitoc Valea Izvorului repose sur les graviers fluviatiles d'une ancienne terrasse du Prut, la terrasse III culminant à 110 m d'altitude soit 20 m au-dessus de la terrasse II de Mitoc Malu Galben (Haesaerts 2007b). Cette séquence de 6 m d'épaisseur montre une superposition de deux dépôts loessiques L1 et L2 séparés par un paléosol brunâtre (horizon argileux Bt) surmonté d'un horizon humifère et de dépôts limono-sableux. De nombreuses pièces (éclats, lames, déchets de débitage) proviennent d'une couche de sables subdivisant le loess L1 (niveaux archéologiques B2 et B3).

Des sondages à la tarière réalisés par P. Haesaerts entre Malu Galben et Valea Izvorului ont montré que ces sables correspondent à ceux de la sous-unité sableuse 1b de Malu Galben, rapportée à la fin du Pléniglaciaire supérieur, laquelle tronque les formations loessiques du site contenant les pièces gravettiennes et aurignaciennes (Haesaerts 2007b). Des pièces de facture paléolithique moyen ont été découvertes dans les unités loessiques sous-jacentes de Valea Izvorului. L'âge IRSL du loess L2 (160 ± 17 ka) suggère une mise en place au SIM 6 (Balescu *et al.* 2010).

Les fouilles récentes montrent donc que le gisement de Mitoc-Valea Izvorului recèle plusieurs niveaux d'industries lithiques attribuables à du Paléolithique moyen et à du Paléolithique supérieur. Ce constat est conforme avec les descriptions de C.S. Nicolaescu-Plopşor et N. Zaharia (1959) qui ont signalé la présence de six niveaux archéologiques différents dispersés dans une épaisse séquence limoneuse. Seul le niveau le plus récent contient de nombreuses lames alors que les cinq autres ont livré du matériel lithique au caractère moustérien. Ces observations, qui vont à l'encontre de l'existence d'une industrie de transition entre le Paléolithique moyen et le Paléolithique supérieur n'ont pas été reprises dans les publications des autres auteurs qui ont fait référence à Mitoc-Valea Izvorului.

3.2. Buda

Le gisement paléolithique supérieur de Buda (commune de Blăgeşti, département de Bacău) se situe au lieu-dit Dealul Viilor sur le flanc des collines subcarpatiques qui dominent la vallée de la Bistriţa. Le substrat est constitué de dépôts miocènes recouverts par des limons et des sables pléistocènes de faible épaisseur. Des fouilles y furent effectuées à la fin des années 1950 (Căpitanu *et al.* 1962 ; Nicolăescu-Plopşor et Bolomey 1961). D'abondants restes de Bison furent découverts.

De nouvelles opérations de terrain ont été réalisées de 2012 à 2014 (Tuffreau *et al.* 2018). Deux niveaux archéologiques (C1 et C2) ont été reconnus. Ils sont identifiables par la présence de pièces lithiques, de fragments de charbons de bois, de petites concentrations d'ocre et de restes osseux de grands herbivores qui, pour chaque niveau, se distribuent sur une dizaine de centimètres d'épaisseur dans un limon à 1,5 m environ sous la surface actuelle. La différenciation entre les niveaux C1 et C2 n'a pas toujours été possible à établir en raison de la répartition verticale du matériel archéologique.

Des dates non calibrées 14C AMS ont été obtenues à partir de fragments osseux : 23.300 ± 160 BP (OxA 29525) et 23.440 ± 160 BP (OxA 29526) ce qui correspond à des âges calibrés BC respectivement de 25.575 + 257/-238 et 25.650 +256/-223 (probabilité de 94,5% selon le programme Oxcal v.4.2 utilisant les données IntCal13) (Tuffreau *et al.* 2018). Ces résultats sont assez comparables à ceux obtenus par la datation 14C conventionnelle non calibrée (23.810 ± 190 BP, GrN-23072), qui avait été réalisée dans les années 80 (Păunescu 1998).

Les ossements fracturés sont surtout des éléments anatomiques des membres. Seuls ceux des extrémités sont entiers (phalanges, calcanéum, astragale...) ce qui est révélateur d'un site d'abattage de bison des steppes (Dumitraşcu et Vasile 2018).

Le matériel lithique, celui des fouilles anciennes ou récentes, comprend une majorité de produits laminaires (lames, lamelles) et d'éclats bruts, en majorité de plein débitage. Les nucléus sont absents. Les outils sont surtout des lames retouchées, des lamelles à dos, des microgravettes, des grattoirs et des burins. La présence de pointes à cran (Căpitanu *et al.* 1962) est à relever. Les matières premières sont variées : du silex pour la moitié des pièces dont une grande partie est originaire de la vallée du Prut, suivi par le chert et le grès. La ménilite, le schiste noir, le jaspe et le quartz sont peu fréquents.

L'industrie lithique de Buda est attribuable à un Gravettien récent, comprenant quelques pointes à cran, faciès, présent en Europe centrale vers 25-23 ka (Kozlowski 1998, 2007 ; Otte 1989) et, notamment, à Mitoc-Malu Galben (Noiret 2009 ; Otte *et al.* 2007).

3.3. Lespezi

Le gisement de Lespezi (département de Bacău) été découvert à quelques kilomètres en aval de Buda lors de l'exploitation d'une carrière située à une quinzaine de mètres au-dessus du cours actuel de la Bistrița. Six niveaux archéologiques (I à VI de haut en bas) sont inclus dans une séquence limono-sableuse de plus de six mètres d'épaisseur recouvrant d'anciennes alluvions (Bitiri et Căpitanu 1972 ; Bitiri-Ciortescu *et al.* 1989). L'étendue chronologique de ces niveaux est cependant relativement courte : dates 14C non calibrées : 18,03 + 0,35 ka BP (Bln 808) à 3,8 m de profondeur dans le niveau III ; 17,62 + 0,32 ka BP (Bln 805) à 1,8 m de profondeur dans le niveau II (Păunescu 1998). Des âges AMS non calibrés ont été obtenus sur les fragments osseux provenant des anciennes fouilles (Tuffreau *et al.* 2018) : 18.500 ± 110 BP (OxA-31557) dans le niveau II et 24.620 ± 190 BP (OxA-31556) dans le niveau VI (secteur T1) ce qui correspond respectivement à des âges calibrés de 20.450 +208/-372 BC et de 26.750 +404/-497 BC à 95,4% de probabilité (programme Oxcal 4.2, courbe IntCal 13). L'âge obtenu pour le niveau II n'est pas très différent de ceux résultant des datations 14C conventionnelles sur charbons de bois (Păunescu 1998) : niveau II (17.620 ± 320 BP, Bln-805) ; niveau III (18.110 ± 300 BP, Bln-806) ; niveau V (18.020 ± 350 BP, Bln-808). Le niveau VI dont le matériel n'avait pas été daté antérieurement, serait plus ancien de six millénaires. Les dates 14C non calibrées des niveaux II à V correspondent sur le plan chronologique au début de l'Epigravettien et celle du niveau VI au Gravettien (24,6 ka BP non cal) ce qui serait cohérent avec la présence de quelques pièces à cran dans la partie inférieure de la séquence stratigraphique (Figure 2).

Une nette organisation des vestiges apparait parfois (niveaux II, III et IV) avec des foyers, des concentrations d'ossements et de matériel lithique. Les grands herbivores sont dominés par le Renne (Rangifer tarandus) et le Cheval (Equus sp.), suivis notamment par le Bison (Bos/Bison, Bison priscus) et l'Elan (Alces alces). Les marques de boucherie sont très nombreuses ainsi que des traces de dépouillage sur les extrémités des membres de Renne (Bolomey 1989).

Par endroits, le sédiment présente des traces de combustion aux limites nettes avec des charbons de bois sur une épaisseur de 8 à 20 cm. Toutefois, il ne semble pas que les plans qui ont été publiés correspondent toujours à des occupations uniques bien différenciées (Bitiru-Ciortescu *et al.* 1989). Des pièces, parfois dispersées verticalement sur une épaisseur assez importante, ont été attribuées au même niveau. Il ne faut pas exclure la possibilité de remaniements occasionnés par des ruissellements sur le versant comme le montre la présence de limons sableux stratifiés observables dans la carrière actuellement en exploitation.

Un examen du matériel lithiques des niveaux II, III et IV provenant des anciennes fouilles a montré la présence de caractères technologiques et typologiques assez homogènes. Le débitage

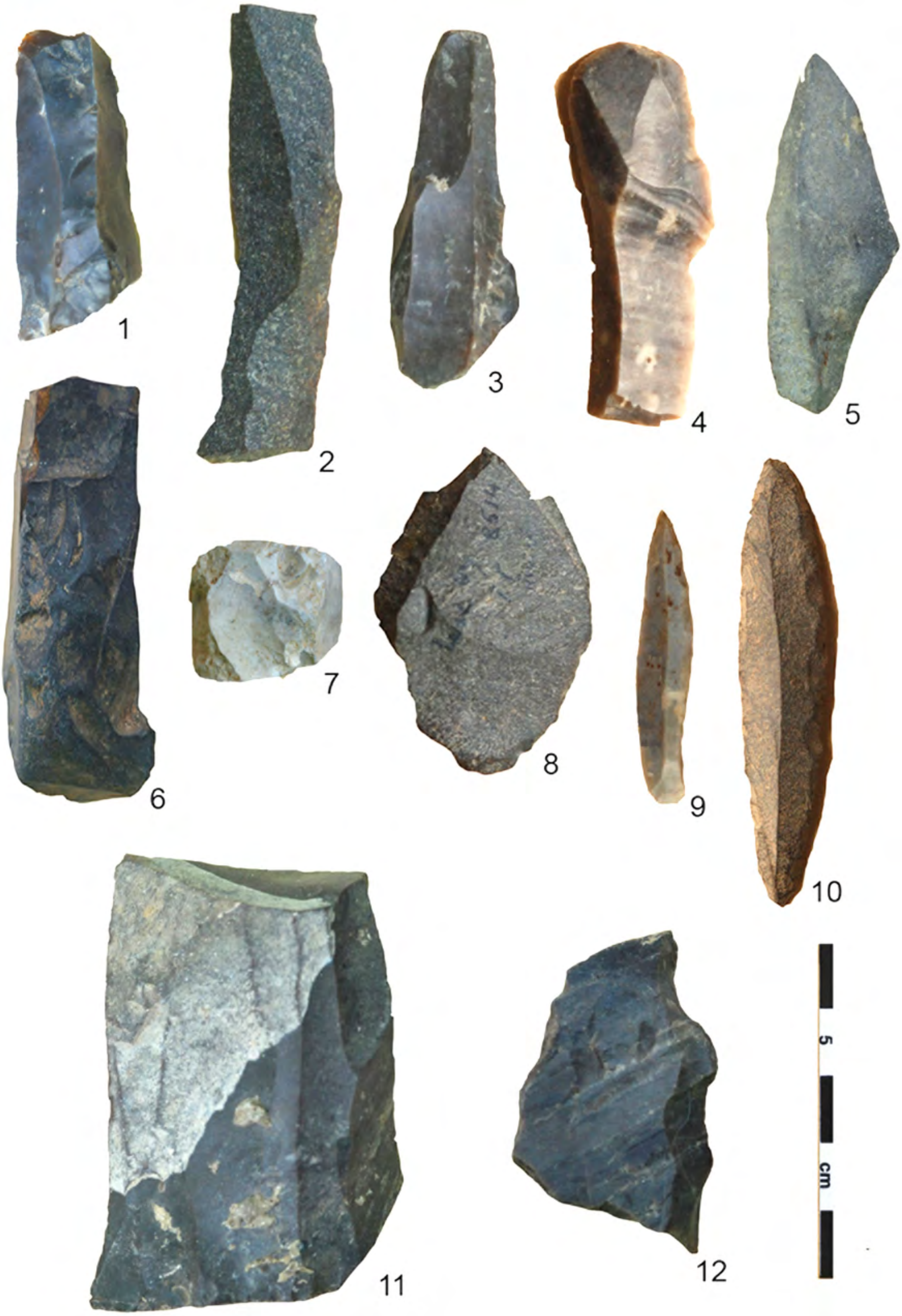

Figure 2. Lespezi. Industrie lithique. 1 à 3 : lames (niveau II). 4 : grattoir (niveau III).
5 : burin (niveau IV). 6 : nucléus (niveau I). 7 : nucléus (niveau II). 8 : burin (niveau VI).
9 : Gravette (niveau III). 10 : lame appointée (niveau VI). 11 : nucléus (niveau V).
12 : encoche (niveau IV).

laminaire prédomine nettement. Toutes les phases technologiques depuis la mise en forme des nucléus jusqu'à leur abandon sont présentes. Les outils, des burins, grattoirs, lamelles à dos et lames retouchées, sont peu nombreux (2,16% à 3,81% du matériel lithique des différentes séries). Les matières premières sont diversifiées (ménilite, silex, chert, grès, schiste noir). Les provenances sont des sources secondaires situées dans le bassin de la Bistriţa mais aussi dans la vallée du Prut et probablement aussi la vallée du Danube (Ciornei 2015 ; Crandell *et al.* 2013 ; Moreau *et al.* 2018).

Le matériel de Lespezi est celui de chasseurs saisonniers de Renne, de Cheval et de Bison qui se sont déplacés le long de la vallée de la Bistriţa. Malgré une étendue chronologique couvrant le Gravettien récent et l'Epigravettien ancien, soit plusieurs milliers d'années, le matériel lithique ne présente pas de différences significatives.

4. Plaine du Danube

Les gisements attribuables au Paléolithique supérieur sont rares au sud des Carpates, dans la Plaine du Danube. Les conditions sédimentaires sont cependant favorables avec la présence d'épais dépôts de loess ainsi que l'atteste la découverte de silex taillés. Leur diagnose est difficile à établir en raison de leur faiblesse numérique (Păunescu 2000). Seuls ceux mis au jour au sud de la Plaine du Danube, à Vădastra-Măgura Fetelor (département de l'Olt), Ciuperceni la Vii1 (département de Téléorman) et à Giurgiu-Malu Roşu (département de Giurgiu) ont un matériel lithique abondant. Les outils retouchés sont rares à l'exception de Vădastra-Măgura Fetelor.

4.1. Giurgiu-Malu Roşu

Des ateliers de débitage ont été fouillés à Giurgiu-Malu Roşu dans deux niveaux d'occupation inclus dans un loess (L1) reposant sur les graviers fluviatiles d'une basse terrasse du Danube (« terrasse de Giurgiu »). Une attribution à un Aurignacien « tardif » a été proposée en raison de la présence de quelques grattoirs (Figure 3) dont la morphologie évoque celle de grattoirs carénés (Păunescu et Alexandrescu 1997). Plusieurs foyers en place ont été identifiés au sein du niveau archéologique inférieur. Deux échantillons de charbon de bois, issus de ces foyers, ont été datés par 14C (21-23 ka BP non calibrées). Un échantillon destiné à la datation IRSL a été prélevé directement sous le niveau inférieur. L'âge IRSL obtenu (27 ± 3 ka) est cohérent avec les dates 14C (Alexandrescu *et al.* 2004 ; Balescu *et al.* 2010).

4.2. Ciuperceni-La Vii 1

Plusieurs niveaux archéologiques sont observables dans une séquence de loess et de limons argileux attribuables au MIS 10 (Balescu *et al.* 2003, 2010). Ces derniers colmatent une dépression incisant un pédocomplexe incluant d'abondantes concrétions calcaires. Des fouilles ont été effectuées de 2006 à 2008, ainsi qu'en 2010, dans une ancienne carrière qui a exploité la couverture limoneuse et les anciennes alluvions du Danube (Dobrescu *et al.* 2015 ; Tuffreau *et al.* 2014). Des recherches y avaient été menées de 1977 à 1979 par V. Boroneanţ (1980). Le matériel lithique avait été attribué à de l'Aurignacien (Paunescu 2000).

Quatre niveaux archéologiques (A, B, C, D1 et CR), uniquement identifiables par la présence de silex taillés, ont été reconnus dans le loess L1 qui colmate une dépression entamant un paléosol rougeâtre. En l'absence de matière organique et de restes fauniques, des datations IRSL ont été réalisées à partir d'échantillons prélevés entre les niveaux archéologiques B et C et dans le paléosol rougeâtre situé à la base de la séquence.

L'âge IRSL obtenu dans le loess L1 entre les niveaux archéologiques B et C est de 30 ± 3 ka ce qui équivaut à une date 14C non calibrée d'environ 25 ka BP. L'âge IRSL du paléosol rougeâtre est de 329

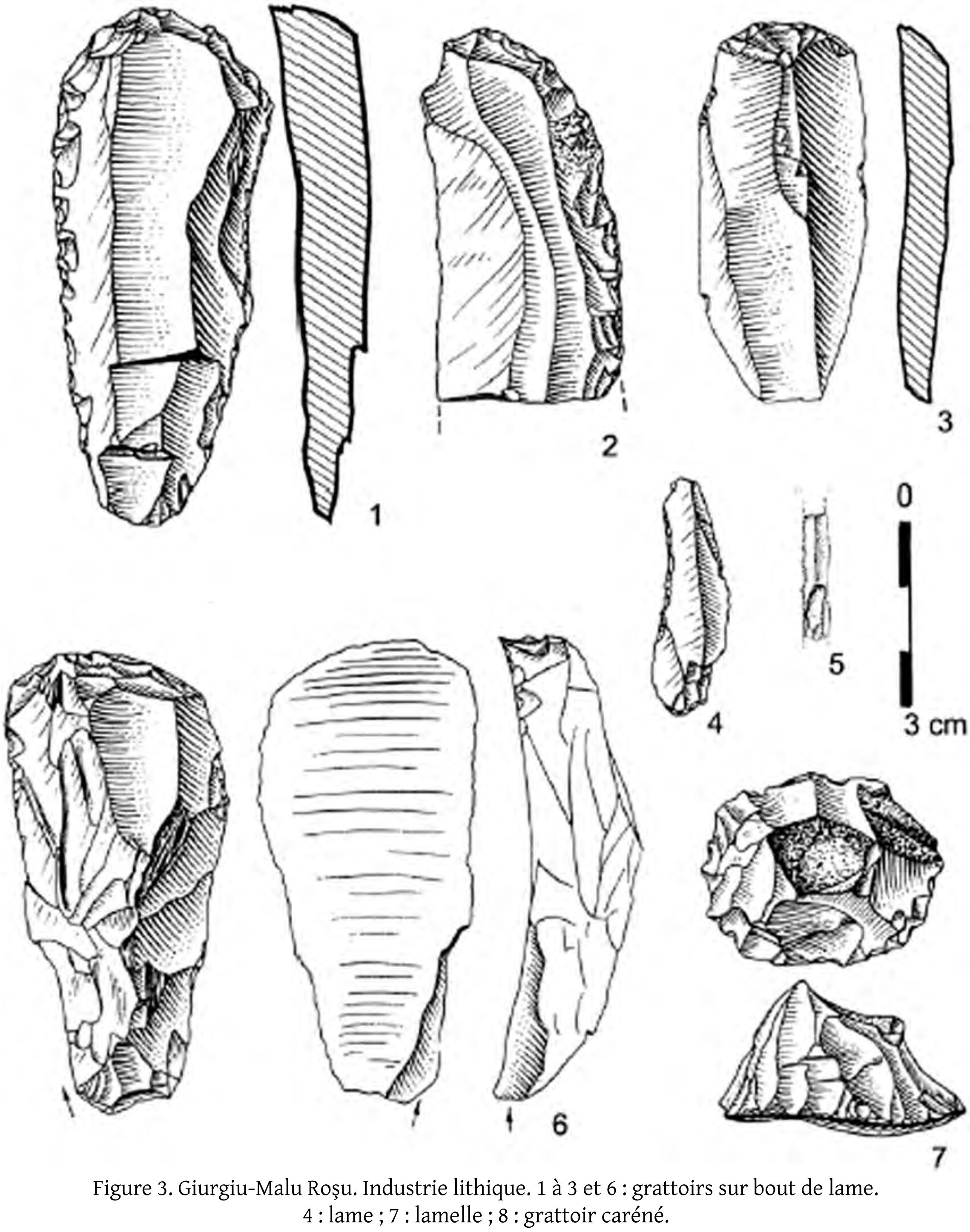

Figure 3. Giurgiu-Malu Roșu. Industrie lithique. 1 à 3 et 6 : grattoirs sur bout de lame.
4 : lame ; 7 : lamelle ; 8 : grattoir caréné.

± 51 ka (Balescu *et al.* 2018). Ce paléosol est donc vraisemblablement l'équivalent du sol rougeâtre S3 observé au sein des coupes de Tuzla, Mircea Vodă et Mostiştea (Balescu *et al.* 2003, 2010).

Le silex de la craie provenant des alluvions du Danube et d'un affleurement local a été utilisé dans toutes les séries lithiques des niveaux de « La Vii1 » (Ciornei 2017). Ces dernières présentent un certain nombre de caractéristiques communes : débitage laminaire au percuteur dur, produits de débitage abondants, nombre élevé d'esquilles, net faciès d'atelier. Les pièces des niveaux A et B appartiennent à la même industrie lithique. Les nucléus ont majoritairement été apportés préformés dans les séries A et B où les éclats corticaux ne sont pas très nombreux. Les nucléus montrent l'existence d'un débitage laminaire semi tournant ou d'un débitage réalisé à partir d'une surface de débitage unipolaire ou bipolaire. Il en est de même dans la série D1. Les outils, quelques lames retouchées, encoches et troncatures, sont peu nombreux.

Dans le niveau CR, les éclats corticaux sont mieux représentés. Le silex local au cortex très frais est plus fréquent ce qui dénote d'une collecte de rognons de silex dans un affleurement proche de la craie. Dans l'ensemble la qualité du silex utilisé est assez médiocre. Les nucléus à débitage laminaire semi tournant et les nucléus à lames à un ou deux plans de frappe dominent nettement avec des changements de direction fréquents. Les lames du niveau CR sont allongées, légèrement arquées et obtenues par un débitage au percuteur dur. L'outillage comprend quelques grattoirs sur bout de lame ainsi que quelques grattoirs carénés, burins, lames tronquées, encoches et denticulés. Il faut souligner la présence dans la série CR de rabots dont la partie fonctionnelle a été aménagée sur des rognons de silex qui ont gardé une grande partie de leur cortex (Figures 4 et 5).

Les pièces des niveaux A à D1 sont probablement attribuables à une phase ancienne du Gravettien ce qui serait en accord avec la datation IRSL. Par contre, le matériel lithique du niveau sous-jacent CR est plus ancien sans que l'on puisse déterminer l'écart chronologique qu'il présente avec les pièces lithiques des niveaux A à D1. Le faible nombre d'outils retouchés constitue un handicap pour une attribution culturelle. Seule la présence de rabots constitue un caractère original.

4.3. Vădastra-Măgura Fetelor

Le gisement de Vădastra (département de l'Olt) est situé dans la Plaine du Danube, à l'ouest de l'Olt, sur une colline dénommée « Dealul Cişmelei » dominant le ruisseau Obârşia. Il est surtout connu pour le riche matériel néolithique et protohistorique mis au jour lors d'importantes fouilles dont les dernières furent menées sur une superficie de 2400 m^2 de 1946 à 1974 par C. Mateescu (1959, 1970). De nombreuses pièces lithiques paléolithiques ont été découvertes, en position secondaire dans les structures néolithiques et protohistoriques ainsi que dans la partie supérieure du loess jusqu'à une profondeur d'environ 2,6 m.

Les pièces paléolithiques se différencient aisément du matériel lithique néolithique par leur patine blanchâtre à beige. Les matériaux utilisés sont variés : opale, jaspe, agate, quartzite, calcédoine, avec une prédominance du silex dont la source d'approvisionnement est un dépôt alluvial similaire dont il n'a pas encore été possible de préciser la localisation (Ciornei *et al.* 2017).

Des analyses palynologiques (Arl. Leroi-Gourhan *et al.* 1967) indiquent un paysage steppique avec la présence de quelques espèces arborées, des pins et aussi des feuillus (Betula, Alnus, Corylus, Quercus, Tilla, Ulmus, Hedera) témoignant d'une amélioration climatique qui a été attribuée à l'interstade de Paudorf.

Le matériel lithique a été brièvement décrit par J. Hahn (1977) qui l'a attribué à un Aurignacien typique. A. Păunescu (2000) se basant sur des considérations typologiques distingua une série moustérienne (490 pièces) et une série aurignacienne (1601 pièces) que rien dans l'état physique des pièces ne permet différencier.

Un sondage d'une quinzaine de m^2 et d'une profondeur d'un peu plus de 3 mètres a été ouvert à 70 m au nord-est du sommet d'un léger tertre « Măgura Fetelor » qui n'est actuellement plus discernable dans le paysage. Le profil stratigraphique observable dans les parois du sondage montre la présence, sous un limon humifère brun foncé, d'un chernozem de surface, comprenant de nombreux fragments de poterie puis d'un loess jaune brunâtre subdivisé par un niveau de granules de craie. Plus bas, la sédimentation observée dans un carottage à la tarière devient sableuse. Il n'a pas été possible de trouver de silex taillés à l'état physique comparable à ceux de l'assemblage paléolithique supérieur, probablement en raison de la superficie restreinte du sondage par rapport aux fouilles de C. Mateescu qui se sont déroulées pendant 28 années et ont couvert une superficie

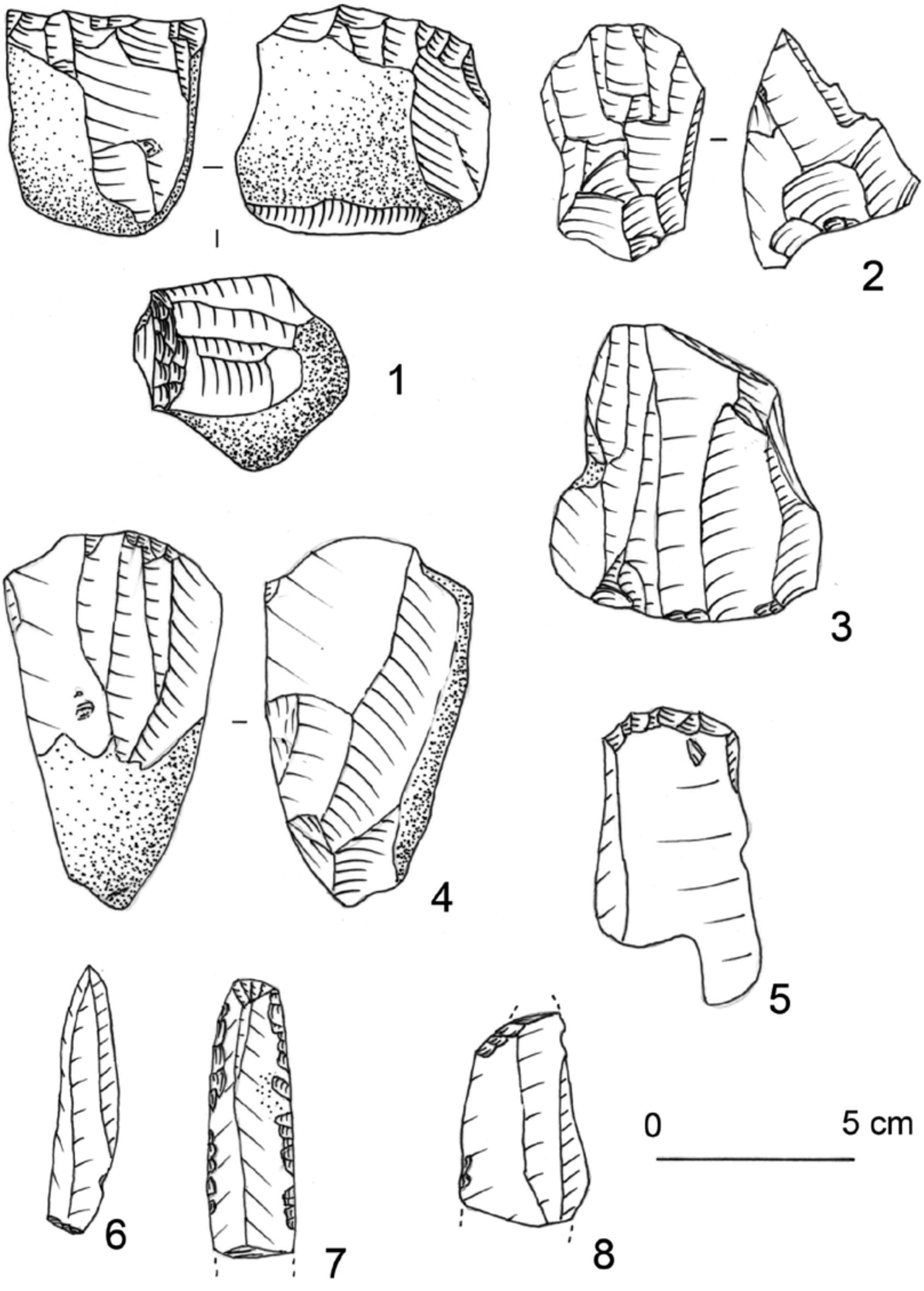

Figure 4. Ciuperceni-La Vii1. Niveau CR. 1 à 4 : nucléus 5 : grattoir.
6 : lame. 7 : grattoir sur lame retouchée. 8 : lame tronquée.

importante. La présence de krotovines avec les mélanges de sédiments que cela implique ne peut que laisser dubitatif sur la validité des analyses palynologiques réalisées par Arlette Leroi-Gourhan (Leroi-Gourhan *et al.* 1967)

Les nucleus à lames (28,57%) et ceux à lamelles (31%) dominent avec pour les ¾ d'entre eux un débitage semi-tournant sur un ou deux flancs, les autres présentant un débitage tournant. Les nucleus à éclats sont moins nombreux. Les supports laminaires bruts comprennent une majorité

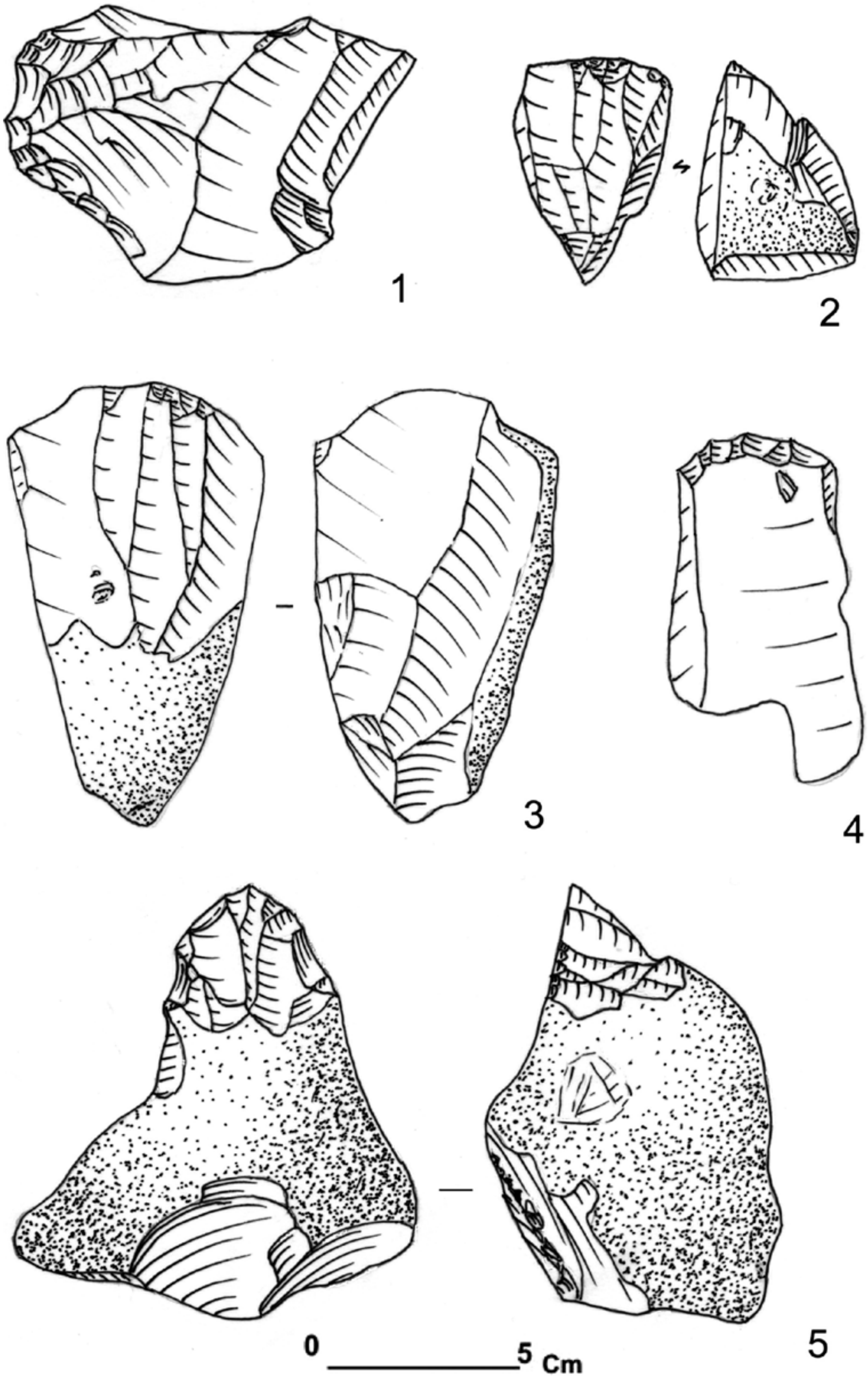

Figure 5. Ciuperceni-La Vii 1. Niveau CR. 1 : grattoir caréné sur nucléus. 2 : nucléus à lamelles. 3 : nucléus à débitage laminaire. 4 : grattoir sur lame. 5 : rabot.

de lames, assez larges, obtenues par percussion dure pour les 4/5e d'entre elles. Leurs talons sont en majorité lisses. Les lamelles, assez nombreuses, sont très fragmentées. Elles ont surtout été obtenues par percussion tendre.

Les outils (249 pièces sur 229 supports) sont dominés par les lames retouchées (21,4%) parmi lesquelles on relève des lames aurignaciennes (16% des lames retouchées). Puis viennent les grattoirs dont 6 carénés, 2 à museau, 2 en bout de lame et 1 sur éclat. Les huit lames aurignaciennes présentent une retouche écailleuse typique. Une des caractéristiques de l'outillage est la présence de légères denticulations sur les lames retouchées et sur les fronts des grattoirs. Les burins (burins dièdres, d'angle sur cassure ou sur troncature, burins carénés, burins busqués) constituent une catégorie assez mal représentée. Par contre, les outils de type paléolithique moyen (racloirs, denticulés, encoches...) représentent le tiers de l'outillage. Il faut souligner l'absence de lamelles retouchées ce qui ne peut être imputable aux méthodes de fouille car les lamelles brutes sont assez nombreuses.

La présence de lames aurignaciennes, de nombreux grattoirs dont des grattoirs carénés, la rareté des grattoirs à museau et des burins correspondent à un Aurignacien ancien, faciès qui pour l'instant est peu représenté en Roumanie alors que technocomplexes à lamelles du début du Paléolithique supérieur sont connus dans le Banat (Mogaşanu 1978).

5. Nord-Ouest de la Roumanie : Oaş et Maramureş

La connaissance que nous avons des gisements du Paléolithique supérieur dans le Nord-Ouest de la Roumanie repose sur les fouilles que M. Bitiri (1972) réalisa au cours des années 1960 et au début des années 1970 à Boineşti, Remetea Somoş et Călineşti (département de Satu Mare), dans le bassin de l'Oaş et à Buşag (département du Maramureş) dans la dépression de Baia Mare. Il faut souligner la présence numériquement importante de pièces en obsidienne. Le matériel lithique des gisements du Nord-Ouest de la Roumanie est dispersé verticalement sans couches clairement distinctes dans des dépôts limono-argileux peu épais. Plusieurs séries lithiques, différenciées à partir de critères techno-typologiques, ont été attribuées à de l'Aurignacien, du Gravettien et parfois à du Paléolithique moyen. Des remontages effectués sur le matériel des fouilles réalisées à Boineşti en 2005 et 2006 et l'examen de l'orientation des pièces ont montré que des remaniements se sont produits à l'Holocène ainsi que le confirment des datations IRSL (Tuffreau *et al.* 2013). Des pièces de facture paléolithique moyen provenant du niveau inférieur D ont été alors incorporées dans les sédiments des niveaux C1 et C contenant de l'Aurignacien Figure 6). Ces observations amènent à considérer avec prudence l'intégrité des ensembles lithiques qui ont été reconnus dans le Nord-Ouest de la Roumanie.

Des matières premières très variées ont été utilisées. L'obsidienne occupe une place relativement importante dans l'outillage (Figure 7). Toutes les phases la chaîne opératoire sont présentes (Dobrescu et Tuffreau 2013). Les sources de l'obsidienne sont localisées jusqu'à une distance de 170 km sur le flanc des Carpates en Hongrie et en Ukraine (Dobrescu *et al.* 2018).

6. Conclusion

Les gisements paléolithiques de la périphérie des Carpates ici présentés se répartissent dans des entités bien distinctes : la bordure orientale (Moldavie roumaine avec son prolongement vers la Plaine du Danube) et les bassins du nord-ouest (Oaş et dépression de Baia Mare) adossés aux Carpates. Une sédimentation importante constituée de loess et de dépôts de versant a permis la préservation d'unités archéologiques souvent bien différenciées dans les vallées du Prut, de la Bistrița et du bas Danube avec une bonne conservation des restes osseux en Moldavie roumaine. Les matières premières locales ont été utilisées, parfois sur des distances de plusieurs dizaines de kilomètres comme le montre l'exemple du silex du Prut. Le transport de silex balkanique confirme la présence d'un axe de circulation nord-sud le long des vallées fréquentées par les chasseurs de grands mammifères (Renne, Bison) lors de leurs déplacements saisonniers. La présence d'industries aurignaciennes anciennes (vallée du Danube) et de technocomplexes à lamelles (Banat) confirme l'existence d'un axe de circulation est-ouest le long du Danube.

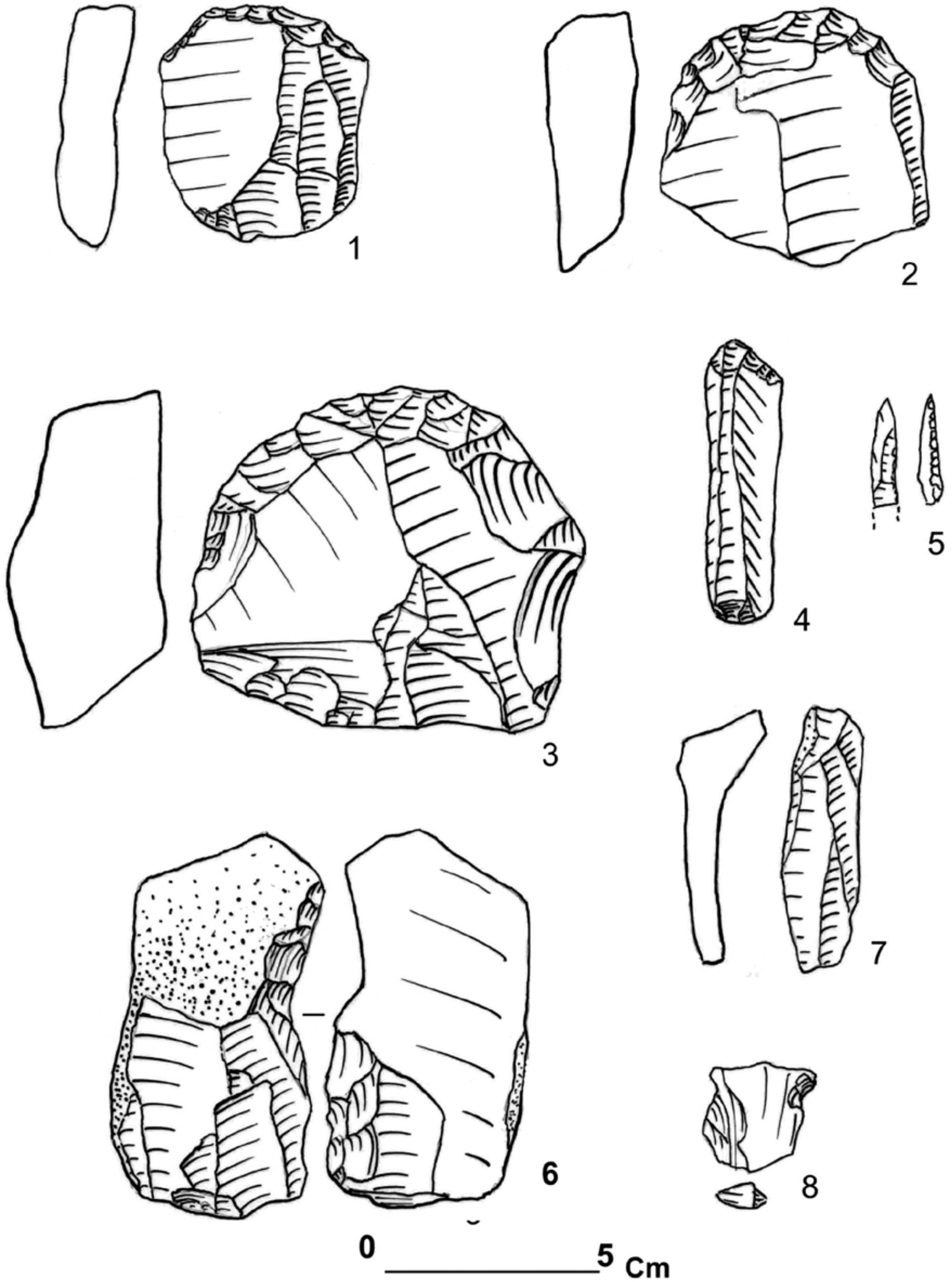

Figure 6. Boineşti. Niveau C1 (sauf le n°5, niveau C). 1 à 3 : grattoirs carénés. 4 : grattoir sur lame. 5 : lamelle à dos. 6 : racloir. 7 : lame outrepassée. 8 : encoche.

Dans le Banat, le bassin de l'Oaş et la dépression de Baia Mare, la faible épaisseur des dépôts du Pléistocène supérieur et des phénomènes taphomiques affectent la distribution verticale du matériel archéologique et, parfois, l'homogénéité des séries lithiques. L'interprétation de la datation des sédiments pour établir l'âge des ensembles lithiques y est souvent délicate.

Figure 7. Bassin de l'Oaş. Outils en obsidienne.
1 et 2 : Buşag. 3, 4 à 13 : Remetea Şomoş I. 14 : Călineşti I.

Les analyses techno-typologiques du matériel lithique et la détermination de la provenance des matières premières minérales exogènes permettent d'individualiser trois ensembles régionaux bien différenciés : la Moldavie roumaine avec, pour le Gravettien, des voies de circulation le long de la plaine du Prut jusqu'au bas Danube ; le Banat avec des technocomplexes à lamelles ; le nord-ouest (Oaş et Maramureş) avec, pour l'Aurignacien, des matières premières provenant de Transcarpatie, du nord de la Hongrie et de Slovaquie.

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So many caves, so little time: a preliminary report from a western Romanian karst survey

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Abstract

The nature and timing of the Neanderthal/modern human transition in Europe is a persistent research question in prehistory. Western Romania plays a key role in providing meaningful answers as it has produced indisputable early modern human fossils at a pivotal crossroads between Central Europe and the Balkan Peninsula. While regional paleogenetic and paleoclimatological records have progressed in the past decade, the associated archeological record has lagged behind providing only slight behavioral context due to a scarcity of well-stratified sites and reliable radiometric dates. In consideration of this, we report on a survey of caves in western Romania. We surveyed locations that previously yielded Paleolithic material and identified new ones where Paleolithic excavations have not taken place. We provide a preliminary assessment of the potential of these caves for future research and discuss some of the implications of the western Romanian karstic record for the Neandertal/modern human transition in Europe.

Keywords: early Upper Palaeolithic; Aurignacian; Gravettian; Neandertal; Romania

Résumé

La nature et le moment de la transition entre l'homme de Néandertal et l'homme moderne en Europe est une question de recherche récurrente dans la préhistoire. La Roumanie occidentale joue un rôle clé en fournissant des réponses significatives, car elle a produit des fossiles humains modernes incontestables, à un carrefour pivot entre l'Europe centrale et la péninsule des Balkans. Alors que les enregistrements paléogéniques et paléoclimatologiques régionaux ont progressé au cours de la dernière décennie, le dossier archéologique associé a tardé à fournir seulement un faible contexte comportemental en raison d'une pénurie de sites bien stratifiés et de dates radiométriques fiables. Dans ce contexte, nous présentons une étude des grottes dans la Roumanie occidentale. Nous avons étudié des endroits qui produisaient auparavant du matériel paléolithique et en avons identifié de nouveaux où des fouilles paléolithiques n'ont pas eu lieu. Nous fournissons une évaluation préliminaire du potentiel de ces grottes pour la recherche future et discutons de certaines des implications du dossier karstique roumain occidental pour la transition néandertal/homme moderne en Europe.

Mots-clés : Paléolithique supérieur ancien ; Aurignacien ; Gravettien ; Néanderthal ; Roumanie

Introduction

The nature and timing of the Neanderthal/modern human transition in Europe continues to be a major focus of prehistoric research. In the Late Pleistocene, modern humans dispersed from Africa spreading westward into the European continent interbreeding with and ultimately supplanting indigenous Neandertal populations. While the Paleolithic record is reasonably well understood in regional 'hotspots' such as southwestern France or the western Levant, other areas are more equivocal. The Carpathian Basin (Middle Danube catchment) is one such region. Despite a flood of high-resolution paleoclimatic reconstructions (Staubwasser *et al.* 2018; Obreht *et al.* 2019) and well-studied human fossil records, such as the Neandertal remains in the Croatian Zagorie (Karavanić *et al.* 2017), the region has been disproportionately absent from archeological discussions due to a paucity of stratified sites and a dearth of reliable radiometric dates (Chu 2018).

From what is known, the Middle Palaeolithic is supplanted by the early Upper Paleolithic beginning with the Initial Upper Paleolithic (Bohunician) and transitional (Szeletian) technocomplexes, though their origin and authorship are still not fully agreed upon. While the former has been suggested as an allochthonous assemblage remnant of a precocious modern human incursion (Tostevin and Skrdla 2006), the latter is seen as an indigenous development from the preceding Middle Paleolithic potentially influenced by incoming modern human populations (Hauck *et al.* 2016). Both the Bohunician and the Szeletian however, seem to be regionally confined to the northern extent of the Basin even though isolated finds are found further afield (Škrdla, 2013; Kaminská 2015). Overall, the early Upper Paleolithic record in the Carpathian Basin is dominated by the Aurignacian where some of the earliest dated deposits in Europe are documented at the extreme ends of the Middle Danube at Willendorf (AT) and Românești-Dumbrăvița (RO; Schmidt *et al.* 2013; Nigst *et al.* 2014; cf. Teyssandier and Zilhão 2018).

The western Romanian karst is a compelling aspect of this region because it attests to the earliest presence of modern humans in Europe (Moldovan *et al.* 2003; Soficaru, Doboș and Trinkaus 2006; Alexandrescu *et al.* 2010; Trinkaus, Constantin and Zilhão 2012). Additionally, because of the high degree of hybridization found among the Peștera cu Oase fossils, it is the only part of Europe where modern humans and Neanderthals are unambiguously known to have been contemporaneous during the Late Pleistocene and therefore provides singular insights into Neandertal/modern human interactions (Fu *et al.* 2015). These evidences are supplemented by other spectacular signs of early hominin presence in the form of early fossil footprints at Vârtop and Ciur Izbuc Caves (Onac *et al.* 2005; Webb *et al.* 2014) and parietal art such as at Coliboaia Cave (Clottes *et al.* 2011; Ghemis *et al.* 2011; Gély *et al.* 2018). However, in all of these instances, these traces are to date, found devoid of associated lithic artifacts.

What is known of the early Upper Palaeolithic in the region hails primarily from the open-air sites where an early Aurignacian is present even though most archeological sites are insecurely dated and stratigraphically mixed (Anghelinu *et al.* 2012; Anghelinu and Niţă, 2014; cf. Cârciumaru, Nițu and Bahn 2019). However, ongoing open-air excavations demonstrate that assemblages are rich in Paleolithic artifacts, contemporaneous with the modern human fossils, and regionally clustered such as in the Banat (Sitlivy *et al.* 2012; Schmidt *et al.* 2013). However, these sites have failed to produce any appreciable amount of organic preservation and it therefore seems evident that a main goal of research in this area is the connection of these cave and open-air archives.

Curiously, the archeological record of the western Romania caves provides little evidence for an early Upper Paleolithic presence potentially in part due to a complicated research history (Horvath 2009). Deep sequences from the investigated caves in western Romania contain early Middle Paleolithic, later MP and then Gravettian: Aurignacian, IUP or other early Upper Paleolithic assemblages are either absent, sparse, palimpsests or undated. This is exemplified by the Peștera cu Oase itself, which while providing direct testimony to modern human presence, failed to yield any concurrent archeological material in recent excavations (Hauck *et al.* 2017).

The situation is strikingly similar in neighboring regions. In the Hungarian Bükk Mountains and Croatian Zagorje, typologically early Upper Paleolithic lithics are exceedingly sparse. Recent efforts in central Serbia have also only yielded faint traces of early Middle/Upper Paleolithic material in short stratigraphic sequences (Kuhn, Mihailović and Dimitrijević 2014; Dogandžić and Đuričić 2017).

Several hypotheses might explain the scarcity of early Upper Paleolithic deposits in western Romanian caves:

- First is that in spite of a significant early Upper Paleolithic presence in the area, a limited amount of systematic research has yet to clarify the situation in the caves. This would appear to be confirmed by the rarity of early Upper Paleolithic finds in the neighboring regions combined with fieldwork continues to demonstrate that in spite of persistent Mousterian finds, the early Upper Paleolithic is notably absent (Cosac *et al.* 2018).
- A second possibility is that hominin populations were thin across the Balkan Peninsula during the Late Pleistocene (Kuhn, Mihailović and Dimitrijević 2014) possibly due to breaks in hominin settlement during Heinrich events 5-4 (Staubwasser *et al.* 2018). Such a scenario would be all the more plausible given demographic estimates suggesting that even at their peak, modern human populations across Europe were low (Bocquet-Appel *et al.* 2005; Schmidt and Zimmermann 2019).
- A third proposal is that upland regions, and by extension caves, were not the preferred habitat for early modern humans (Alex *et al.* 2019). The paucity of early Upper Paleolithic artifacts in caves suggest short, exploratory stops (Anghelinu and Boroneanț 2019) that may be the result of brief hunting incursions rather than sustained occupations (Patou-Mathis *et al.* 2016).
- A similar proposition is that Neanderthal populations persisted in western Romanian until relatively late (39 ka cal BP). These populations may have stymied the influx of early modern human populations into upland areas and restricted their movements to the river valleys (Borić *et al.* 2012; Marín-Arroyo and Mihailović 2017);
- A final hypothesis is that Late Pleistocene climate-driven sedimentation, erosion, and/or rockfall has erased or inhibited archeological excavations (Iovita *et al.* 2014).

It was with these hypotheses in mind that we (re)surveyed caves in western Romania in Brașov, Hunedoara, Bihor and Caraș-Severin counties to assess their Palaeolithic prospects.

Survey aims, objectives and methods

In this initial phase of investigation, we set ourselves two aims: first, to consider the potential of western Romania to examine the interrelationship between early human settlement and landscape evolution and second, to make an initial assessment of Paleolithic find spots for future archeological investigations. Among these were previously identified sites that were revisited. None of these sites were re-excavated or cleaned as part of our survey.

With these broad aims, our specific objectives were to:

1. Record the archeology (i.e. surface finds) and assess the potential of caves for future investigation.
2. Identify areas of archeological potential for more localized and intensive survey and record archeological material discovered during the course of the general reconnaissance.

A GPS device was taken so the survey team could identify topographic position and obtain precise coordinates of finds and other features (Figure 1). A photographic record was kept and all photographs were related to their position using a series of waypoints with GPS coordinates (Figure 2).

Results

20 caves were visited during the course of our survey. The following section reports on our preliminary assessment of the potential of sites for future study evaluated in terms of previous finds, lithic surface accumulations, cave morphology and geological and geomorphological context by observing existing sections. Our results are summarized in Table 1.

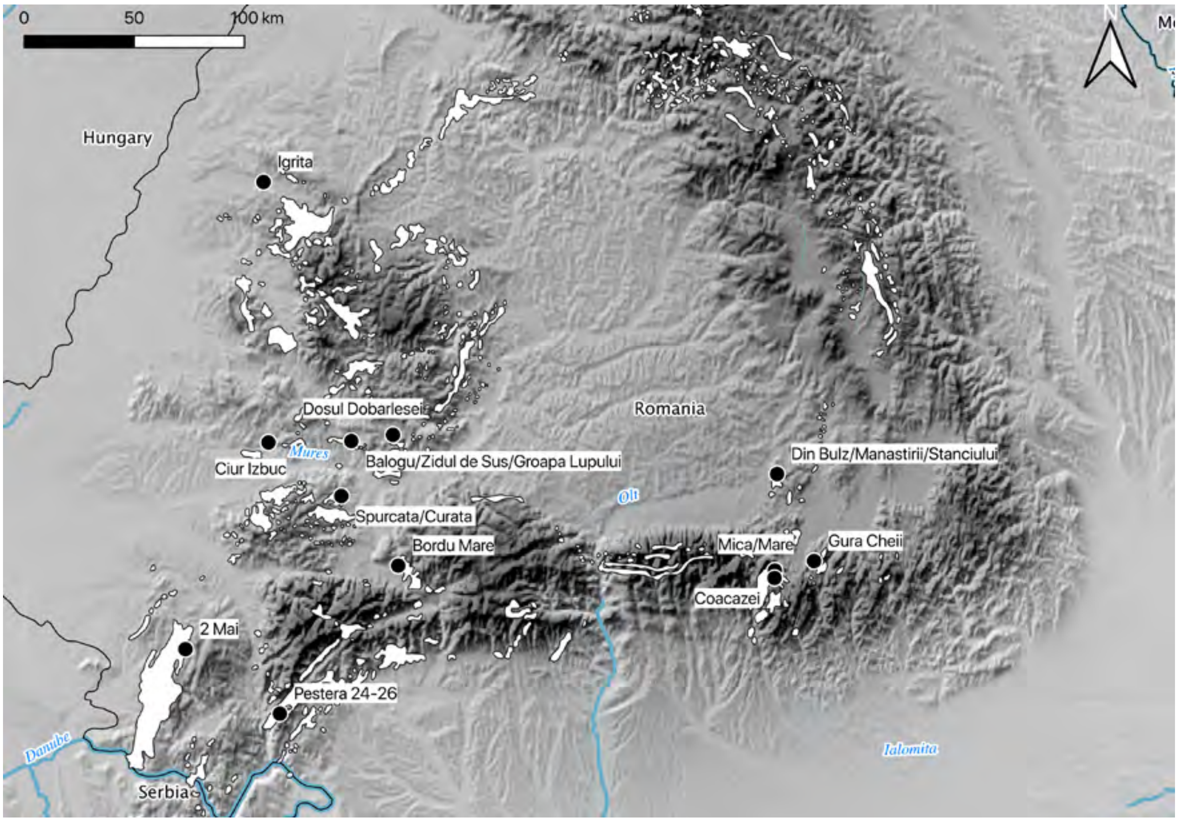

Figure 1. Map of caves visited in August 2018 along with other major human occupation finds. Including karst and major river systems. Karst is shown in white after Ponta and Onac (2019).

Braşov County

Mică and Mare (Liliecilor) Caves are located directly next to each other and were periodically excavated in the 1950s and 1990s. Test trenches at Mică Cave showed a ca. 0.8 m stratigraphic sequence where two sparse occupations were identified; one assigned to the Aurignacian and one to the Gravettian. In the Gravettian layer, a hominin femur diaphysis was reported. A sample of burned charcoal from the Gravettian layer indicated an age of 20,470 ± 140 BP (Păunescu 2001, p. 330). Limited *in situ* sediments were identified inside the cave during our visit.

The larger Mare Cave has a main gallery, ca. 160 m long, with a ca. 30 m long entrance with good daylight exposure. A previous ca. 80 sqm of excavated surface revealed a ca. 1.2 m thick stratigraphic sequence in which three Paleolithic layers were identified: one assigned to the Middle Paleolithic (featuring 44 lithics and dated to 38,700 ± 850 BP), one assigned to the Aurignacian (ca. 170 lithics) and an upper layer assigned to the Gravettian (39 lithics). Faunal remains were found throughout the sequence (Păunescu 2001, p. 319). However, the existence of the aforementioned three layers has been challenged stratigraphically (Cârciumaru *et al.* 2010). While a large portion of the cave entrance was excavated, there appears to be some areas with undisturbed sediments.

Valea Coacăzei (Gaura Sbârcioarei) was periodically excavated in the 1930s through the 2000s totaling ca. 25 sqm to a maximum depth of 2.8 m, though bedrock was never reached. Three Paleolithic layers (total number of lithics <50) containing faunal remains were attributed to the Middle Paleolithic, Aurignacian and Gravettian (Păunescu 2001, p. 332) though doubts have been raised regarding the cultural attribution of these assemblages (Cârciumaru *et al.* 2010). Although more than a half of the cave surface remains unexcavated, the steep ground slope may have significantly contributed to a displacement of archeological material.

Figure 2. Selected photographs of caves taken during the August 2018 survey.

Gura Cheii was last excavated in the 2000s. During previous excavations, two Middle Paleolithic, one Aurignacian and one Gravettian layers were identified throughout a ca. 2.2 m thick stratigraphic sequence all featuring dozens of lithics each (Păunescu 2001, p. 336). However, the Aurignacian character of the first Upper Paleolithic layer has again been contested (Cârciumaru *et al.* 2008). No prospective areas where *in situ* deposits might still be preserved were identified thus Gura Cheii has low potential for further excavation.

Din Bulz Cave is situated close to a hilltop overlooking a steep valley. No systematic research has been carried out, but Bronze Age pottery shards and bone fragments were scattered across the surface. The cave entrance is less than one meter in maximum diameter so natural light does not enter the cave despite its southern orientation. Nevertheless, it is possible that the cave entrance was previously larger and has the potential to yield artifacts in the talus.

Manastirii Cave is on a hilltop overlooking the same valley as Din Bulz Cave. In front of the entrance, massive boulders indicate previous roof collapse(s). The cave has an active floor below, connected to the surface through a narrow vertical shaft/sinkhole. It is likely that even the upper floor is not completely fossilized as a small spring flows through the shaft towards the lower floor presumably transporting sediment .

Valea Stanciului Cave is a system of twin caves with southeastern exposure currently a few meters above a creek. While traces of treasure hunting excavations were visible, no archeological material was found on the surface. Their position next to a stream may have caused recurrent flooding of the cave and consequently may have hampered the preservation of the archeological material.

Hunedoara County

Spurcată and Curată Caves are located next to each other and have both been most recently excavated in the 1990s. Curată Cave features a 10 x 3 m, northeast opening and a main gallery 30 x 10 m. Two Middle Paleolithic layers were discovered, each containing ca. 150 lithics. Numerous faunal remains and hearths were also recovered. Radiometric ages indicate ages of ca. 45 ka ages for the Middle Paleolithic occupations (Păunescu 2001). At Spurcată Cave, the main archeological level was assigned to the Middle Paleolithic. Although the assemblage is small, it is dominated by tools, among which there were six were bifaces. Two lithics were assigned to the Gravettian (Nicolăescu-Plopşor *et al.* 1957; Păunescu 2001). At both caves, in situ sediments appear to be nearly absent.

Bordu Mare Cave is located on the slope of a limestone hill overlooking the valley. The cave features a single gallery, opening towards the southwest. Research has been carried out here in the 1920s, 1950s, 1980s, 1990s and 2000s. Four Middle Paleolithic and a single Aurignacian layer were identified (Nicolăescu-Plopşor *et al.* 1957). The site was rich in Pleistocene fauna, and three hominin phalanges were reported from the Middle Paleolithic layers. The cave still preserves some patches of undisturbed sediment along the side walls where open profiles are still observable and quartzite flakes were found in small gullies at the entrance of the cave.

Balogu and Zidul de Sus caves are both located on Magura Hill. Former test pits at Balogu revealed a brown-reddish sandy clay between 15-0.50 m depth containing Mousterian ‘hardened limestone’ flakes, broken bones (some purportedly with use-wear), cave bear bones and a large bovid bone (Breuil 1925; Roska 1925). There has been no previous archeological research at Zidul de Sus but lithics were found washed on the scree slopes below the entrance. The small amount of undiagnostic material co-occurred with ceramics, suggesting that the material at the site may have been post-Paleolithic.

Groapa Lupului was excavated periodically from the 1920s to 1999 (Breuil 1925; Roska 1925; Păunescu 2001, p. 234). The small excavations reached bedrock at 1.9 m and yielded a few flint flakes that were radiocarbon dated to 27 ka BP and a few quartzite Mousterian flakes dated to ca. 34 ka. Open profiles were still observed in the cave.

Dosul Dobârleseii Cave is located in the limestone massif on the left side of Geoagiu Valley. The cave has two entrances, separated by a medial wall and several ceramic and osteological fragments have been found at the surface of the soil. A small trench (1.5 x 1.5 m) at the entrance entrances revealed in .35 m, two layers containing medieval, Bronze Age and Neolithic ceramics.

Bihor County

Igrița Cave was previously excavated by M. Roska and H. Breuil (1925) where test pits deep within the main gallery reportedly yielded worked bone and lithics, including bifacially worked quartzite pieces from a 4 m thick stratigraphic sequence. Bone tools included flaked bone artifacts a bone point (possibly Mladeč type; Beldiman, 2003) and a *lissoir*. Large open profiles from previous excavations were present and were abundant in micro- and macrofaunal throughout the stratigraphy.

Ciur-Izbuc Cave has revealed human footprints dated to ca. ~36.5 ka cal BP (Webb *et al.* 2014). It is currently only accessible from a secondary entrance as the presumed earlier entrance that is now clogged by a debris cone. No excavations have been carried out so far and we were unable to visit the cave due to rusting of the protective iron door.

Caraş-Severin

In Caraș-Severin, three caves were visited and the area is of particular interest due to its proximity to the Iron Gates. The first, 2 Mai Cave, has an open plan with a broad, high northeastern entrance. The front of the cave has a flat surface and appears to have little erosion. The cave has a modern iron gate 25 meters deep into the cave. No previous excavations have been undertaken in the cave but behind the gate, unsystematic excavations have yielded *Ursus spelaeus* remains.

A further three caves, (Peștera 24, Peștera 25, Peștera 26) are found next to each other in the narrow canyon of the Cerna Valley northeast of Băile Herculane. The three caves are found next to each other and have been used for animal penning in the recent past. No previous excavations have been conducted here and they have potential for further archaeological work.

Discussion

From previous work is appears that there are no long, dense occupational sequences post-dating the Middle Paleolithic in western Romania caves though given the richness of select caves in northern Bulgaria at Kozarnika, Temnata and Bacho Kiro (Kozłowski and Ginter 1982; Tsanova 2006; Sirakov *et al.* 2010; Tsanova *et al.* 2012), this may simply be a question of finding the right location. The lack of long stratified sequences and the proclivity towards small early Upper Paleolithic assemblages suggests that hominin populations were fleeting across the region during the Late Pleistocene due in part to possible hiatuses in hominin settlement.

Ecological factors may have contributed to the sparse late Middle and Upper Paleolithic occupation of western Romania and it has been suggested that repeated cold and arid stadials caused depopulation–repopulation cycles between 44-34 ka ago (Staubwasser *et al.* 2018). Such regions with apparent discontinuous occupations, such as the western Romanian karst, have thus far provided fewer data and consequently have so far contributed less to our understanding of Late Pleistocene human subsistence.

Still, the unambiguous presence of hominins in the region illustrates the potential to uncover singular aspects of the behavior of Neanderthals and early modern humans that are known from more richly-documented areas such as in the local open-air localities and in other parts of Eurasia.

There are three areas that can help to clarify the picture:

1. From our initial work it appears that the majority of previously excavated cave sites demonstrate limited archeological potential as the majority have been largely emptied of Pleistocene sediments and their few associated artifacts are either poorly provenienced, lacking robust geochronology, or unavailable for further study. Fortunately, archaeologists have yet to begin to explore the more than 12,000 known caves in Romania (Ponta and Onac 2019, p. vii) and the happenstance discoveries at the Pestera cu Oase and Coliboaia Cave in the past 15 years suggest that systematic excavation would likely yield even more finds. Furthermore, few if any rock-shelters, have been targeted for Paleolithic excavation to our knowledge. Such records have yielded high density artifact scatters in other parts of Europe and identifying and testing such archives may be another valuable, untested resource.
2. Clearly, geochronology plays a vital role in determining the origins and development of the early Upper Paleolithic in western Romania and many of the previous radiometric dates from key sites would benefit from critical reevaluations and redating with modern methods. At some caves (e.g. Bordu Mare), larger collections combined with *in situ* stratigraphic profiles may in tandem, still retain enough information for targeted keyhole excavations or collection studies. However, given the limits of radiocarbon chronology in this time range and the large error margins of luminescence dating, burgeoning new methods such as tephrachronology may also prove to be useful avenues forward (Veres *et al.* 2019).
3. Finally, we are beginning to understand the regional signals of Paleolithic assemblages and variations in local traditions and in raw materials may have inhibited our ability to slot western Romanian lithic assemblages into the better-known reference sites from Western Europe. Furthermore, other more local traditions such as the Bohunician, Bachokiran or Szeletian remains less understood in this region and in some cases, are still far from being well defined (Mester 2018).

The results of our survey of only a small part of the Eastern Carpathian karst have yet to provide any meaningful data to discussions about the central questions of the nature and timing of the Neanderthal/modern human transition in Europe, at least from an archaeological perspective. Nevertheless, these preliminary results support that our plan to continue to investigate the karstic archives of the Western Romania is promising given the indisputable evidences of both late Neandertals and early Modern humans in the area and the preservation of Pleistocene sediment bearing caves.

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Cave name	County	Locality	Main entrance opening	Surface finds	Previous Paleolithic excavation finds	Lithic assemblage size	Reference(s)	Notes
Mică	BV	Peștera	E	none	-Aurignacian -Gravettian -hominin femur	Small	Păunescu 2001	-Limited *in situ* sediment identified
Mare (Liliecilor)	BV	Peștera	E	none	-Middle Paleolithic -Aurignacian -Gravettian -fauna preserved throughout	ca. 250	Păunescu 2001; Cârciumaru *et al.* 2010, p. 145	-Some *in situ* sediments identified -inconsistent stratigraphy and artifact provenience
Coacăzei (Gaura Sbârcioarei)	BV	Moieciu	SE	none	-Middle Paleolithic -Aurignacian -Gravettian -fauna preserved throughout	<50	Păunescu 2001; Cârciumaru *et al.* 2010	-Some *in situ* sediments identified but heavily sloping surface
Gura Cheii	BV	Râsnov	SW	none	-Middle Paleolithic -Aurignacian -Gravettian -fauna preserved throughout		Păunescu 2001; Cârciumaru 2008	-Limited *in situ* sediment identified
Din Bulz	BV	Comăna	S	-bones -bronze age ceramics	N/A	N/A	N/A	-Treasure hunting pits identified
Mănăstirii	BV	Comăna	S	-ceramics	N/A	N/A	N/A	-Active hydraulic action in parts
Valea Stanciului	BV	Comăna	SE	none	N/A	N/A	N/A	-Treasure hunting pits identified -Sediments appear to have been disturbed by stream
Curată	HD	Nandru	NNE	none	-Middle Paleolithic -fauna	ca. 300	Păunescu 2001	-Limited *in situ* sediment identified
Spurcată	HD	Nandru	NE	none	-Middle Paleolithic -Gravettian	Small, but high tool count	Nicolăescu-Plopșor *et al.* 1957; Păunescu 2001	-No *in situ* sediment identified

Table 1. Table of the archeological cave sites visited in western Romania between August 16 and 30th 2018.

Cave name	County	Locality	Main entrance opening	Surface finds	Previous Paleolithic excavation finds	Lithic assemblage size	Reference(s)	Notes
Bordu Mare	HD	Ohaba Ponor	SW	none	-Middle Paleolithic -Aurignacian -fauna -human phalanges	Small Aurignacian count (18?) but larger Mousterian assemblages	Nicolăescu-Plopşor *et al.* 1957; Păunescu 2001, p. 296	-Limited *in situ* sediment identified along the edges of the cave -Aurignacian layer disturbed with assorted post-Paleolithic material and the radiocarbon dates of between 33.7–32.8 ka cal BP cannot be securely linked to the assemblage (Anghelinu and Niță 2014)
Balogu	HD	Crăciunești	SSW	none	-Middle Paleolithic -fauna	Small	Breuil 1925	-'Hardened limestone' flakes and broken bones
Zidul de Sus	HD	Crăciunești	ESE	-bones	N/A	N/A	N/A	
Groapa Lupului	HD	Crăciunesti	WSW	none	-Middle Paleolithic -Aurignacian	Small	Păunescu 2001	
Dosul Dobârlesei	HD	Balșa	N	none	-None	N/A	N/A	
Igrița	BH	Peștere	ENE	-bones	-Bifacial tools -Bone tools	Small	Breuil 1925	
Ciur Izbuc	BH	Roșia	WSW	none	N/A	N/A	Webb *et al.* 2014	
2.May	CH	Carașova	NE	none	N/A	N/A	N/A	-Treasure hunting pits identified rich with cave bear bones and other fauna
Peştera 24	CS	Băile Herculane	NNW	-ceramics	N/A	N/A	N/A	
Peştera 25	CS	Băile Herculane	N	none	N/A	N/A	N/A	
Peştera 26	CS	Băile Herculane	N	-ceramics	N/A	N/A	N/A	

Table 1. Continued.

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New fieldwork at Mitoc-Malu Galben (Romania): An overview of the 2013 to 2016 excavations

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Abstract

Mitoc-Malu Galben is a key sequence for the European Upper Palaeolithic with abundant Aurignacian and Gravettian layers embedded in a long loess-paleosol sequence of about 14 metres depth. Here we present an overview of our 2013 to 2016 fieldwork campaigns resulting in 22 excavated trenches. We present new data on archaeological occurrences corresponding to the late Aurignacian as defined by the 1978 to 1995 excavations at the site.

Keywords: Upper Palaeolithic; Aurignacian; Gravettian; Romania; Mitoc-Malu Galben

Résumé

Mitoc-Malu Galben est une séquence clé pour le Paléolithique supérieur européen avec d'abondantes couches aurignaciennes et gravettiennes enchâssées dans une longue séquence loess-paléoosol d'environ 14 mètres de profondeur. Nous présentons ici un aperçu de nos campagnes sur le terrain de 2013 à 2016 qui ont mené à l'excavation de 22 tranchées. Nous présentons de nouvelles données sur les occurrences archéologiques correspondant à la fin de l'Aurignacian tel qu'il a été défini par les fouilles de 1978 à 1995 sur le site.

Mots-clés : Palaeolithique supérieur ; Aurignacien ; Gravettien ; Roumanie ; Mitoc-Malu Galben

1. Introduction

One of the key research themes in Palaeolithic archaeology is how Pliocene and Pleistocene hominins adapted to changing climatic conditions. On the one hand, anatomically modern humans are often contrasted with Neanderthals and earlier representatives of the human lineage, while on the other hand studies also frequently focus on only one species, e.g. modern humans, and explore their adaptations and responses to environmental and climatic change across time and space. Key for both types of studies are sites characterised by long stratigraphic sequences with high environmental resolution.

In western Eurasia, the Upper Palaeolithic, from roughly 50,000 years ago to the Holocene, shows a remarkable variability in human behaviours. This is often described by archaeologists in terms of technocomplexes, like the Aurignacian and Gravettian. However, the western Eurasian Upper Palaeolithic hunter-gatherer groups experienced quite some changes in environmental and climatic conditions during Marine Isotope Stage (MIS) 3 and MIS 2, including the Last Glacial Maximum. The time period between roughly 43,500 to 21,000 years ago, is characterised by the presence of archaeological assemblages attributed to the Aurignacian and Gravettian. The human groups

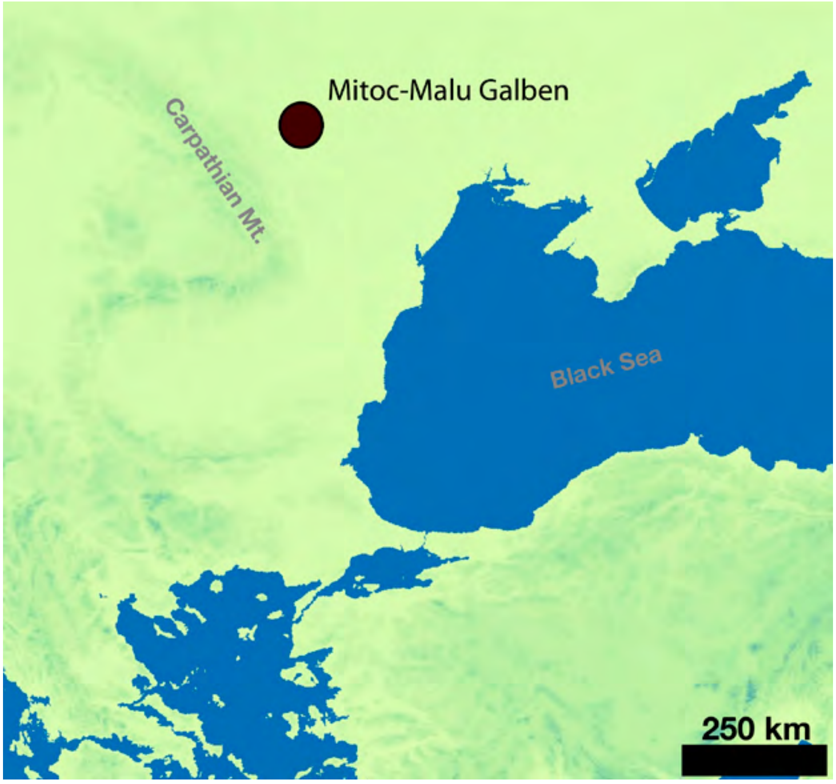

Figure 1. Location of Mitoc-Malu Galben. Base map using GTOPO30 HYDRO1K dataset provided by U.S. Geological Survey's Center for Earth Resources Observation and Science.

producing those assemblages occupied Europe under varying climatic conditions, including both interstadial and stadial conditions. In general, we can observe a trend towards lower temperatures and more aridity during MIS 3 and MIS 2, culminating in the Last Glacial Maximum. Some of the key research questions in Upper Palaeolithic archaeology include: How did Upper Palaeolithic hunter-gatherers respond to this general trend towards cooler and more arid climatic conditions? Were they only present under interstadial conditions? Are there any significant relationships between the adaptations and changes in climate change among Aurignacian and Gravettian hunter-gatherers? To pursue these and similar questions, we need newly excavated datasets from long stratigraphic sequences with high climatic resolution and a solid chrono-stratigraphic framework. A lot of sites with these characteristics are located in the western Eurasian loess areas and characterised by long loess-paleosol sequences. Good examples of such sequences include Willendorf II in the Middle Danube Region (Nigst *et al.* 2014), Molodova V in Ukraine (Haesaerts *et al.* 2003, 2010) Cosăuţi in the Moldavian Republic (Haesaerts *et al.* 2003, 2010) and Mitoc-Malu Galben in Romania (Chirica 2001; Otte *et al.* 2007).

Here, we report on our new collaborative fieldwork at one such site, Mitoc-Malu Galben. Since 2012 research on Mitoc-Malu Galben has been renewed through a memorandum of understanding between the Iaşi Branch of the Romanian Academy of Sciences and the University of Liège, Belgium. This new research also includes collaboration with the Department of Archaeology (University of Cambridge, UK) and the Royal Belgian Institute of Natural Sciences (Brussels, Belgium). The new fieldwork project includes conducting new excavations using highest-standard methods for field documentation and a detailed analysis of the stratigraphy, site formation processes, and palaeoenvironment. Since then, our team has conducted four excavations seasons between 2013 and 2016 (Chirica *et al.* 2014, 2015, 2016, 2017; Libois *et al.* 2017, 2018; Noiret *et al.* 2016). Below, we introduce the site and fieldwork methods and provide an overview of the research conducted so far.

2. Mitoc-Malu Galben: Site and history of research

Mitoc-Malu Galben (48°05'52''N, 27°01'23''E) is located in northeastern Romania (Figure 1) in the Botoşani county, along the right bank of the Prut river valley. It is situated in a ravine (Ghireni ravine), about 450 metres from where the ravine meets the main Prut river valley (Otte *et al.* 2007). The sequence covers a loess-paleosol succession of about 14 m depth (Haesaerts 2007). In this sequence, a set of archaeological layers has been documented and attributed to the Aurignacian and Gravettian. The chronostratigraphy of the sequence is based on the stratigraphic record and more than 40 radiocarbon dates (Haesaerts 2007).

The approximately 14 m deep sequence is currently subdivided in 13 lithostratigraphic units (Figure 2), each representing a distinct sedimentation phase. The lower half of the sequence, i.e. stratigraphic units 13 to 7, consists of silty deposits. The stratigraphic units 13 to 11 also contain deposits of colluvial origin. Stratigraphic unit 7 shows the onset of aeolian input, initiating the deposition phase of loess recorded in the upper half of the sequence, i.e. stratigraphic units 6 to 1. Each sedimentation phase is usually associated with a stabilization phase marked by pedogenesis (Haesaerts 2007). Depending on the climatic events, the pedogenesis phases are represented by tundra gleys (e.g., stratigraphic unit 3a), i.e. periglacial conditions, or humic soils (e.g., stratigraphic unit 9a), i.e. subarctic to boreal conditions.

Within this long sequence of rather high palaeoenvironmental resolution, a large number of archaeological occurrences has been documented since 1978 (see Otte *et al.* 2007 for a summary), grouped by the 1978 to 1995 excavators into packages of archaeological layers, including five 5 Aurignacian 'layers' in stratigraphic units 12b to 8b and four Gravettian 'layers' in stratigraphic units 7b to 4a (Figure 2).

Mitoc-Malu Galben has a long research history. By the end of the 19th century, the area of the village Mitoc was known as a locality of prehistoric lithic artefacts, making it the first recognised Palaeolithic site in Romania (Chirica 2001). In the first half of the 20th century, N. Moroşan excavated and studied several Palaeolithic locality in the area including Mitoc-Malu Galben (Moroșan 1938).

In the second half of the 20th century, C. Nicolăescu-Plopşor and N. Zaharia conducted surveys in 1956-1957 (Chirica 2007). After these fieldwork seasons, V. Chirica started his long-term fieldwork at Mitoc-Malu Galben in 1978 (Chirica 2007), which exposed until 1990 the entire 14 m deep sequence and identified the rich Aurignacian and Gravettian archaeological layers. The current appearance of the site is a direct result of V. Chirica's excavations. These successive fieldwork campaigns have created an excavation pit about 20 metres long, 20 metres wide, and nearly 14 meters deep (Figure 3).

From 1991 to 1995, the fieldwork at Mitoc-Malu Galben was carried out in collaboration with M. Otte and P. Noiret (University of Liège, Belgium) and P. Haesaerts and F. Damblon (Royal Belgian Institute of Natural Sciences, Brussels, Belgium). The goal was to control the stratigraphy, to sample the different archaeological layers and to collect samples for new radiocarbon dates. In the course of this research the different horizons originally identified by V. Chirica were clearly delimited (four Gravettian layers and five Aurignacian layers), and placed within the lithostratigraphy studied by P. Haesaerts. The results of this collaboration (and previous excavations) are described in detail in Otte *et al.* (2007).

Since 2012, the research on the site has been re-started by a new collaboration between the Iaşi Branch of the Romanian Academy of Sciences and the University of Liège. This led to four excavation campaigns from 2013 to 2016 (Chirica *et al.* 2014, 2015, 2016, 2017), involving V. Chricia (Iaşi Branch of the Romanian Academy of Sciences), P. Noiret (University of Liège), Ph.R.

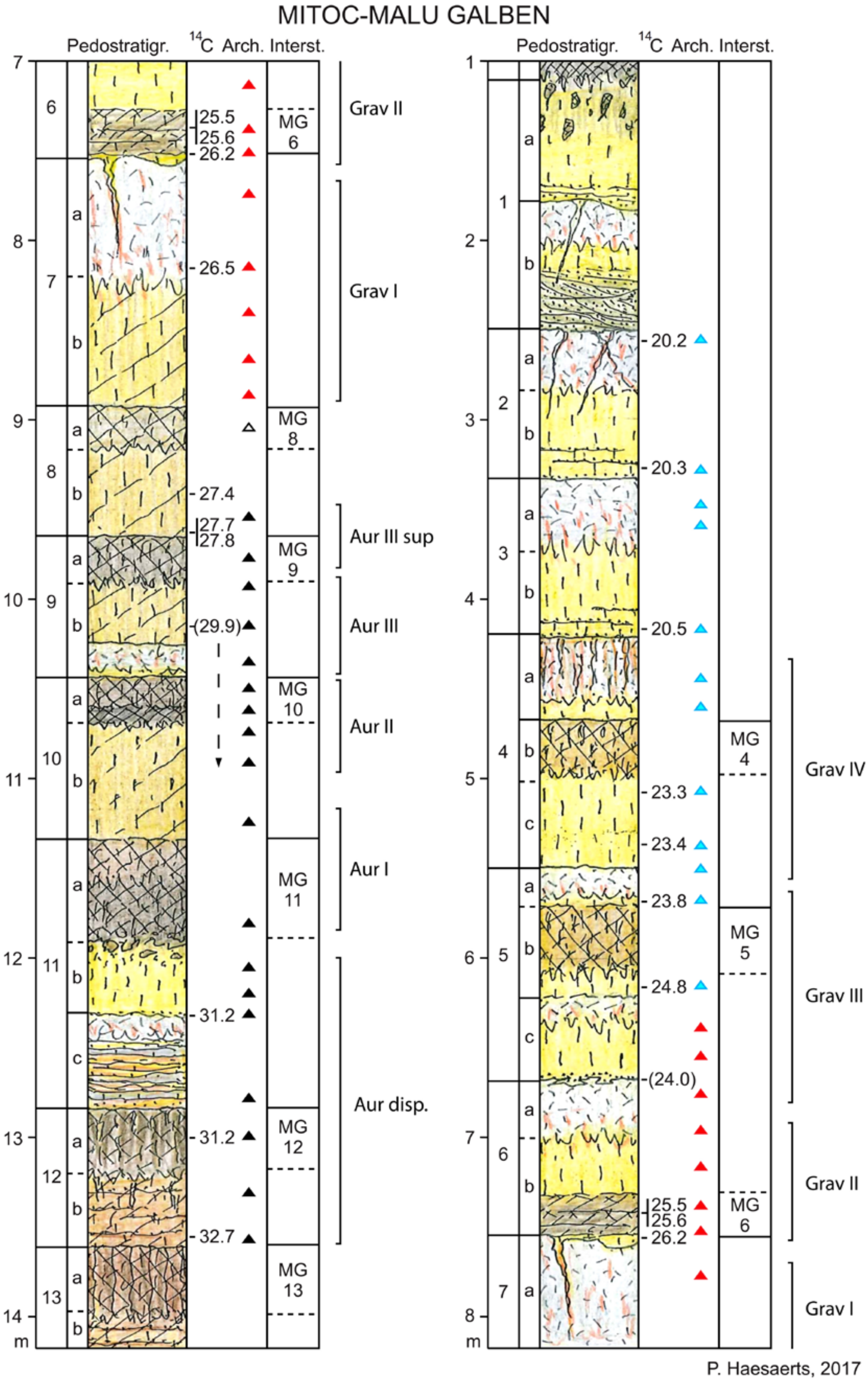

Figure 2. Mitoc-Malu Galben: Stratigraphic log of the sequence (drawing: P. Haesaerts). Abbreviations: Pedostrati.: Pedostratigraphy, Arch.: Archaeology, Interstad.: Insterstadial, Grav.: Gravettian, Aur.: Aurignacian, disp.: disperse (see Otte *et al.* 2007 for labels of archaeological layers).

Figure 3. Mitoc-Malu Galben: Excavation in 1992 (a) and 2013 (b).
Photos: P. Noiret.

Nigst (University of Cambridge) and P. Haesaerts (Royal Belgian Institute of Natural Sciences). Since 2016 research has been focused on the analyses of the archaeological and other samples collected during the 2013-2016 fieldwork campaigns. The present paper reports on these latter fieldwork campaigns.

3. Fieldwork methods

Fieldwork methods are oriented on the highest standards of Palaeolithic excavations in open-air loess sites (e.g., Nigst *et al.* 2014), and include stratigraphic excavations taking into consideration the lithostratigraphic boundaries and pedological horizons. Key in this regard is the presence of a Quaternary geologist, P. Haesaerts, during the excavations. Excavations are conducted either horizontally in small areas with good stratigraphic control via vertical sections, or vertically as so-called vertical excavations. The goal is to maximise the stratigraphic control of any excavated sample/material via vertical sections. All excavated sediment is collected and wet-sieved using an 1 mm mesh.

All objects (and samples) are documented with 3D co-ordinates in the excavation grid system using totalstations (Leica TCR 805) (Nigst *et al.* 2014). All data is stored in field data collectors (Trimble Recon) running a field database and EDM measurement software (EDM Mobile; http://www.oldstoneage.com/software/edm-mobile.shtml; McPherron and Dibble 2002). During the excavation process, all objects > 10 mm are piece-plotted. Most objects are documented by one point at the base of the object, while elongated objects (length greater than twice the width) are documented by two points, one at each end of the long-axis, and massive, larger objects (e.g., cores) are documented by six points (each of these points corresponds to the centre of one of the faces of the smallest cuboid in which the object fits).

Each piece-plotted object is assigned a unique ID number consisting of the square (e.g., N3) and a running number from 1 to n, resulting in a unique ID of, for example, N3-45). The unique ID number is automatically assigned by the EDM Mobile database management software. All information including measurements (X, Y and Z coordinates), stratigraphic unit, archaeological layer, object code (lithic, stone, bone, ochre, charcoal, etc.), and the position of the face on which the object rests (dorsal or ventral side down) are saved in the EDM Mobile database.

Sections are documented through photos and drawings. After the sections have been studied by the project geologist (P. Haesaerts) they are drawn at scale 1:10. All lithostratigraphic boundaries are precisely documented and find objects visible in the section are documented on the drawings as well. In addition, all sample locations of palaeoenvironmental and soil micromorphology samples are marked on the drawings.

4. Results

4.1. Relocating the previous excavations' square system and height

The first task of our 2013 fieldwork season was to re-locate the exact position of the square system and height of the 1978 to 1990 and 1991 to 1995 excavations. With regard of the square system, it was consisted of 2 by 2 metres squares labelled with letters in south-north direction and by numbers in west-east direction (see, e.g., Otte *et al.* 2007) (Figure 4). Our goal was to use the same square system to facilitate comparisons between the old collections and our newly generated collections. Regarding the height, it is worth noting that the previous fieldwork at the site utilized several different altitudes as zero. There is the system used from 1978 to 1990 by V. Chirica, the one used since 1990 by P. Haesaerts and the one used between 1992 and 1995 by the team of M. Otte and P. Noiret. All three systems are mapped in the site monograph and the altitude used by Haesaerts has been the preferred system because of its link with the stratigraphic record by Haesaerts. We, therefore, decided to use it also for our fieldwork since 2013.

We were able to precisely re-locate both the height used by Haesaerts and the square system of the 1978 to 1995 excavations, because there were several locations within the site, where points and grid-lines of the sections for drawing and/or grid lines of the square boundaries were preserved

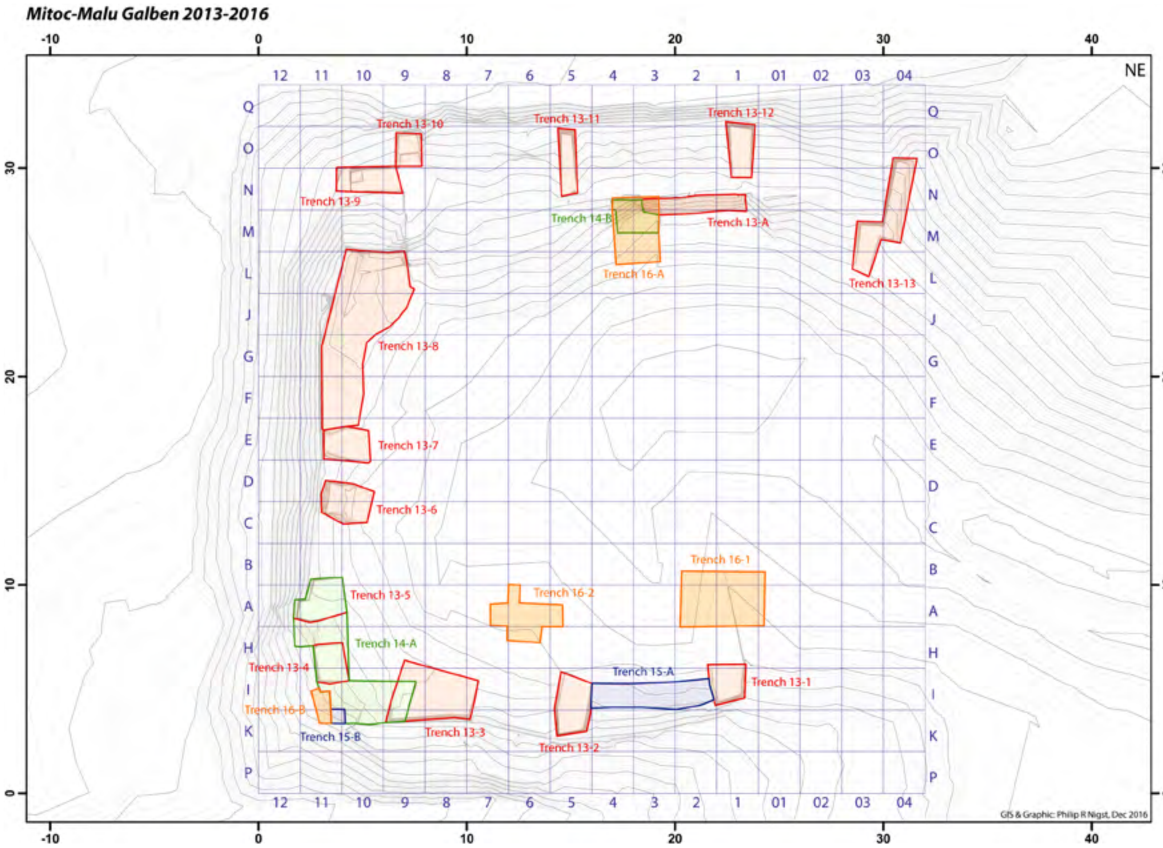

Figure 4. Mitoc-Malu Galben: Map of the site in local coordinate system. Squares shown after Otte *et al.* 2007. Trenches are colour coded by year: red: 2013, green: 2014, blue: 2015, orange: 2016. GIS & Graphic: Philip R Nigst.

and X-, Y-, and/or Z-coordinates were known. In addition, other features boundaries of some of the still visible old trenches, the width of the western section at the top of the site, and the position of a Sarmatian grave at the top of this section have allowed us to correctly reposition of the grid-system of the squares (X- and Y-coordinates). For the height used by Haesaerts, the depth of certain reference horizons in the still preserved and visible sections of the old excavations made it possible to find in several places a series of points measured in altimetry by P. Haesaerts between 1990 and 2000, allowing us to reconstruct the height (Z-coordinate) precisely. It was thus possible to set up a new excavation grid (squares) and height that matches precisely the X- and Y-coordinates by the Chirica-grid and the Z-coordinates by Haesaerts, ensuring compatibility with the information as published in Otte *et al.* (2007).

We subsequently installed new topographic reference points first in 2013 and expanded the system in the subsequent years. These new datums are made of either wooden stakes or metal bolts and are normally located at the base or the lower part of the sections of the trenches excavated since 2013 to ensure longest preservation even if the upperpart of the sections should erode in the future. Some of the datums installed by us, were removed in subsequent years of excavation when extending a trench and excavating down a section. If this was the case we installed new datums at other locations to maintain more or less the same amount of datums.

4.2. Overview of the trenches excavated between 2013 and 2016

Between 2013 and 2016 we conducted four fieldwork seasons and excavated 22 trenches (Figure 4), which include 15 trenches for stratigraphic work (labelled with numbers, e.g. Trench 13-1) and seven trenches for excavation of archaeological material (labelled with letters, e.g. Trench 13-A) (Table 1). Trenches for stratigraphic work included removing backdirt and exposing and renewing

Excavation year	Stratigraphic trenches	Archaeological trenches
2013	13-1 to 13-13	13-A
2014	–	14-A and 14-B
2015	–	15-A and 15-B
2016	16-1 and 16-2	16-A and 16-B

Table 1. Mitoc-Malu Galben 2013-2016: List of stratigraphic and archaeological trenches per excavation year.

old excavations' sections with minimal necessity to excavate archaeological materials. Given the state of the site after several years of no fieldwork between 1995 and 2012 (with the exception of a brief fieldwork season in 2011 for collection of samples for palaeomagnetic and other analyses), the old sections and trenches had eroded quite a bit. Hence it was necessary to relocate the old grid of squares, height used by Haesaerts, and lithostratigraphic boundaries in order to precisely position any newly excavated of material in the stratigraphy of the site (see above). The other task achieved by the trenches for stratigraphic work was a refinement of the stratigraphic sequence in particular for stratigraphic units 4 and 5 in the north section of the site as well as stratigraphic unit 11 in the southern part of the site.

Trenches for excavation of archaeological material targeted areas to sample archaeological layers known from the old excavations. In those trenches work started with the removal of the backdirt and then excavating back old sections through either horizontal or vertical excavations, and sections were analysed and documented.

The 2013 fieldwork campaign (Figure 4: red coloured trenches) was designed to (i) relocate the 1978 to 1995 excavations' squares and grid system as well as the height used by Haesaerts, (ii) re-analyse parts of the stratigraphic sequence, particularly the stratigraphic units 4 and 5 in the northern section, and (iii) excavate a block of sediment that likely otherwise would have collapsed due to erosion (abundant lithic artefacts were collected on the slope below) resulting in Trench 13-A. This latter work in Trench 13-A concentrated on squares N1 to N3 and focused on stratigraphic units 6b and 7b with abundant objects (mainly lithic artefacts) of archaeological occurrences corresponding to the so-called 'Gravettian II' (stratigraphic unit 6b) and 'Gravettian I' (stratigraphic unit 7b) archaeological layers of the old excavations.

During our fieldwork in 2014 (Figure 4: green coloured trenches), we focused on the southwestern corner of the site and the so-called 'Aurignacian I' package of archaeological layers occurring in stratigraphic unit 11a (Trench 14-A). Additionally, we continued excavation along the northern section, especially in square N4 (Trench 14-B), which allowed us again to sample the archaeological occurrences belonging to the so-called 'Gravettian I' (stratigraphic unit 7b) and 'Gravettian II' (stratigraphic unit 6b) archaeological layers of the old excavations.

In 2015 our excavation (Figure 4: blue coloured trenches) focused on the last Aurignacian layers at Mitoc-Malu Galben and we aimed to find them along the southern section. We excavated a trench (Trench 15-A) containing parts of the squares I1 to I4 and focused on stratigraphic units 10a through to 7b. We found archaeological occurrences in stratigraphic units 9a and 8b related to the previous excavations' archaeological layer called 'Aurignacian III upper' ('Aurignacien III superieur'). During our 2015 fieldwork campaign we also continued excavation in the southwestern corner (Trench 15-B) in squares K10/11. This work – as in 2014 – sampled so-called 'Aurignacian I' package of archaeological layers occurring in stratigraphic unit 11a.

Our excavations in 2016 (Figure 4: orange coloured trenches) aimed to explore the presence of a late Aurignacian in the area underlying the one excavated in 2013 and 2014 along the northern section (Trench 16-A), in squares L3, M3 and M4. We excavated archaeological occurrences in stratigraphic units 9b and 10b corresponding to the old excavations' so-called 'Aurignacian III' (stratigraphic unit 9b) and 'Aurignacian I' (stratigraphic unit 10b) archaeological layers. We also continued in 2016 excavation in the southwestern corner of the site in squares K11 and I11 (Trench 16-B) sampling archaeological occurrences equivalent to the 'Aurignacian I' archaeological layer of the old excavations in stratigraphic unit 11a. Further, we excavated two trenches for stratigraphic work (Trenches 16-1 and 16-2) to examine the lower part of the stratigraphic sequence.

4.3. A brief look at the end of the Aurignacian sequence at Mitoc-Malu Galben

Here we briefly want to highlight our new collections for the late Aurignacian within the Mitoc-Malu Galben sequence. The materials originate from two excavations seasons, 2015 and 2016. In 2015, we excavated a small assemblage in Trench 15-A, distributed in stratigraphic units 9a and 8b, which makes our assemblage equivalent to the 'Aurignacian III upper' layer of the old excavations, while in 2016 we excavated an even smaller assemblage in Trench 16-A, in stratigraphic unit 9b, which makes our assemblage equivalent to the 'Aurignacian III' layer of the old excavations.

The Trench 16-A assemblage of stratigraphic unit 9b comprises 197 lithic artefacts >10 mm including flakes, shatter, and one tool (endscraper) originating from two small concentrations. The concentrations are spatially quite limited and contain abundant refitting lithic artefacts (Libois 2017). Within the 197 lithic artefacts are no pieces that one could consider 'culturally' diagnostic, i.e. such that would allow one to assign the assemblage to either the Aurignacian or Gravettian.

The assemblage from stratigraphic units 8b and 9a in Trench 15-A is with 427 lithic artefacts >10 mm a little bit larger. The assemblage is dominated by flakes (48.5%), followed by shatter (~20%), blades (11.2%), bladelets (10.5%), one core, and other lithics (including burin spalls, chips, and core tablets) (Branscombe 2016) (Table 2 and Figures 5 and 6). The assemblage is characterised by a high refitting rate among the lithic artefacts. The faunal remains are poorly preserved and by far not as numerous as the lithic artefacts. It comprises six faunal remains >10 mm, of which four could be identified to species, i.e. to Equus ferus, while one other piece belongs to an ungulate of size class 3-4 (e.g., reindeer to horse size) and the sixth faunal piece is unidentifiable. Horse is equally frequent or the dominant taxa in the faunal assemblages from previous excavation campaigns (López Bayón and Gautier 2007; Noiret 2009).

Both assemblages briefly described above are interesting in the context of the discussion of the transition from the Aurignacian to the Gravettian on a regional scale as well as on an European

Dataclass	Frequency	Percentage
Blade	48	11.2
Bladelet	45	10.5
Flake	207	48.5
Core tablet	2	0.5
Burin spall	2	0.5
Chip	33	7.7
Core	1	0.2
Shatter	89	20.9
Total	**427**	**100.0**

Table 2. Mitoc-Malu Galben, Trench 15-A, stratigraphic units 8b and 9a, 'Aurignacian III upper': Basic dataclasses of the lithic assemblage piece-plotted during excavation in 2015.

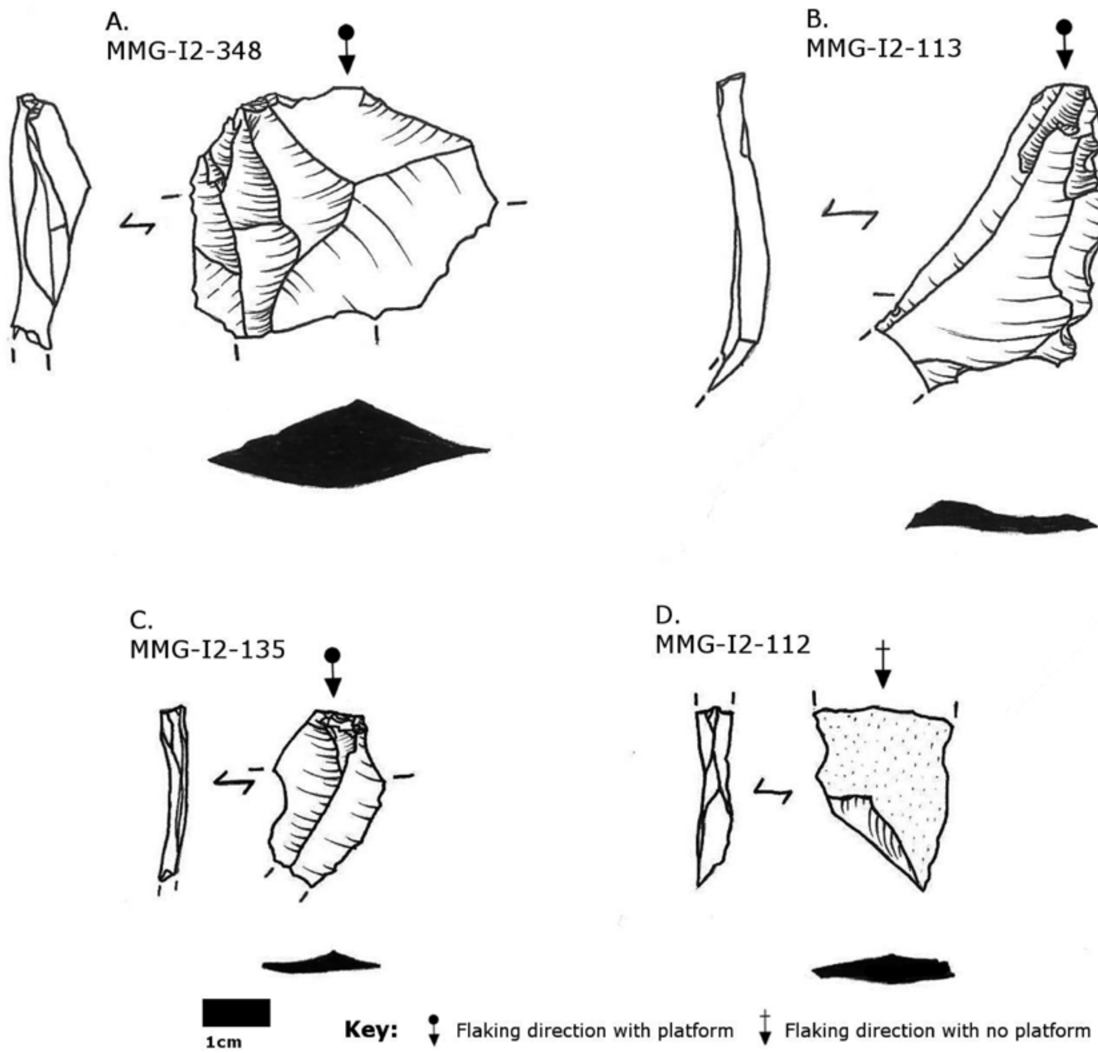

Figure 5. Mitoc-Malu Galben, Trench 15-A, stratigraphic units 8b and 9a, 'Aurignacian III upper': Selection of flakes (A-D). Drawings: Tansy Branscombe.

scale (e.g., Pesesse 2008; Moreau 2007, 2009, 2012; Noiret 2009). They occur at a time when there are Gravettian assemblages well stratified and securely dated at sites like Molodova V (Haesaerts *et al.* 2003) and Willendorf II (Haesaerts *et al.* 1996; Nigst and Haesaerts 2012; Nigst *et al.* 2014). While at the present stage of analysis of our new Mitoc-Malu Galben assemblages we cannot securely assign them to either a late Aurignacian or an early Gravettian, we hope to do so in the future. Future work will also have to include a discussion and evaluation of models (e.g., Conard and Moreau 2004) about the driving factors behind the changes in archaeological technocomplexes, whether they are caused by changes in populations (replacement, mixing, etc.), in the density and structure of those populations, or other factors.

5. Concluding remarks

In this paper we present a brief overview of our fieldwork at Mitoc-Malu Galben, conducted between 2013 and 2016. We were able to sample different parts of the site as well as multiple parts of the stratigraphic sequence with new high-resolution methods. Our new assemblages include collections equivalent to the following old excavations' layers: 'Aurignacien I', 'Aurignacien III', 'Aurignacien III superieur', 'Gravettien I', and 'Gravettien II'. A lot of analyses are still in progress and most of our laboratory research at the moment is focussing on the late Aurignacian archaeological occurrences of the site.

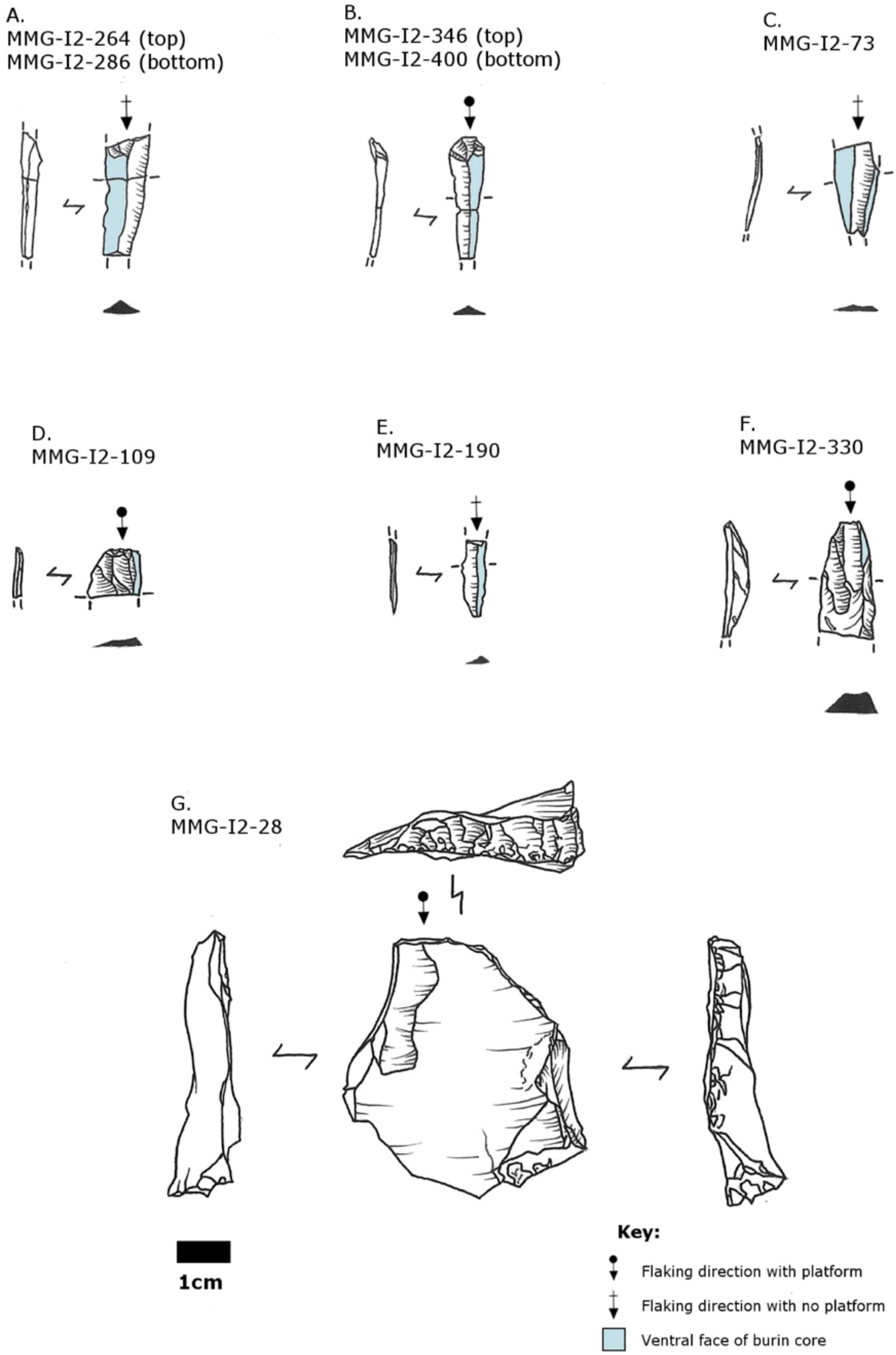

Figure 6. Mitoc-Malu Galben, Trench 15-A, stratigraphic units 8b and 9a, 'Aurignacian III upper': Selection of bladelets (A-F) and core tablet (G). Drawings: Tansy Branscombe.

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The cultural dynamics of Upper Paleolithic to the East of the Carpathians reflected by the characteristics of the Bistriţa Valley settlements (Romania), with special focus on the occupations from Poiana Cireşului site

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Abstract

Most of the Upper Paleolithic settlements in Romania are located at the East of the Carpathian Mountains, on the Bistriţa and Prut rivers valleys. By their chronological framework and their lithic technical system, most of them seem to belong to a gravettian technical tradition. Nowadays, around 20 settlements were described on the Bistriţa river alone, even though not all of them have been equally studied. One of the key-sites for this region is Poiana Cireşului-Piatra Neamţ, where several research campaigns have been carried out recently. The research in this site revealed four archaeological layers: one Epigravettian layer and three Gravettian ones, separated by thick sterile levels. Chronologically, these occupations overlap almost the entire *lato sensu* Gravettian development period (20-27 ka uncal. BP), thus covering a wide time frame before and after the Last Glacial Maximum. Preliminary analysis of the archaeological assemblages showed a diversity of techno-economic and symbolic behaviors for each layer. This diversity reflects certainly the cultural variability of the groups that occupied the site, and more broadly, the one which is also expressed in the vast European technical entity named 'Gravettian'.

Keywords: Upper Paleolithic; East of the Carpathians; technology; ornaments; cultural dynamics

Résumé

La plupart des gisements du Paléolithique supérieur de Roumanie sont situés à l'est des Carpates, dans les vallées des rivières de la Bistriţa et du Prut. Par leur cadre chronologique et leur système technique lithique, ces gisements semblent se rattacher à une tradition technique gravettienne. A ce jour, une vingtaine de gisements ont été décrits pour la seule vallée de la Bistriţa, même si tous n'ont pas été étudiés de la même manière. Poiana Cireşului-Piatra Neamţ, où plusieurs campagnes de fouilles programmées ont été menées ces dernières années, est l'un des sites clés de cette région. Quatre couches archéologiques y ont été identifiées : une couche épigravettienne et trois couches gravettiennes, séparées par des niveaux stériles épais. Chronologiquement, ces occupations recouvrent presque toute la période de développement du Gravettien *lato sensu* (20 à 27 ka BP), couvrant ainsi une large période avant et après le dernier maximum glaciaire. Une analyse préliminaire des ensembles archéologiques a permis de mettre en évidence une diversité diachronique des comportements techno-économiques et symboliques pour chacun des niveaux; cette diversité reflète certainement la variabilité culturelle des groupes qui ont occupé le site, et plus largement, celle qui s'exprime aussi au sein de la vaste entité technique européenne nommée « Gravettien ».

Mots-clés : Paléolithique supérieur ; est carpatique ; technologie ; parure ; dynamiques culturelles

Introduction

One of the richest areas of Palaeolithic findings in Romania is the Bistrița valley, which stands out through a remarkable density of sites (approximately 20 settlements), located on the eastern mountain rim of the Carpathians (Figure 1). This region has become an area of high densities of Palaeolithic sites due to the archaeological research programme initiated in 1955, when the construction of the Izvorul Muntelui Dam began. Until then, no Paleolithic settlement had been mentioned on this valley. Throughout the four archaeological campaigns between 1955 and 1958, extensive excavations (about 3,000 sq. m in 13 sites) were carried out mainly in the Ceahlău basin, so most of the finds in these sites were made in that period (Nicolăescu-Plopșor *et al.* 1966; Păunescu 1998).

Besides the Ceahlău basin, there are two other areas of Palaeolithic discoveries: the Piatra Neamț city area, where until 2018 there is only one site, namely Poiana Cireșului (Cârciumaru *et al.* 2018), and the lower basin of the Bistrița valley, with two sites, Buda and Lespezi (Tufreau *et al.* 2018).

Recent results obtained after the resumption of investigations in some important sites of this region (Poiana-Cireșului, Bistricioara Lutărie, Ceahlău-Dârțu) have revealed a cultural succession simultaneous with the development of the Gravettian and the Epigravettian as well as the absence of Aurignacian occupations (Cârciumaru *et al.* 2010; Steguweit *et al.* 2009). Due to the position of the Bistrița valley settlements between two great Gravettian traditions (e.g. the eastern Gravettian and the cultures typical of settlements of the Great Russian Plain on the one hand, and the central European Gravettian traditions on the other hand), the characterisation of Gravettian levels may contribute to highlighting the regional features of this culture in south-eastern Europe.

Of all Paleolithic settlements, Poiana Cireșului is the best researched site on the Bistrița valley and remains a landmark of the cultural succession in this region; therefore, our study will include a synthesis of the general characteristics of each Gravettian level investigated so far. Moreover, the recent results obtained at Poiana Cireșului contribute substantially to the characterization Mid Upper Paleolithic and has many implications regarding the origin of the Gravettian in this area. Given that the osseous and lithic materials are still under analysis, the observations will be only preliminary. Except Poiana Cireșului, a few chronostratigraphic considerations will be made on significant settlements in the Ceahlău basin: Bistricioara Lutărie I and II, Ceahlău Dârțu, Cetățica I and II.

Poiana Cireşului-general characteristics of occupations

The Palaeolithic settlement of Poiana Cireșului-Piatra Neamț (Neamț County) is located on a cut terrace of the Bistrița River, at the confluence with the Doamna rivulet (46º55'919'' North latitude and 26º19'644" East longitude), 395 m absolute altitude (Figure 1). This site has benefited from systematic archaeological excavations since 1998 that have covered an area around 100 sq. m. Four Palaeolithic levels have been researched until 2018, but the surveys have revealed that the geological deposit is, in some areas, 8 m thick and traces of two Early Upper Paleolithic occupations have been detected under the oldest Gravettian layer. In terms of the geological stratigraphy, the following sequence has been identified: 1 – Holocene pale brown soil (cambisol); 2 – yellow Late Glacial carbonate free loess layer; 3 – compact, decalcified light reddish brown gelistagnic cambisol; 4 – heavily carbonated clay-loessic light olive layer; 5 – calcic olive sandy-loessic layer.

The four archaeological levels were assigned to Epigravettian (layer I located in the second geological deposit, partially disturbed by a Neolithic occupation) and to Gravettian (layers II-IV, numbered Gravettian I, II and III, located in the geological deposits 4 and 5) (Figure 2). Thick sterile levels, roughly 1.5 m and 40-50 cm, separate these occupations.

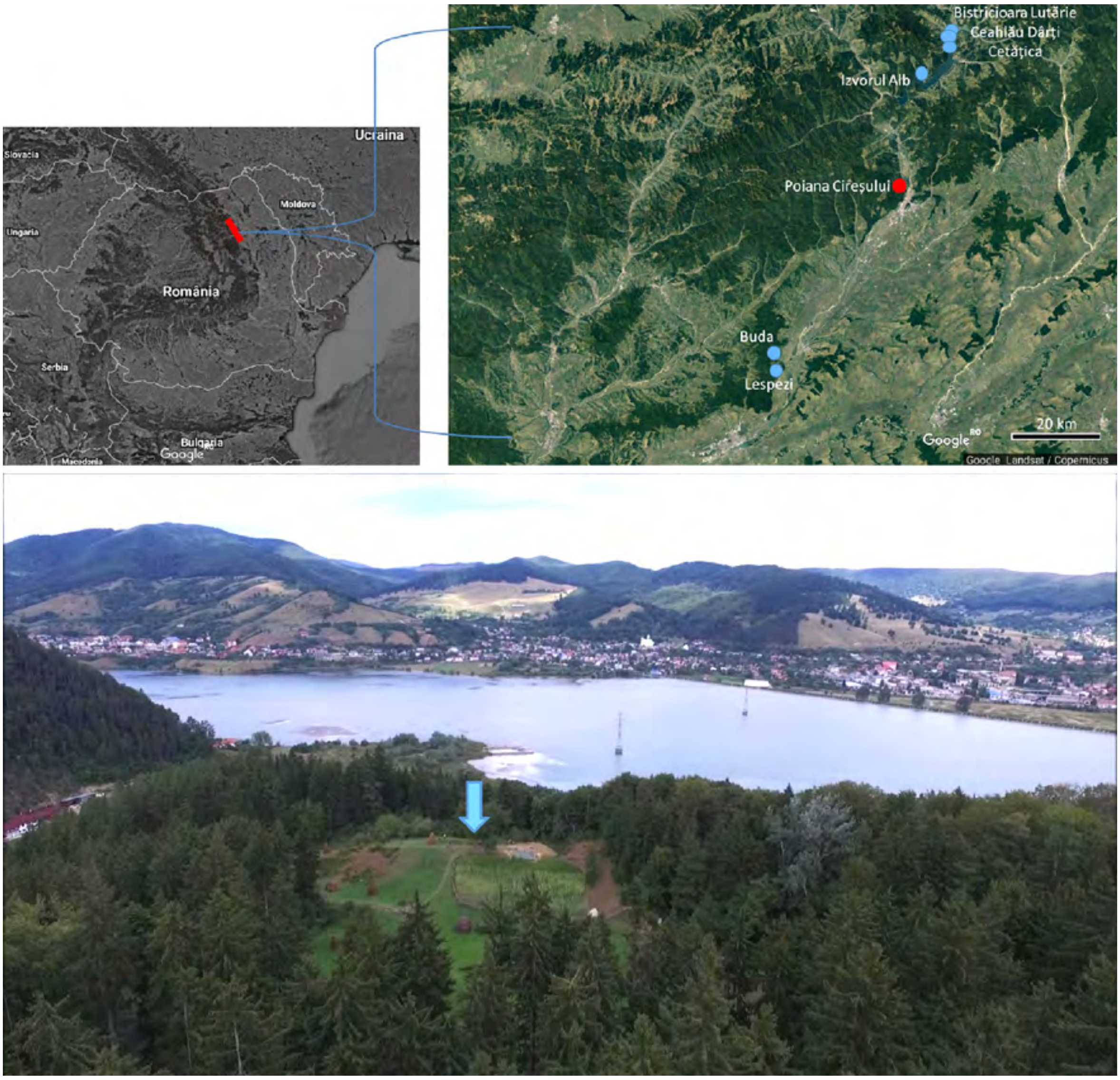

Figure 1. The settlement of Poiana Cireşului – site location and the map with the main paleolithic sites discovered on the Bistriţa valley.

The first Gravettian layer is the richest occupation in the settlement and in the entire valley of the Bistriţa river (Figure 2/2). The 19 absolute dating place the occupation between 19,320 ± 80 uncal. BP (OxA-36785) (23,538-22,992 cal. BP) and 20,154 ± 97 uncal. B.P. (ER 12.163) (24,484-23,959 cal. BP) (for a list of all the datings, see Cârciumaru and Niţu 2018). Hence, this layer is contemporaneous with the Last Glacial Maximum, which means that the area was nevertheless favourable to habitation in this period. Located at the chronological conjectural boundary between the Gravettian and Epigravettian, its belonging to the former culture is entailed by the characteristics of materials found.

According to archaeozoological analyses, reindeer (*Rangifer tarandus*) was the most hunted animal, followed by bison (*Bos*/Bison), red deer (*Cervus elaphus*), horse (*Equus sp.*), chamois (*Rupicapra rupicapra*) and fox (*Vulpes/Alopex*) in modest proportions. The existence of the mammoth can only be mentioned due to the presence of a few ivory tools, and of the wolf only in terms of the existence of a pendant made from a canine and of an awl. The study of lower dentition and of reindeer antlers proves that hunting took place from the beginning of autumn until early winter, when mainly adult females and young specimens of both genders were hunted, particularly for food (Cârciumaru *et al.* 2006, 2007-2008).

Figure 2. The settlement of Poiana Cireșului: 1. stratigraphic profile in section IX and the sequence of Gravettian layers; 2-4 images during excavation (2 – Gravettian I, 3,4 – Gravettian II); 5-7. selected tools from Gravettian II (5. backed point; 6. double endscraper; 7. tanged point).

With regard to the osseous materials, until 2015, the collection had included around 60 items, but a few dozens of new pieces were added after the resumption of analysis and of excavations (Cârciumaru *et al.* 2018). Except for a single bone awl, no other bone tool has been found. Working mainly reindeer antlers and less red deer antlers represents a significant part in the economy of communities, and a trait of the osseous industry in this level is the almost exclusive use of *Cervidae* antlers as tool blanks. These are represented by a few projectiles points, numerous tools with rounded and massive active part (wedges and/ or smoothers), and rare bone awls. A few ivory objects, among which two at least are processing-tools, have also been discovered.

The lithic material is extremely numerous (more than 15,000 items) and is made mainly on diverse local raw materials: menilite, various cherts, flint, siliceous sandstone, jasper, radiolarite. The technical categories discovered prove that the debitage occurred in the site. The cores, though diverse, comprise three major categories: cores with a single flat debitage surface (unifacial cores) and one or two opposing striking platforms, narrow-fronted cores, having mainly two opposite platforms, and burins-cores, uni or bipolar, debitage focused on the blank thickness (mainly thick flakes).

The resulting products are small blades with straight or slightly curved profile, bladelets, but also micro-bladelets. The burins represent the most numerous category of tools and some of the bladelets and micro-bladelets resulted from their shaping. In fact, in many cases, it is difficult to distinguish between burins in a strictly typological sense and cores used for the production of bladelets/micro-bladelets. It is possible that the large number of burins should be due to the intense exploitation of Cervidae antlers, as shown by the osseous assemblage which comprises, alongside of finite objects, a large number of debris. Most of the burins are dihedral, simple or double, made on various blanks: blades, flakes, debris. The backed tools, represented mainly by backed bladelets and less microgravettes, are not too numerous. Instead, there is a significant group of bladelets and micro-bladelets with twisted profile which were retouched. Also, a few denticulated bladelets differentiate this occupation in relation to other sites on the Bistrița valley.

This layer preserves the largest collection of art objects discovered so far in the Romanian Palaeolithic (Cârciumaru and Nițu 2018; Cârciumaru *et al.* 2016, 2018). The diversity of shapes, of raw materials used and of blanks is striking, and in some cases, it is difficult to find analogies in the Gravettian or Epigravettian in Europe.

Within the category of personal suspended objects, five pendants, one made of stone and four made of animal teeth (wolf, fox, red deer), a stone bead and perforated fossil shells of *Cyclope sp., Dentalium sp.* and *Potamides picostatus* stand out. In addition to adornments, several engraved bones have been found as well. Four items were incised with parallel lines on the edges: a rib, a diaphysis, a metapodium and a very small bone. Two bone fragments are engraved on the surface, one of them having a female schematic representation. Moreover, a few very small bone fragments were engraved with parallel lines. These items were probably part of more complex decorations (Cârciumaru *et al.* 2018).

The same engravings on the edge of blanks noticed on bones are also found on a quartzite pebble. Beside the engraved items, a reindeer phalanx with a perforation on one face, transformed into a whistler, a schematic female figurine made of silicified wood, four aragonite moulds of lamellibranchiate fossils of the *Congeria sp. aff. Congeria (Mytilopsis) subcarinata* species and an amber fragment have also been discovered.

The second Gravettian layer is probably defined by short occupational sequences and has 11 absolute datings, the average being around 24,500 uncal. BP. (28-29 ka cal. BP). This level is characterised by several thousands of lithic items and osteological fragments (Figure 2/3-7). Except a hearth discovered during the 2013 campaign and a few burning spots, no complex habitation structure has been located so far. The lithic material is carved out of flint, as well as of siliceous sandstone, and diverse cherts. Tools are made mainly of flint and are represented by backed bladelets, microgravettes, endscrapers, retouched blades and bladelets, ventral retouched tools/points. The simple or double endscrapers are made on thick blades and a few samples have traces of resharpening (Figure 2/6). Two points are pedunculated, one of them with distal fractures resulted probably from a strong impact (Figure 2/7). A point exhibits a partial abrupt retouch on one edge (backed tool) and inverse retouch on the distal end (Figure 2-5). Although the lithic industry is not too numerous, there is a clear difference from the collection in the first Gravettian level.

The fourth layer (Gravettian III) represents the oldest Gravettian occupation on the Bistrița valley. Stratigraphically, the existence of two occupational sequences has been noted, but they could not be traced over the entire surface. There are 17 AMS dating for this level, and the majority of them provided ages around 26,000 uncal. BP (30-31 ka cal. BP). More than 3,000 lithic items were found, as well as osseous elements belonging to large herbivores (Bos/Bison), very thick hearths, traces of habitation structures, pits etc. (Figure 3/1,2). Two habitation complexes were located during the 2004 and 2016 campaigns. In the latter campaign, a shallow hearth, 20 cm thick, with well preserved and intense burning traces, was delimited. On top of it, there were bone fragments from large herbivores (Bos/Bison) and a small number of lithic materials. Near the hearth, there is a pit with a maximum diameter of 30 cm, which had been filled with angular limestone fragments, with burning traces (perhaps a water heating pit). A few other small pits may come from a habitation structure.

The lithic material is made mostly of flint and siliceous sandstone and less of menilite, chert and a black siliceous rock known as the black schist of Audia. The siliceous sandstone, the menilite and the cherts are all local rocks. The flint used in this level has been defined in time as a rock carried from about 250 km, from the valley of the Prut river. Most items have a bluish patina on the surface. Previous studies specify that, as regards the Prut flint, only items from the final stage of operational sequences are present, but our analysis on a small part of the collection highlights the existence of products in the entire operational sequence, being made three partial refittings. Cortical items are not too numerous, but they exist and flakes are an important part of the collection. Flint laminar products fall into three categories: large thick blades with slightly curved profile; narrow blades from bipolar systems; regular bladelets, mostly straight in profile.

The observations made on 2016 and 2017 lithic collections reveal that the tools are shaped almost exclusively on flint blanks, with only a few retouched items of siliceous sandstone. The typological range is very narrow, being defined mainly by backed tools (backed bladelets, microgravettes, la Gravette points) (Figure 3/5), alongside of a few retouched flakes and blades (Figure 3/3), some endscrapers on thick and large blades, a tanged tool (Figure 3/4) as well as a few splintered pieces. The tanged tool is a transversally fractured retouched blade transformed into an endscraper. Some blades were shaped by non-marginal scalar retouch. Burins are almost absent from the lithic assemblage. In fact, even in previous analyses they are scarce (Niță-Bălășescu 2008) and should be re-examined for better determination.

Except the lithic materials, no bone tool has been found and ornaments are exclusively represented by perforated shells. Overall, 48 perforated shells have been uncovered, of which 35 specimens of *Lithoglyphus naticoides*, 3 of *Lithoglyphus aperture* and 10 specimens of *Homalopoma sanguineum*, an exclusive Mediterranean species (Figure 4) (for a detailed description see Nițu *et al.* 2019).

The presence of a Mediterranean species at the Poiana Cireșului settlement, located more than 900 km from the nearest source, suggests the connection of communities here with the Mediterranean area, as well as the possibility of a movement of populations from the south of the

Figure 3. Images during excavation and selected tools from the Early Gravettian layer (III) at Poiana Cireşului: 1, 2. images during the excavation of the hearth in section XII; 3. retouched blade; 4. tanged tool; 5. backed tools (microgravettes, backed bladelets).

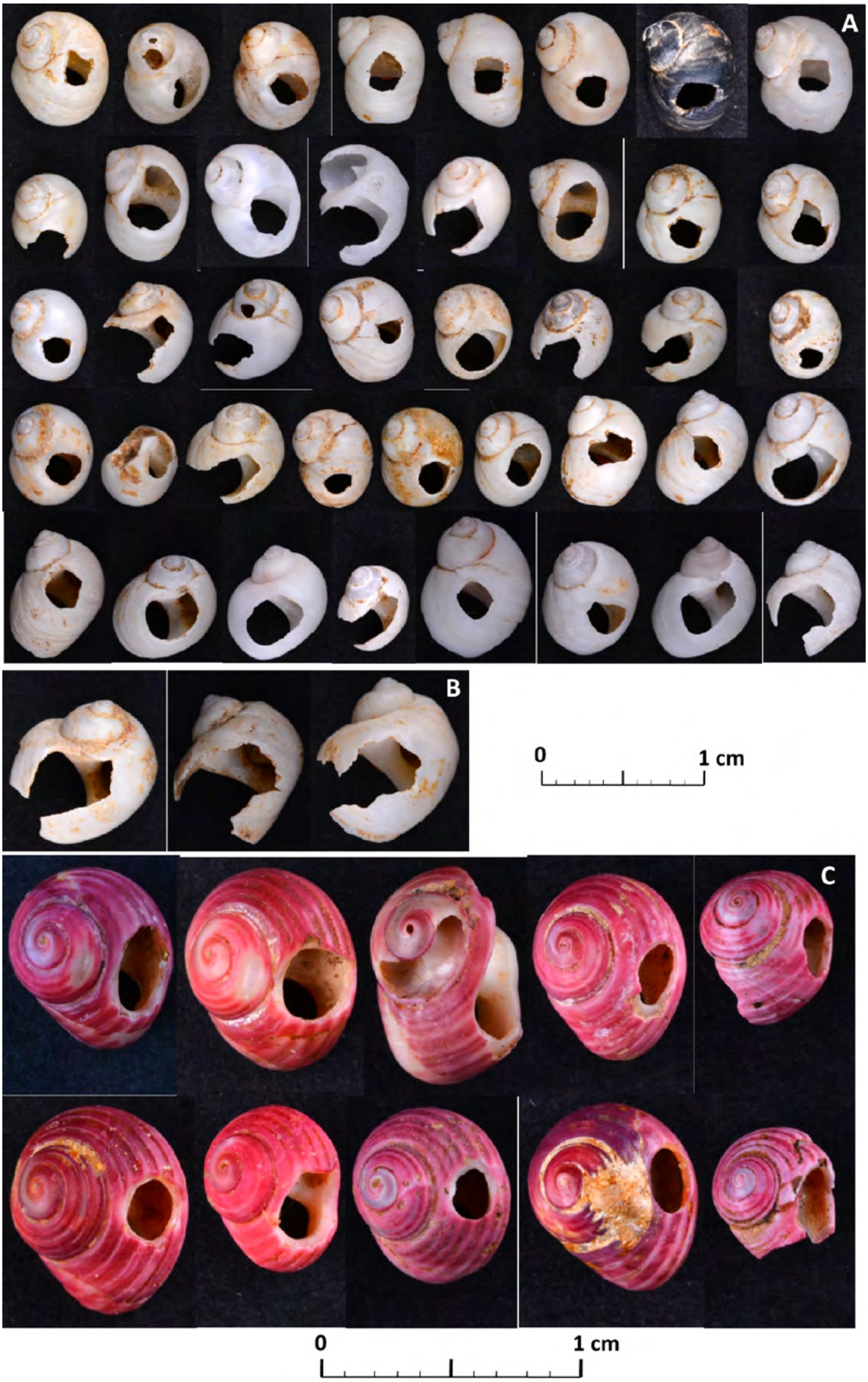

Figure 4. Perforated shells discovered in the Early Gravettian layer (III) at Poiana Cireșului:
A. Lithoglyphus naticoides; B. Lithoglyphus apertus; C. Homalopoma sanguineum.

continent to the east of the Carpathians. We believe that a possible route of these populations' movement may be from the east of the Mediterranean Sea, following the Black Sea coast and the great watercourses. The route along the valley of the Siret and then directly by the Bistrița is obviously the straightest. Taking into account the supply of the Poiana Cireșului communities with sources of lithic raw material from the Prut, we may consider this a plausible route. In addition, the general features of this occupation (such as the characteristics of the lithic material) suggest connections with the Mediterranean area. All these aspects have implications regarding the origin of the Early Gravettian in the east-Carpathian area (Nițu *et al.* 2019), given that most studies have suggested connections with the Gravettian in Central Europe (Otte and Keeley 1990, Bicho, Cascalheira and Gonçalves 2017).

Chronostratigraphic considerations on the settlements in the Ceahlău basin

With regard to the settlements discovered in the Ceahlău basin, there are a few absolute dates and, unfortunately, since 2006 the resumption of investigations has not brought remarkable improvements to the chronostratigraphic framework. Estimating the earliest occupations is therefore very difficult. Initially, the oldest levels found in the settlements of this area were attributed to the Aurignacian (Nicolăescu-Plopșor *et al.* 1966; Păunescu 1998), but recent analyses have shown the absence of any Aurignacian characteristics for these habitations (Cârciumaru *et al.* 2010; Steguweit *et al.* 2009). We shall further on use the term Aurignacian associated to these layers in order to better recognise them, especially since the stratigraphy of sites was established following old excavations; currently, all these layers were defined as belonging to the Gravettian.

Level I of the Cetățica I settlement seems to represent an Early Upper Palaeolithic habitation and is characterised by the presence of bifacial items, sidescrapers, endscrapers and retouched blades. However, the only existing dating provided an imprecise age (>24,000 years B.P-GrN 14629). The second level in the settlement was dated to 23,890 ± 290 (GrN-14630). The two 'Aurignacian' levels of Cetățica II have a single dating each: level I – 26,700 ± 1.100 (GrN-14633), level II – 21,050 ± 650 (GrN-14632). Unfortunately, there are no sufficient dates for these settlements and their chronological framing is hard to do.

For the so-called 'Aurignacian' level I of Bistricioara Lutărie (I and II), there are four datings that provided contradictory ages: 23,560 +1150/ -980 (Gx-8845), 24,100 ± 1300 (GrN-10529), 24,760 ± 170 (GrN-11586), 27,350 +2100/ -1500 (Gx-8844). Also, the dates of the two 'Aurignacian' levels of Dârțu (level I and II) are as follows: for level I ages are of 24,390 ± 180 (GrN-12673) and 25,450 + 4450/ -2850 (Gx-9415), while for level II there is only one date, 21,100 + 490/ -460 (GrN-16985).

At Bistricioara Lutărie and Ceahlău Dârțu, several AMS datings were carried out in surveys conducted in 2006-2007. Some datings, which provided high ages, have been included in articles on the 'reassement' of the Palaeolithic on the Bistrița valley (Anghelinu *et al.* 2018), but they do not date any Palaeolithic occupation, as samples were recovered from geological levels without archaeological context. Moreover, it has been considered that the Gravettian of Bistricioara Lutărie I began around the ages of 28-26 ka BP (Steguweit *el al.* 2009, p. 152), but the samples were gathered from a level that revealed traces of burning without any archaeological material. This level was also identified in older campaigns of the 1950's, published as traces of natural fires (Mogoșanu, 1959). Similarly, at Ceahlău Dârțu, two recent datings of 30,772 ± 643 BP (Erl-9971) and 35,775 ± 408 BP (Erl-12165) have been carried out on isolated charcoal samples recovered from level without archaeological context.

The deposits of the Bistricioara Lutărie and Dârțu-Ceahlău settlements were subjected to the pollen analyses allowing the reconstruction of the Upper Pleistocene landscape on the valley of the Bistrița river (Figure 5).

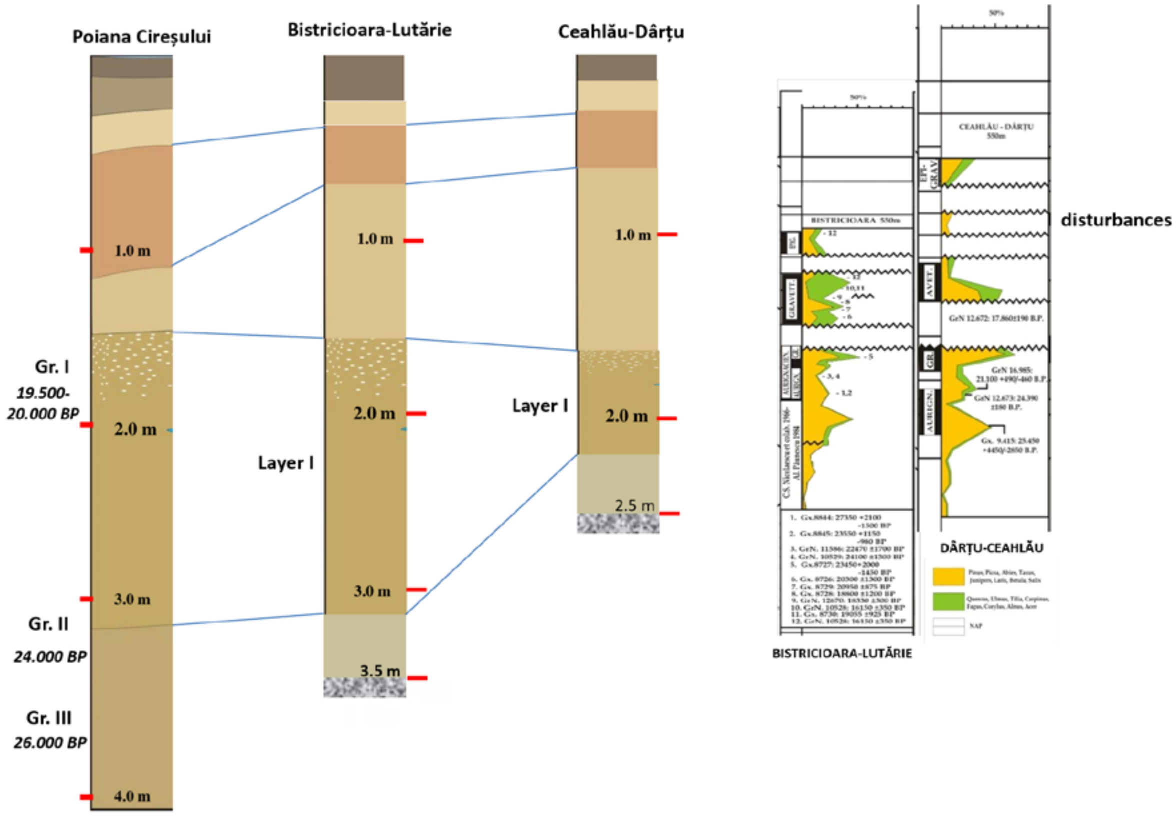

Figure 5. Simplified profiles of Poiana Cireșului,
Bistricioara Lutărie and Ceahlău Dârțu sites.

According to the pollen analysis, the 'Aurignacian' occupation of Dârțu started in a period of slight climatic amelioration, marked by the emergence of forested areas, made up mostly of willow, some conifers and a bit of birch. A C-14 date indicates the age 25,450 + 2100/ -2850 B.P. (GX 9415) for this episode. Then, this so-called 'Aurignacian' evolved in a landscape in which the forest diminished drastically and only towards the end of this habitation did a slight recovery of thermophilic trees occur around the date 24,390 ± 180 B.P. (GrN 12.673). As results from comparing the two pollen diagrams, the first occupation of Bistricioara Lutărie seems to have started later than Dârțu. More specifically, the end of the 'Aurignacian' habitation of Dârțu is relatively contemporaneous with the beginning of that of Bistricioara Lutărie. There are two C-14 dates for the beginning of the occupation at Bistricioara Lutărie. The first, GX 8844: 27,350 + 2100/ -1500 B.P., seems much too high as compared to the second, GX 8845-G: 23,560 + 1150/ -980 B.P., which, in our opinion, indicates an age that is in accordance with the evolution of landscape revealed by the two pollen diagrams. In fact, two other datings attributed to the 'Aurignacian' habitation provided the following ages: GrN 11,586: 24,760 ± 170 B.P.; GrN 10,529: 24,100 ± 1300 B.P. (Cârciumaru 1989, 1999; Cârciumaru *et al.* 2007). Climatically, the middle 'Aurignacian' of Bistricioara Lutărie evolved in a cold climate which caused a fairly open landscape, with trees surviving only along the rivers, in the form of gallery forests, through species of conifers, particularly pine, as well as other deciduous species such as birch and willow. Initially, a second level defined as 'Upper Aurignacian' was mentioned in this settlement, but later it was defined as 'pre-Gravettian' (Păunescu 1984). The pollen analysis reveals that it occurred in a period of slight climatic amelioration, for which there is the date of 23,450 + 2000/ -1450 B.P. (GX 8727-G). The area was now more forested by the emergence, alongside of the pine, of juniper and other deciduous trees such as hazel. The climate, though still quite cold, gains in humidity.

Unfortunately, in the upper part of the deposit, pollen diagrams do not have the same consistency, being interrupted by several remouldings or disturbances caused by the sedimentation process

(Figure 5). Therefore, the fragmentation of pollen diagrams makes it difficult to evaluate the aspect of vegetation and climate features.

As can be noted, the chronology of Palaeolithic occupation in the Ceahlău basin, as was published after many research campaigns, is far from offering us a coherent picture regarding the cultural succession in this area. Although things seem impossible to elucidate, we believe there is an explanation for the chronostratigraphic incongruity of Palaeolithic levels in this area, which comes from failing to understand the sequence of geological deposits that were explained and published (Cârciumaru 1980), but have been completely overlooked in recent studies (Anghelinu *et al.* 2018), thus providing a somewhat chaotic image of the Palaeolithic on the Bistrița valley. If cultural succession may be the result of subjective interpretations of archaeologists, geological succession is a more reliable tool of chronological framing. In a deposit undisturbed by subsequent processes, elementary principles of sedimentology have established that a layer is younger than the one it overlaps. These things have been neglected lately, leaving room for erroneous interpretations of some C-14 dates carried out a long time ago, on small samples, ensuing the excavations proper, with margins of error that are hard to accept.

According to the description of deposits, the 'Aurignacian' levels of Ceahlău Dârțu, Bistricioara Lutărie, Cetățica I and Cetățica II have been found in a grey deposit, with sandy-loam texture and high content of calcium carbonate having a pseudomycelial aspect (Nicolăescu-Plopșor *et al.* 1966; Cârciumaru 1980; Păunescu 1998) (Figure 5). This deposit has also been noted at Poiana Cireșului, being defined as heavily carbonated clay-loessic light olive layer (geological layer 4).

As mentioned, the first Gravettian layer of Poiana Cireșului is located in the upper part of geological layer 4 and is dated between 19,320 ± 80 uncal. BP (OxA-36785) and 20,154 ± 97 uncal. B.P. The second Gravettian layer is located in the lower part of the pseudomycelial level, being dated c. 24,500 uncal. BP. (28-29 ka cal. BP). Therefore, we may say that the beginning of the deposition of the pseudomycelial level occurred around 24/25,000 BP and ended probably around the age of 19,000 BP. Given the position of the first occupations in the Ceahlău Basin, all found in the pseudomycelial level, it is obvious that they can be dated either around the age of 24,000 BP, or even younger (Figure 5). The only older occupation may be only the first level of Cetățica I, as aforementioned, being located below the pseudomycelial deposit, but we have no dating for it.

In view of these observations, there is no surprise that some datings of 'Aurignacian' levels in the Ceahlău Basin have provided ages of 24, 23, or 21 ka uncal. BP. In fact, unlike dates that provided higher ages, these ones have the smallest margins of error. For example, of the four dates existing for the first layer of Bistricioara Lutărie, only the danting of 24,760 ± 170 (GrN-11586) has a much smaller margin of error as compared to the others whose margin often exceeds 1000 years. Moreover, above this so-called Aurignacian level, a Gravettian level, with 4 rather contradictory datings, has been determined. The age with the smallest margin of error is 20,310 ± 150 BP (GrN-16982), which is closer to the dates of the first Gravettian level of Poiana Cireșului.

Our arguments regarding the age of the pseudomycelial deposit are also supported by recent dating for samples from the Gravettian level I of Buda settlement. It was found in the middle part of this deposit (Păunescu 1998; Tuffreau *et al.* 2018). The two recently obtained AMS dates have provided the ages of 23,300 ± 160 (OxA 29525) and 23,440 ± 160 (OxA 29526) (Tuffreau *et al.* 2018), which are consistent with an older dating of 23,810 ± 190 BP.

Discussions and conclusions

A first discussion on the cultural succession of the Palaeolithic on the Bistrița valley is the age of paleolithic occupations. The earliest levels of the Bistrița Valley were discovered recently in 2018 at Poiana Cireșului. Two Early Upper Paleolithic occupation were identified and provided the following datings: layer V – Beta 507.489: 32,400±180 uncal. BP (36,750-35,850 cal. BP), Beta 507,487 -32,630 ± 190 uncal BP (37,250-36,077 cal. BP); layer VI – Beta 507,488: 37,550 ± 360 uncal BP (42,475-41,417 cal. BP). These recent results have changed the chronology of Eastern Carpathian area by proving the existence of Early Upper Paleolithic occupations much older than previously known levels.

Regarding the Gravettian, at this moment, we have no chronological argument to attest habitations that are older than 26/27 ka BP, which are the ages obtained for the Gravettian III level of Poiana Cireșului. The highest dates in the Ceahlău basin are around 24 ka BP, while the recent samples that have provided older ages do not date any archaeological level, but only perhaps point to how old the deposits are. The same age of 24 ka BP is the boundary of the oldest levels in the settlements located in the lower basin of the Bistrița River (Tuffreau *et al.* 2018).

The oldest Gravettian level of Poiana Cireșului is characterised technologically by the selective use of local raw material (mainly siliceous sandstone) and the preference for shaping tools on blanks made of non-local raw materials (the Prut flint); most of the tools are retouched blades and bladelets, mainly backed tools. The symbolic behaviour distinguishes this occupation from the Central and Eastern European Gravettian: the exclusive use of small shells to make personal ornaments. The species of shells used also particularise the communities here: perforated shells of Lithoglyphus naticoides are not used in any Gravettian settlements, while the Homalopoma sanguineum is a species that was scarcely used in the Gravettian, not to be encountered in any settlement of Eastern Europe (Nițu *et al.* 2019). Moreover, the Mediterranean provenance of Homalopoma sanguineumi shells is the only clue to the origin of Poiana Cireșului Early Gravettian communities. So far, this level can be paralleled to no other habitation on the Bistrița or Prut valleys and the attempt to relate it to the early Gravettian levels of Mitoc Malul Galben (Anghelinu *et al.* 2018) has no plausible argument.

A second stage of occupation on the Bistrița valley can be dated c. 23/24 ka BP and is represented by levels documented in settlements of Poiana Cireșului, Bistricioara Lutărie I and II, Ceahlău Dârțu, Cetățica I and II, Lespezi, Buda. Even if they are chronologically synchronous, as the discovered materials are presented, it is hard to state that there is a clear connection among habitations in these settlements. For example, the tanged points and other types of points, which are difficult to fit in the classical Gravettian typology, are only encountered in the Gravettian level II of Poiana Cireșului.

In an attempt to connect the Gravettian on the Bistrița valley with that on the Prut valley and, in a wider sense, with Central European settlements, some occupations dated between 25-23 ka BP were included in a so called phénomène à cran (Anghelinu *et al.* 2018), which presumably is to be encountered in the sites of Poiana Cireșului, Bistricioara Lutărie and Buda. Indeed, there is a level with shouldered tools at Mitoc Malu Galben, but defining them on the Bistrița valley has been erroneous. In the Gravettian level II of Poiana Cireșului 3 shouldered tools were initially invoked (a point, a blade and a proximal fragment of blade) (Cârciumaru *et al.* 2006), but these items later became tanged and shouldered (Cârciumaru *et al.* 2006, 2010), or only tanged (Niță-Bălășescu,2008); in recent studies they have again turned into shouldered (Anghelinu *et al.* 2018). Actually, the tools mentioned are two tanged points, one of them with prominent traces of impact on both faces, and a proximal-mesial fragment of blade that preserves backed retouches on the side, representing a stage of working backed bladelets.

As regards the other settlements invoked (Bistricioara Lutărie and Buda), the confusion concerning the so-called horizon with shouldered tools is even greater. Within the lithic material of Bistricioara Lutărie taken from old excavations, only one atypical shouldered item is mentioned and illustrated (Nicolăescu-Plopșor 1966, fig. 21/16, Păunescu 1998), in level VI, whereas in level V there is an atypical shouldered point (Păunescu 1998). These levels are younger than level IV, for which there are two datings: 19,055 ± 950 BP (GX-8730) and 16,150 ± 350 BP (GrN-10528). Whatever the real age, it is much too recent as compared to the presumed horizon with shouldered items. Also, a shouldered point has been identified in level III of Cetățica I, dated to 19,760 ± 470 BP (Păunescu 1998). No shouldered tool has been described in the material recovered from recent excavations of Bistricioara Lutărie I (Steguweit *et al.* 2009). We might say that in the case of the settlements in the Ceahlău basin, shouldered items belong to late Epigravettian habitations, not to middle or late Gravettian. At Buda-Dealul Viilor, M. Bitiri *et al.* (1989) mention five shouldered points, while according to Al. Păunescu (1998) there are 3 shouldered items and one atypical shouldered point. Four items considered to be shouldered are illustrated, of which only three seem to be accurately attributed (Bitiri, fig. 18/10; Păunescu, fig. 176/64, 65). No shouldered tool has been noted in the material found in a section excavated in 2012 in the same settlement (Tuffreau *et al.* 2018).

Therefore, we consider that a so-called horizon with shouldered tools unfolding between 23-25 ka B.P. (Anghelinu *et al.* 2018) is not well defined on the Bistrița valley. The few items described in old studies at Buda cannot represent a solid argument.

The Bistrița valley, around the age of 20,000 uncal. B.P., seems to be an intensely inhabited area, with several archaeological levels having ages close to this date: Bistricioara Lutărie (levels II, III, IV), Cetățica I (level III) Ceahlău Dârțu (level II), Poiana Cireșului (Gravettian level I), possibly Lespezi. Unfortunately, except Poiana Cireșului that has many AMS dates with coherent ages, the chronological situation for the other settlements is difficult to establish. Moreover, Poiana Cireșului clearly stands out through the remarkable density of materials and habitations structures as well as through the number and diversity of art objects (Cârciumaru 2016, 2018).

In conclusion, the evaluation of the Upper Palaeolithic on the Bistrița valley must be made with much more attention and the integration of old investigations should take into account that excavations were not carried out with the same accuracy; therefore, the comparison and analogies of materials are hazardous given such inconsistencies. Even the lithic material from old excavations sometimes requires a careful techno-typological reinterpretation. Taking into account all the variables, we consider that the Bistrița valley may finally represent a model of exploitation of a microregion in the Upper Palaeolithic, which should be integrated into the wider area of Central and Eastern Europe.

Acknowledgements

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Zooarchaeological analyzes of the faunal remains of the upper layer of Climăuţi II (Republic of Moldova)

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Abstract

The upper layer of Climăuţi II, located in the Middle Dniester, delivered many archaeological remains relied to the first part of the upper Pleniglacial (between 20,500 and 20,000 BP). The lithic industry is rich, dominated by scrapers, burins and blades, and presents epi-Aurignacian characters. From our zooarchaeological analyzes we highlighted that this assembly was relatively quickly accumulated and little affected by sediment movements. The woolly mammoth is the main species, probably as important food resources, for ivory and as raw material to build structure. All the remains attest to various activities, as flint knapping, hunting and butchering activities, also as bone working. It corresponds to an important camp probably occupied several times during short-termed period. Compared to the rather contemporary sites of the Dniester valley, Climăuţi II is a unique site in the region with a clear and important status accorded to mammoth by Paleolithic human groups.

Keywords: Zooarchaeology; Dniester valley; Upper Palaeolithic; Mammoth exploitation; Moldova

Résumé

Le site de Climăuţi II/sup., située dans la vallée du Dniestr, a livré de nombreux vestiges archéologiques rattachés à la première partie du Pléniglacial supérieur (entre 20.500 et 20.000 BP). L'industrie lithique est riche, dominée par les grattoirs, les burins et les lames, et présente des caractères épi-aurignaciens. Les analyses archéozoologiques démontrent que cet assemblage a été accumulé assez rapidement et est peu remanié. Le mammouth est la principale espèce, exploitée en tant que ressource alimentaire, pour l'ivoire et comme matériaux de construction. Les vestiges archéologiques témoignent d'activités variées, telles que la chasse, la boucherie, le travail des matières lithiques et des matières dures d'origine animale. Il s'agit d'un campement important, probablement occupé à plusieurs reprises au cours d'une courte période. Comparé aux sites pseudo-contemporains de la vallée du Dniestr, Climăuţi II est un site unique dans la région, avec un statut particulier accordé au mammouth par les groupes humains.

Mots-clés : Archéozoologie ; vallée du Dniestr ; Paléolithique supérieur ; exploitation du mammouth ; Moldavie

1. Introduction

In The East European Plain, within the extra-Carpathian area the Prut and Dniester valleys were settled by Paleolithic human populations. The landscapes are characterized by middle mountains

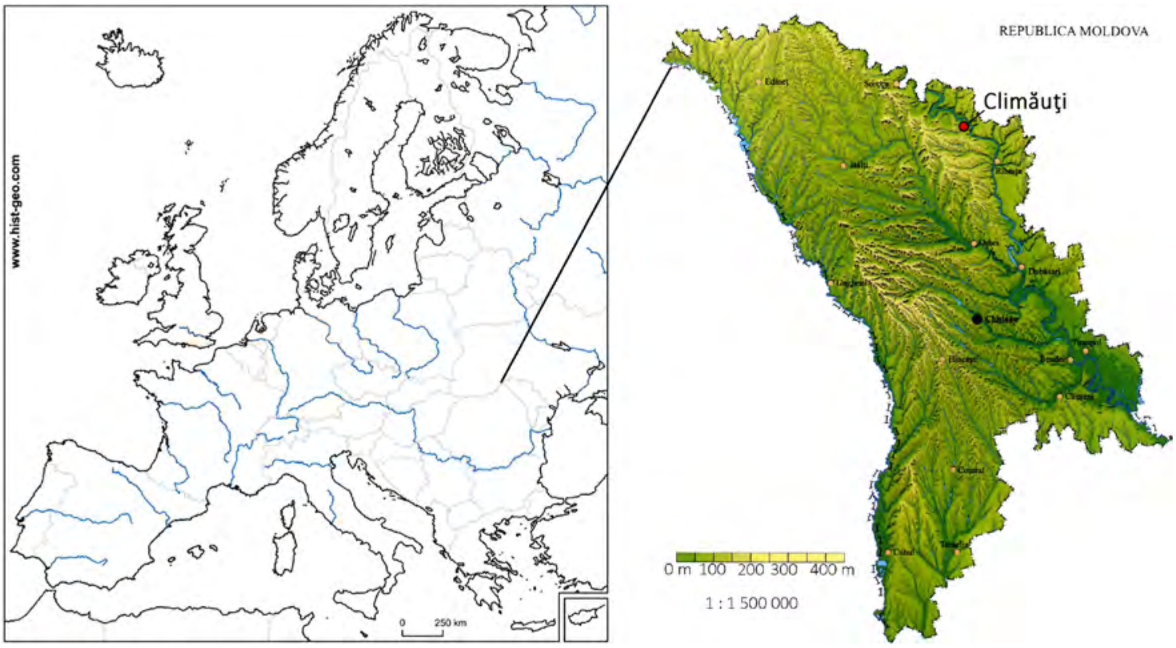

Figure 1. Localisation of the site of Climăuţi II in Republic of Moldova.

with hilly lands alternating with mountainous lands intersected by enclosed or meandering valleys. Molodova V, Mitoc-Malu-Galben, Korman IV, Cotu-Miculinţi, Cosăuţi and Dorochivtsy III provided important sedimentary and archaeological sequences which permitted to better define the chrono-cultural and palaeoenvironmental frameworks between 33,000 and 10,000 BP (Chernysh 1959; Kozarski 1980; Ivanova, Tzeitlin 1987; Otte *et al*. 1996; Damblon, Haesaerts 1997; Noiret 2007a; Haesaerts *et al.* 2007; Koulakovska, Usik and Haesaerts 2012; Chirica, Bodi 2014; Demay, Patou-Mathis and Koulakovska 2015). However there was little information about the Last Glacial Maximum (23,000-20,000 BP). We are particularly interested by this period wich correspond to the transition between the first part of Upper Pleniglacial (26,000-20,000 BP) to the second part of Upper Pleniglacial (20,000-14,000 BP) (according to Haesaerts *et al.* 2003) which relatively corresponds also to the transition from the Mid Upper Palaeolithic (29,000-24,000 BP) to the Late Upper Palaeolithic (23,000-10,000 BP). In this area an original culture was developed within the Gravettian called Molodovian or Eastern Gravettian and Epigravettian of Ukraine (Boriskovskyi 1953; Grigor'ev 1970; Chernysh 1954, 1973, 1985; Otte *et al.* 1996; Borziac 1998; Borziac and Koulakovska 1998; Borziac, Chirica 1999; Borziac, Haesaerts and Chirica 2005; Noiret 2004; 2007; Nuzhnyi 2009). We focus on the site of Climăuți II (Republic of Moldova) (Figure 1), to better determine the situation of this site, the human activities and its place in the chronocultural framework.

2. Site location and chronostratigraphy

The first discoveries in Climăuţi de Jos (District Soldăneşti, Republic of Moldova) were made by I. Borziac in 1971, with the site of Climăuţi I. In 1989, the building of a kindergarten in the village permitted to process to researches. On this occasion, T. Obadă found the site of Climăuţi II. Then rescue excavations have been carried out under the direction of I. Borziac. The site was excavated over 164 m^2. It is located on a promontory formed by river beds Dniester and Gârla, on the third terrace, 27-35 meters high above the Dniester, on the right bank (Figure 2A). The cultural remains were situated in loessic loams, which would correspond to the first part of Upper Pleniglacial (between 26,000 and 20,000 BP) (Borziac, David and Obadă 1992; Obadă, David and Borziac 1994). Two cultural layers were discovered. We present here the upper layer situated 1.50-2.20 meters deep from the zero point, 1.60-2.30 meters deep from the actual surface. In the northeastern part the layer was 0.25-0.30 meters thick and then to the southwest it increased gradually until reach 0.50-0.60 meters thick (Figure 2B).

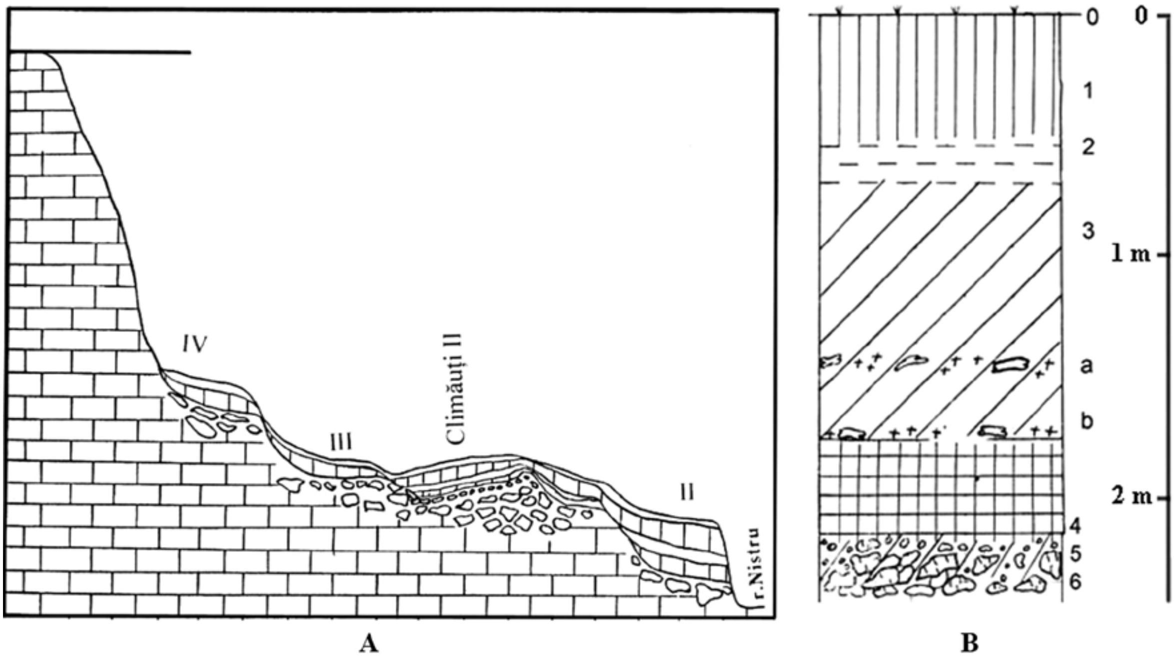

Figure 2. Geologic data of Climăuţi II, excavations 1989 A: location on the third terrace of the Dniester (Borziac, Chirica and David, 2007); B: stratigraphy (Borziac, David and Obadă, 1992); 1: chernozem; 2: horizon of transition between Holocene and Pleistocene; 3: loess level (clay with fine quartz sand); 4: fossil soil; 5: loess deposits, mixed with detritus and calcareous gravel; a: upper cultural layer; b: lower cultural layer.

Two radiocarbon dates were realized. The upper layer furnished a result of 20,350 ± 230 BP (LU-2431; M.V. Lomonosov University of Saint-Petersburg) from a mammoth cheek teeth. The lower layer was dated from 24,840 ± 230 BP (LU- 2351; Institute of Geography of the Academy of Sciences of Moldova) from humus.

We will can do new datings about the material from an archaeological survey realized in 2017 (Covalenco, Obadă and Demay 2018).

3. Palaeoenvironmental and archaeological data

3.1. Palynology

According to the palynological data (Medeanik and Borziac in Borziac, Chirica and David 2007), the upper layer presents species from periglacial cold steppe associated with bushes and conifers. This ecosystem was adequate for the development of large mammalian fauna.

3.2. Malacofauna

Within the upper layer, some terrestrial molluscs were discovered. Four species were identified by Prepelitsa (in Borziac, Chirica and David 2007): Vallonia tenuilabris, Pupilla muscorum (Moss Chrysalis Snail), Vallonia pulchella (Smooth Grass Snail), Trichia cf. Hispida terrena = Trochulus hispidus (Hairy Snail). It corresponds to cold and arid climates slightly mild in bound with cold steppe associated to bushes and conifers, near water.

3.3. Fauna

According to the identified fauna (David, Obada in Borziac, Chirica and David 2007), the faunal spectrum is typical of the 'Mammoth steppe', characterized by a cold open landscape. The presence of red deer could testify of the proximity of an arboreal area near water.

3.4. Lithic industry

The upper layer furnished 4514 lithic pieces. They were realized from local flint, granite and quartzite and from imported schist and volcanic tuff. They are represented by untouched flint nodules and pebbles (0.4%), fragments of quartzite nodules and pebbles (1.2%), prenucleus (0.4%), nucleus (3.3%), fragments of nucleus (1.4%), bladelets (0.7%), crested pieces (0.3%), tools (5.6%) and dominated by blades (11.9%), splinters (11.8%) and flakes (63%). Among the nucleus, some of them were complete and others are characterized a maximum exploitation of the raw material. There are 254 tools: retouched flakes (6.7%), notched retouched pieces (2.7%), nucleiform tools (2.4%), scaled pieces (3.2%), scrapers (1.6%) dominated by end scrapers (13%), burins (36.6%) and retouched blades (33.4%) (Borziac, David, et Obadă 1992; Borziac, Chirica and David 2007). This industry is characterize by epi-aurignacian characters corresponding to the Epigravettian aurignacoid or Epi-Aurignacian (Borziac, Chirica and David 2007; Noiret 2009).

The Epi-aurignacian corresponds to the resurgence of techniques used in the Aurignacian. This phenomenon has been observed in several sites (notably Raşkov VII in the Dniester Valley), without any direct cultural affiliation between them (Covalenco 2003-2004; Zwyns 2004; Noiret 2007b; Chirica and Valeanu 2007).

Moreover a sandstone plate with engraving was discovered (Borziac, Chirica and David 2007).

3.5. Ochre

Several pieces of animal origin were covered by red ochre (Borziac, Chirica and David 2007).

3.6. Mobiliary bone supports

The upper layer furnished a rich series of objects modified (points, hoe, lissoirs, retouchers, handles, ivory rings/bracelets, and metapod and long bone diaphysis cylinders with sawing marks and perpendicular incisions) or collected from animal resources: bone, antler, ivory, shells and echinoderm (Abramova 1995; Chirica, Borziac 1995; Borziac, Chirica and David 2007; Noiret 2009). 60 seashells (Tritia reticulata: Netted Dog Whelk and Cerithium vulgatum: Common Cerithe) were scattered in the layer. 24 of them were perforated, probably used as pendants. Among them 15 were also covered by red ochre. These seashells could have been imported or extracted from sarmatian limestones of the Dniester valley. A fossil sea urchin was discovered characterized by anthropogenic notches and deposits of ochre. It could also be from sarmatian limestones.

3.7. Anthropogenic structures

The southern part of the excavation underwent reworking when the kindergarten was started. In the square D-5/6 a rubefied soil with ashes was excavated. It reaches 30 x 35 centimeters in diameter and 5-6 centimeters deep. It could correspond to a fireplace. Nearby was a pit 34 x 37 centimeters in diameter and 40-45 centimeters deep. It was filled with grayish sediments (Figure 3). Several limestone blocks were scattered in the area. They fell from the upper part of the terrace. Some of them could have been used as support by human. A circular accumulation of mammoth bones was observed. The bones were gathered and stacked by types of elements (Figure 3). Moreover, according to Borziac, Chirica and David (2007), seven long bones (4 humerus and 3 undetermined) of mammoth were characterized by anthropogenic perforations (from 5 to 12 centimeters in diameter). According to the authors they were used to elaborate a structure with ropes.

4. Material and methodology

We proceeded to the zooarchaeological analyzes of the faunal remains of the excavations from 1989. This material is kept in the Institute of Zoology of Academy of Sciences in Chişinău (Republic of Moldova).

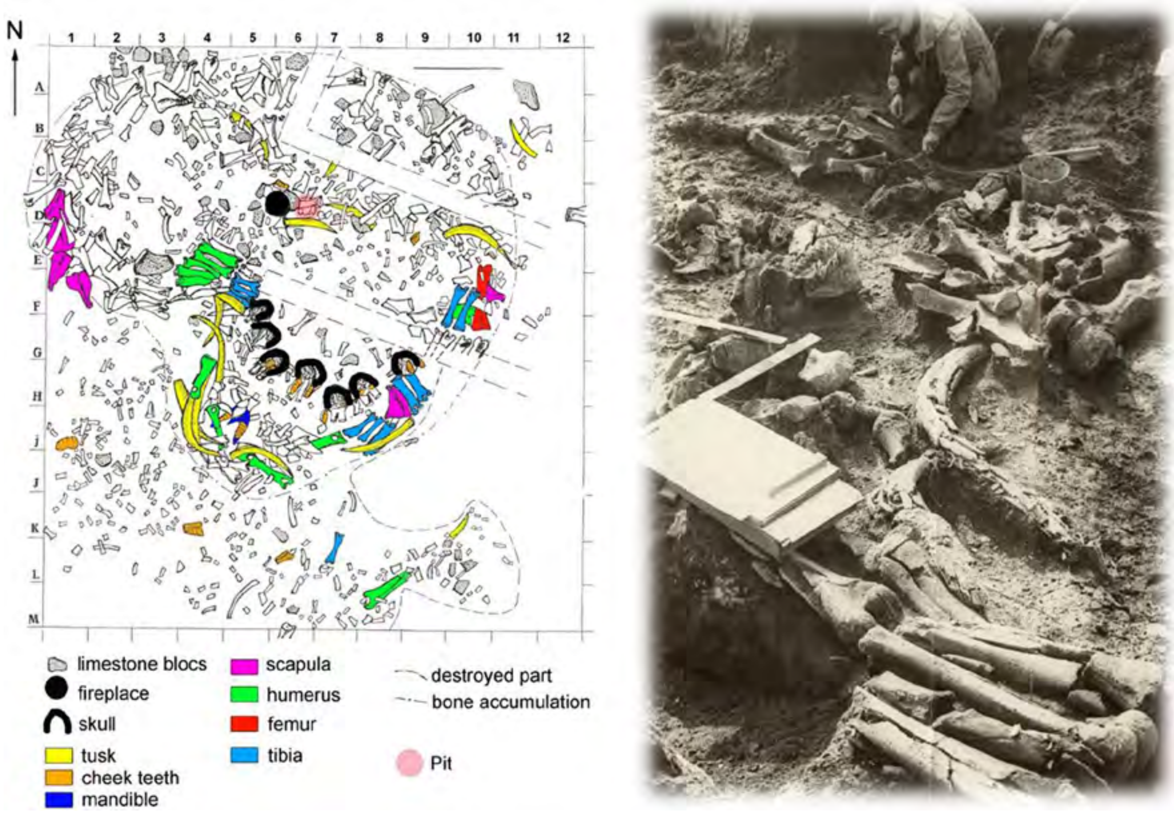

Figure 3. Planigraphy of elements and structures of Climăuţi II/upper in 1989
(modified from Borziac, Chirica and David, 2007) and view on excavations (© A. Simanovschi).

The study includes paleontological analyzes, the biology and ethology of the species, by means of actual comparisons. In addition, the description and quantitative analysis of the anatomical elements associated with taphonomy (climate and edaphic factors and non-human biological agents) will make it possible to identify the conditions that make up the fossil assemblage. The combination of these analyzes in relation to the stigmas that may have been left by humans, will lead to a better understanding of the anthropogenic impact on this assemblage (Poplin 1976; Binford 1979; Behrensmeyer 1978; 1990; Lyman 1994; Denys, Patou-Mathis 2014; Fernández-Jalvo, Andrews 2016). Taxonomic references and systematics are based on the zoological nomenclature code (1999). The vernacular anatomical terms are used according to the criteria of Barone (1986) taking into account the current nomenclatures. Here we adopt the quantization units defined by Poplin (1976), and Lyman (2008). The skull (cranium and face) is considered an element. The frontal appendages can also be considered as a separate element. The hemi-mandible is counted as an element, except for the mammoth whose mandible is a complete element. A tooth, whether isolated or in place, is considered as an element. To estimate the Minimal Number of Individuals (MNI) we proceeded to reassembling, pairing, associations, according to the criteria of age and sex.

Osteometric measurements follow the procedures of von den Driesch (1976), and concerning mammoth, of Agenbroad (1994), Lister (1996) and Göhlish (1998).

For the identification of mammoths (Mammuthus primigenius), age determination is based on epiphyseal stages of long bones and eruption and eruption/wear sequence of the cheek teeth (Osborn 1942; Vaufrey 1955; Coppens 1965; Laws 1966; Krumrey, Buss 1968; Roth 1984; Roth, Shoshani 1988; Haynes 1991). The identification of sex is based on the morphometry of the bones (Averianov 1996; Shoshani, Tassy 1996; Lister 1999). For the age identification of horses (Equus sp.) (Barone 1966; Guadelli 1998), bison (Bison sp.) (Koch 1932 in Duffield 1973; Koch 1935; Grant 1982), reindeer (Rangifer tarandus) (Bouchud 1953, 1966; Miller 1972, 1974; Hufthammer 1995; Enloe 1997; Weinstock 2000), wolf (Canis lupus) (Barone 1976), we used the same methods. For bison, we used the Klein-Spinage formula which permits to describe the curvilenar relation between the age and the hight of crown (Spinage 1973; Klein *et al.* 1981, 1983). Here, for the original unworn crown height we used data from Brugal and David (1993).

Seasonality can be estimated in relation with biological cycles of bison (Walde 2006) and reindeer (Murray 1993; Kuntz 2011).

Patterns in the age at death (mortality profiles) of animals are used to infer the origins of assemblages (Klein, Cruz-Uribe 1984; Haynes 1987; Stiner 1990; Magniez 2010). Moreover a model of ternary diagram was put in place to compare the mortality profiles to highlight the origins of death (Stiner 1990, 1991; Costamagno 1999; Discamps, Costamagno 2015). We have developed theoretical diagram for mammoth.

The skeletal preservation on%MAU by anatomical segments related with bones density (from Lam *et al.* 1998; Lam, Pearson 2003) is based on Lam *et al.* (1999) for horse and Kreutzer (1992) for bison.

The nutritional strategies are estimated (Binford 1978, 1987; Metcalfe 1988; Jones, Metcalfe 1988; Lyman 1994; Faith, Gordon 2007), from Outram, Rowley-Conwy (1998) and Morin (2012) for horse and from Emerson (1990, 1993) for bison.

The intensity of the occupations according to weight of meat and the available calories is based on Rozoy (1978) and Noiret (2009) who synthesized the data of Klein (1973), Chernych (1977), Soffer (1985), Delluc, Delluc and Roques (1995), and López Bayón, Gautier (2007).

5. Zooarchaeological analyses

5.1. Faunal spectrum

The fauna is dominated by proboscideans (M. primigenius), then artiodactyls (Bison sp., R. tarandus, C. elaphus), then perissodactyls (Equus sp.) and carnivorous (C. lupus, Vulpinae) and finally rodents (Lepus sp.) (Table 1).

Species	Vernacular name	NR	MNE	MNI
Mammuthus primigenius	Woolly mammoth	311	243	17
Equus sp.	Horse	68	68	5
Bison sp.	Bison	19	17	4
R. tarandus	Reindeer	15	14	2
C. elaphus	Red deer	3	3	2
Canis lupus	Wolf	52	48	3
Vulpes sp./*A. lagopus*	Fox	5	5	1
Lepus sp.	Hare	2	2	1
Number of identified specimens		475	400	35
cervid		1		
large-sized mammal		1		
large-sized herbivores		5	4	
large or medium-sized mammal		5		
medium-sized mammal		10	9	
medium or small-sized mammal		6		
TOTAL		503	413	35

Table 1. Counting of faunal remains of Climăuţi II/upper in number of remains (NR), minimal number of element (MNE) and minimal number of individuals (MNI).

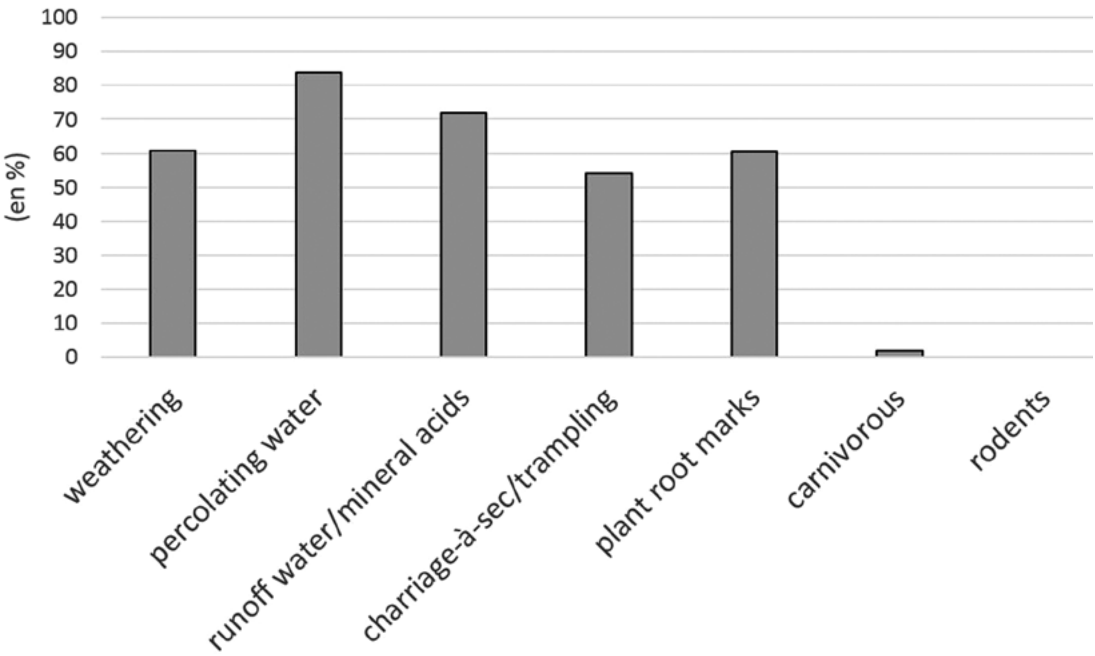

Figure 4. Alterations due to climato-edaphic and non-human biological agents in percentage of number of remains of Climăuţi II/upper.

5.2. Preservation of bones and taphonomy

Splinters were not kept, so we have mainly quasi-complete and identifiable bones. Bone surfaces are well preserved. They are characterized by fresh and dry fracturations. Several vertebrae of mammoth were still in anatomical connection.

Surfaces are damaged by relatively short-time weathering (stages 1-2 [Berhensmeyer 1990]), water effects, some marks of charriage-à-sec and plant root marks. We have only few marks of carnivorous (Figure 4). We did not observe differences of preservation between the different species (Figure 5).

5.3. Paleontology and skeletal preservation

5.3.1. Mammoth

Mammoth is the most abundant taxon. It is represented by 311 remains corresponding to at least 243 elements belonging to 17 individuals. Different teeth are missing, so we could have initially two other individuals. Cranial skeleton, particularly teeth, and limb bones are the most represented. Bones are a little bit fragmented, most for skull and tusks which are naturally more fragile.

All anatomical parts are represented except caudal vertebrae and metapodials. As we said, splinters are absent. So we have few fragmented bones. However we can observe fragmentation of skull and tusks which are naturally more fragile in terms of their morphology and structure.

According to the skeletal conservation indices, cranial and limb bones are the most represented (Figures 6 and 7).

It could be relied to natural preservation or anthropogenic selection.

Comparing skeletal preservation by lateralized elements we have a similar representation between left and right sides. The general index of skeletal conservation (IGCS; cranial bones/postcranial bones) shows that the cranial skeleton is overrepresented (theoretical indexes are respectively 0,07 and 0,05): IGCSNR= 114/182=0,62 ; IGCSNME= 92/144=0,64. The dental preservation index (ICD;

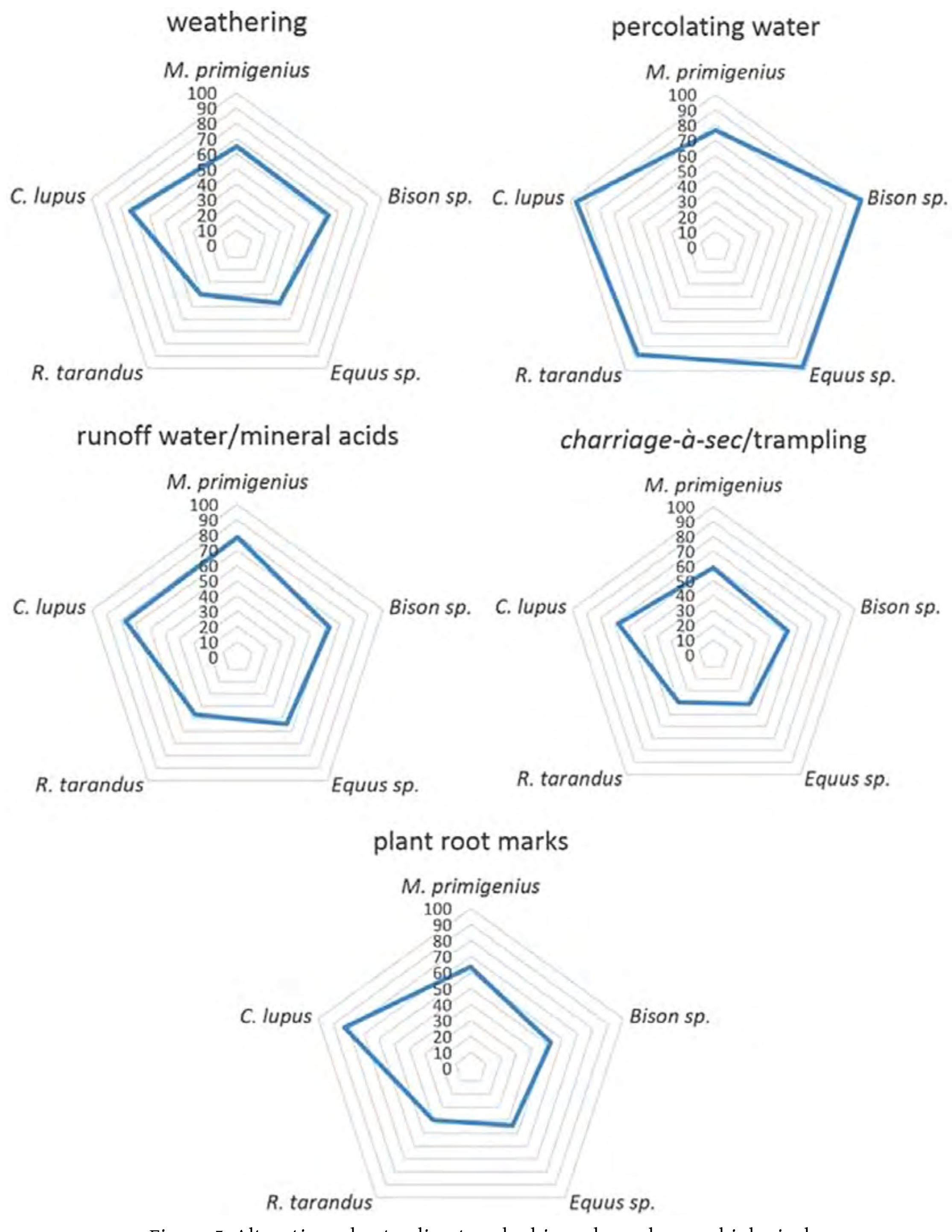

Figure 5. Alterations due to climato-edaphic and non-human biological agents in percentage of number of remains by species of Climăuţi II/upper, (without species represented by ≤ 5 remains).

dental bones/postcranial bones) shows that the dental elements are overrepresented: ICDNR= 84/182=0,46; ICDNME= 72/144=0,5. It would not correspond to a natural dispersion phenomenon.

We proceeded to the refitting of mammoth bones and to the determination of age classes and genders. One individual presents a pathology, fused left radius and ulna.

According to teeth we determined at least 15 individuals and to other bones there is 16 individuals (Table 2).

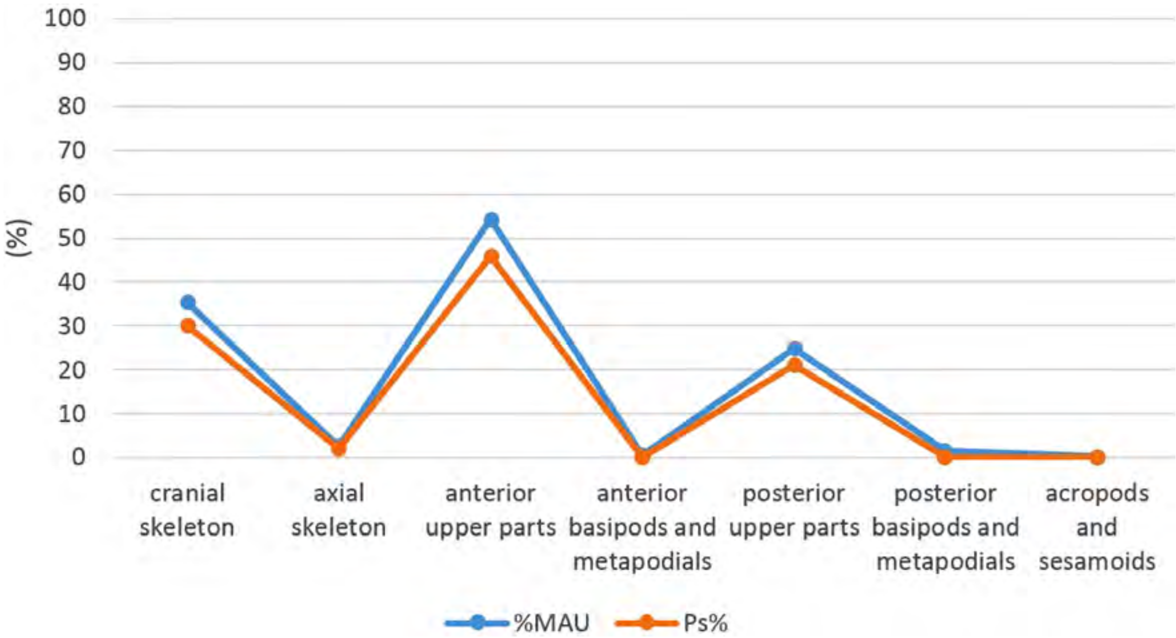

Figure 6. Skeletal preservation by anatomical parts in percentage of minimum animal unit (%MAU) and percentage survival (Ps%) of mammoth from Climăuţi II/upper.

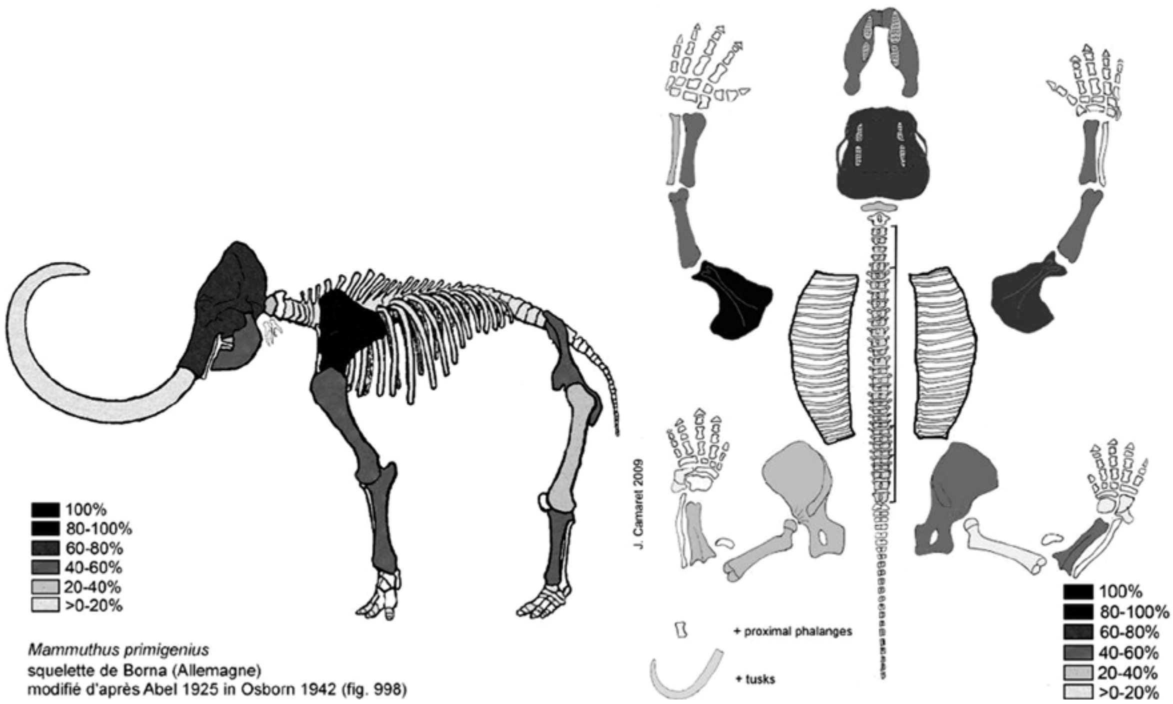

Figure 7. Skeletal preservation by elements and lateralized elements in percentage survival (Ps%) of mammoth from Climăuţi II/upper.

Comparing adult s.l. and juveniles, juveniles are mainly represented by cranial skeleton (Figure 8). According to osteometric data we determined 4 males and 5 females adult s.l.. We proceeded to the refitting of mammoth bones and teeth and to the determination of age classes and genders by combination we identified at least 17 individuals (Table 3; Figure 9).

5.3.2. Other herbivorous mammals

Horse is represented by 68 remains corresponding to 68 elements, mainly cranial and limb elements (Figure 10).

Table 2. Determination of mammoth age classes according to teeth and other bones from Climăuţi II/upper.

TEETH	
Classes	**Number of individuals**
juvenile	5
young adult	4
intermediate adult	1
intermediate or mature adult	3
mature adult	2
old adult	0
Total	**15**
BONES	
Classes	**Number of individuals**
juvenile	4
young adult	4
intermediate adult	1
intermediate or mature adult	3
mature adult	2
old adult	0
adult *s.l.*	2
Total	**16**

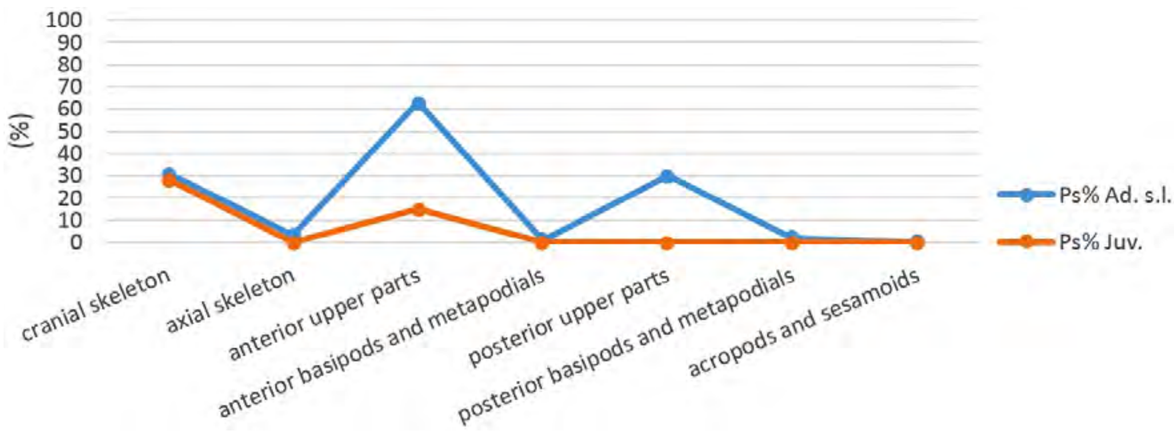

Figure 8. Skeletal preservation by anatomical parts in percentage survival (Ps%) of mammoth between adults s.l. and juveniles from Climăuţi II/upper.

Classes	**Stages**	**Gender or type**	**Number of individuals**
juvenile	IX	/	5
	V	/	
	VIII	/	
	VIII-IX	/	
	V-VII	/	
young adult	IX-X	/	4
	XIV	M	
	IX-X	/	
	XV-XVI	F or Y.A.	
intermediate adult	XVI-XVIII	F	1
intermediate or mature adult	XVII-XX	F	3
	XVII-XIX	M	
	XVII-XIX	F	
mature adult	XXI-XXII	M	2
	XXI-XXIII	F	
old adult			0
adult *s.l.*	> XVI	F	2
	VIII-XX	M	
Total			**17**

Table 3. Determination of minimum number of individuals by mammoth age classes and gender from Climăuţi II/upper.

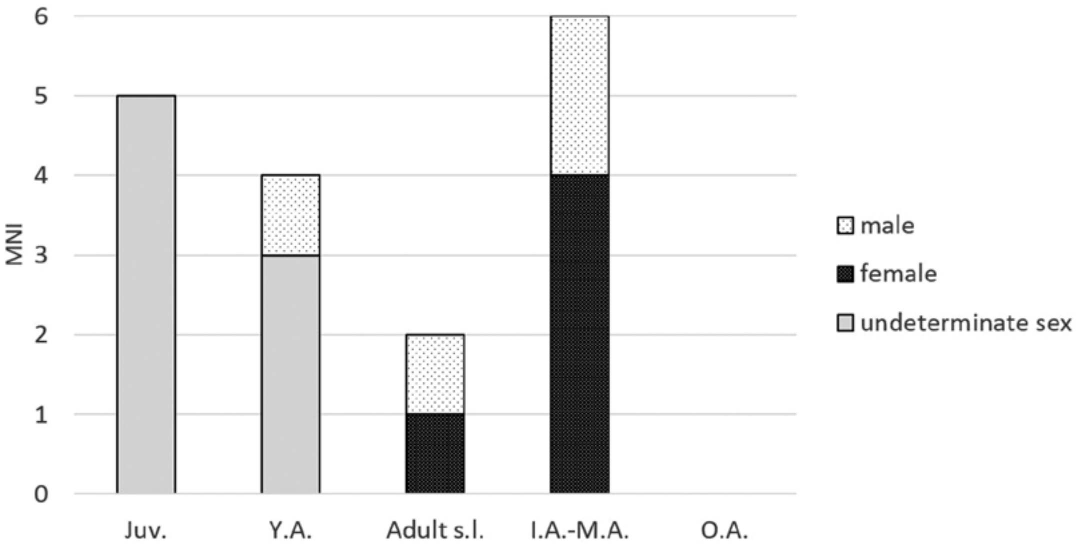

Figure 9. Minimum number of individuals by combination by age classes and gender of mammoth from Climăuţi II/upper.

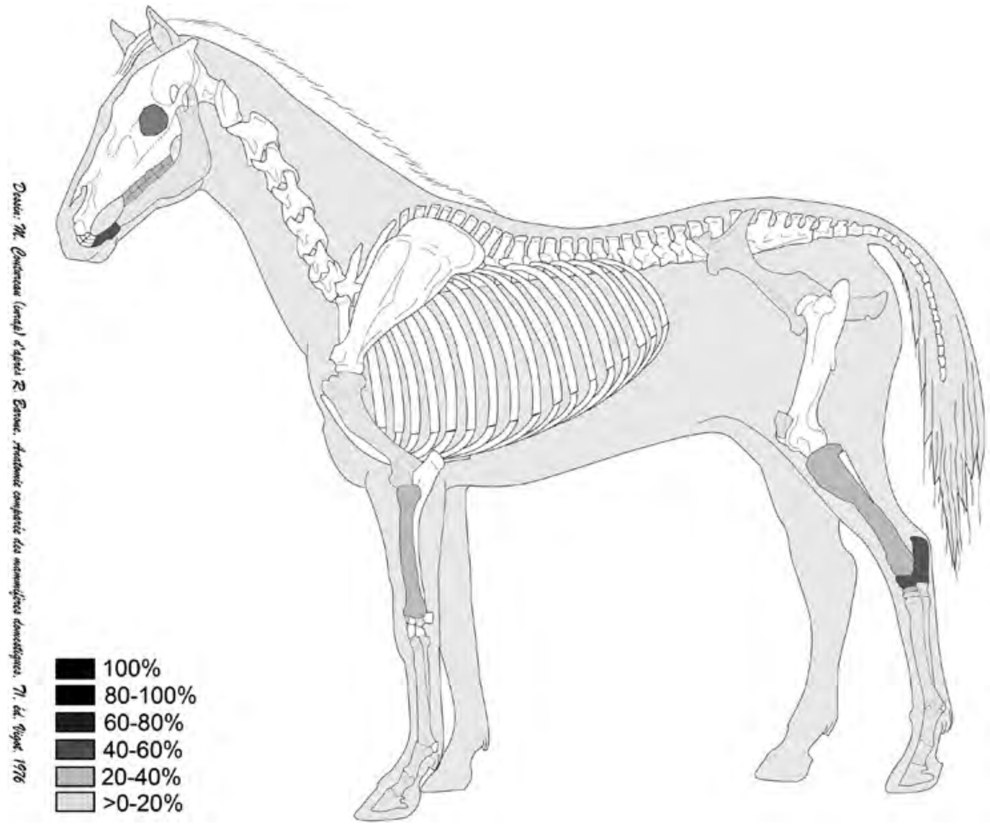

Figure 10. Skeletal preservation by elements in percentage survival (Ps%) of horse from Climăuţi II/upper.

Considering the skeletal preservation by anatomical part in%MAU related to the density of bones (R=0,14; p-value= 0,388899/not significant at p < 0.10 and at p < 0.01), this type of preservation is not due to natural processes of dispersion.

We identified at least 5 individuals, a juvenile and four adults s.l. whose at least two mature adults. It would correspond to mixt herd(s).

Comparing the size of teeth with those from different species, the specimens of Climăuţi II/upper would correspond to Equus latipes (Figure 11).

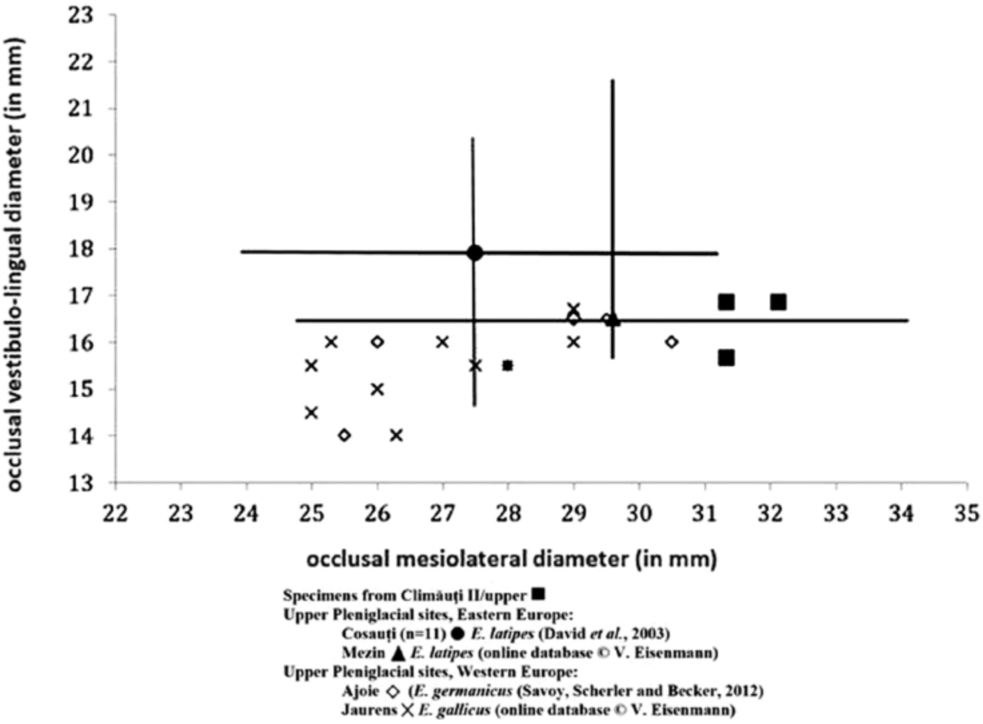

Figure 11. Osteometric comparisons of Equus sp. M1.

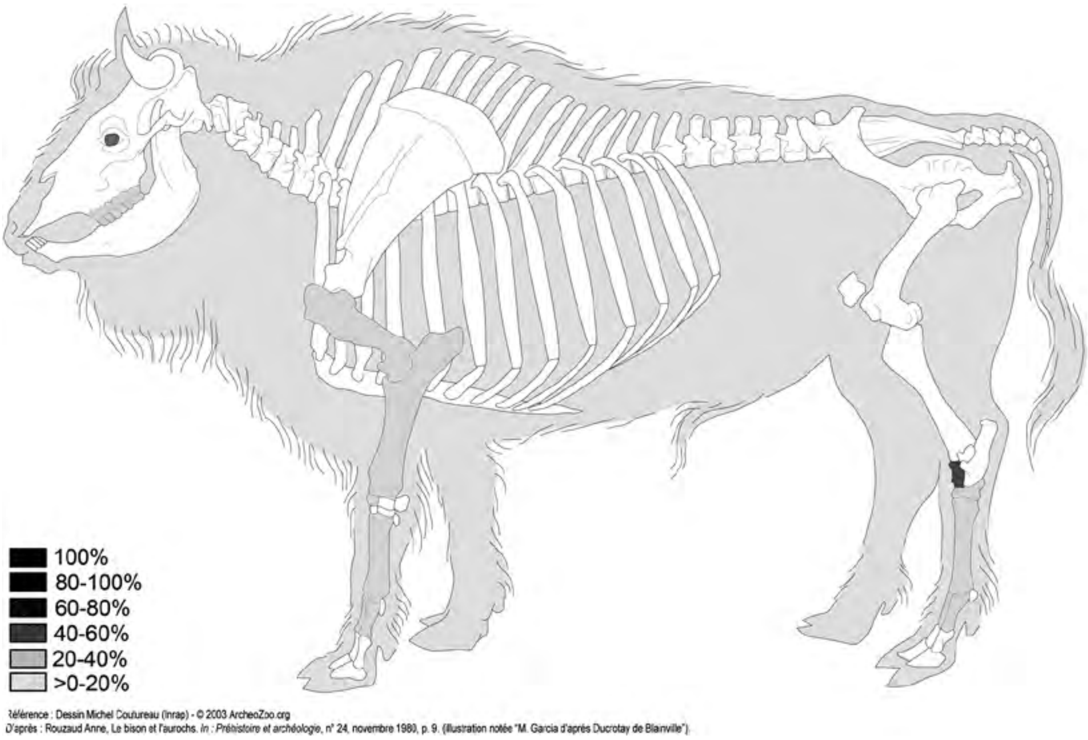

Figure 12. Skeletal preservation by elements in percentage survival (Ps%) of bison from Climăuţi II/upper.

Bison is represented by 19 remains corresponding to at least 17 elements, mainly cranial and limb elements (Figure 12).

Considering the skeletal preservation by anatomical part in%MAU related to the density of bones (R=0,37; p-value= 0,052623/ significant at $p < 0.10$ and not at $p < 0.05$), this type of preservation is not due to natural processes of dispersion.

element	eruption	wear	Klein-Spinage formula				
			AGEm	AGEe	CH	CHo	age
M_2 n°352	>43-45	f: 54	240	44	58	65,67	48
M_1 n°353	>21-25	g: 66	240	23	43	54,25	34
M_2 n°354	>43-45	h: 78	240	44	52	65,67	54

Table 4. Identification of age (in months) from teeth of bison from Climăuţi II/upper
AGEm: potential ecological longevity; AGEe: age of eruption for a tooth; CH: the crown height as measured at death; CHo: the original unworn crown height.

According to bone refitting and pairings we identified 4 individuals. All of these indivuals are young adults (Table 4).

We identified a younger individual and probably two females and a male (Figure 13). Reindeer is represented by 15 remains corresponding to at least 14 elements, mainly cranial and limb elements (Figure 14).

According to the bone refits and the identification of age we identified at least 2 individuals, an adult s.l. and a mature adult. A non-shed antler permitted to determine a large-sized male (Figure 15).

Red deer is represented by 3 remains corresponding to 3 elements, only antlers, belonging to 2 matured males (Figure 16).

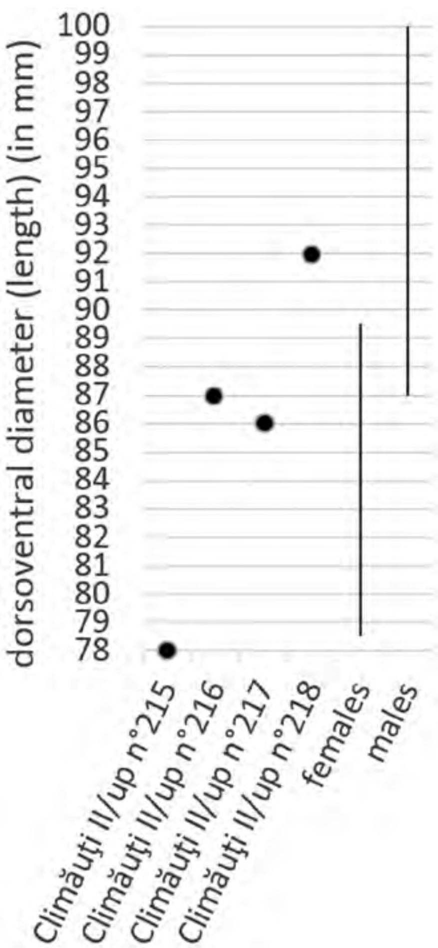

Figure 13. Osteometry of bison talus from Climăuţi II/up and reference specimens (Prat *et al.* 2003).

Hare is represented by 2 remains corresponding to 2 elements (two metapodials) belonging to at least 1 individual.v

5.3.3. Carnivores

Wolves are represented by 52 remains corresponding to 48 elements: cranial bones, vertebrae, shoulder and pelvic girdles and limb bones (Figure 17).

We identified at least 3 individuals, a juvenile and 2 adults s.l..

Fox is represented by 5 remains corresponding to 5 elements (two canines, a pelvis, a fragment of long bone and a fragment of a metapodial) belonging to at least 1 individual.

5.4. Animal resources and human activities

5.4.1. Mammoth

Among mammoth remains, 8 fragments of ivory were shaped (Figure 18). Four pieces are finished workpieces: fragments of «bracelets » (D-E), cone (F) and plate (G). The piece (A) was being shaped. Concerning the other ivory rings (B-C), they could be finished or the process was under way, for exemple maybe to refined edges. It would be necessary to seek outside expertise to study the technical processes.

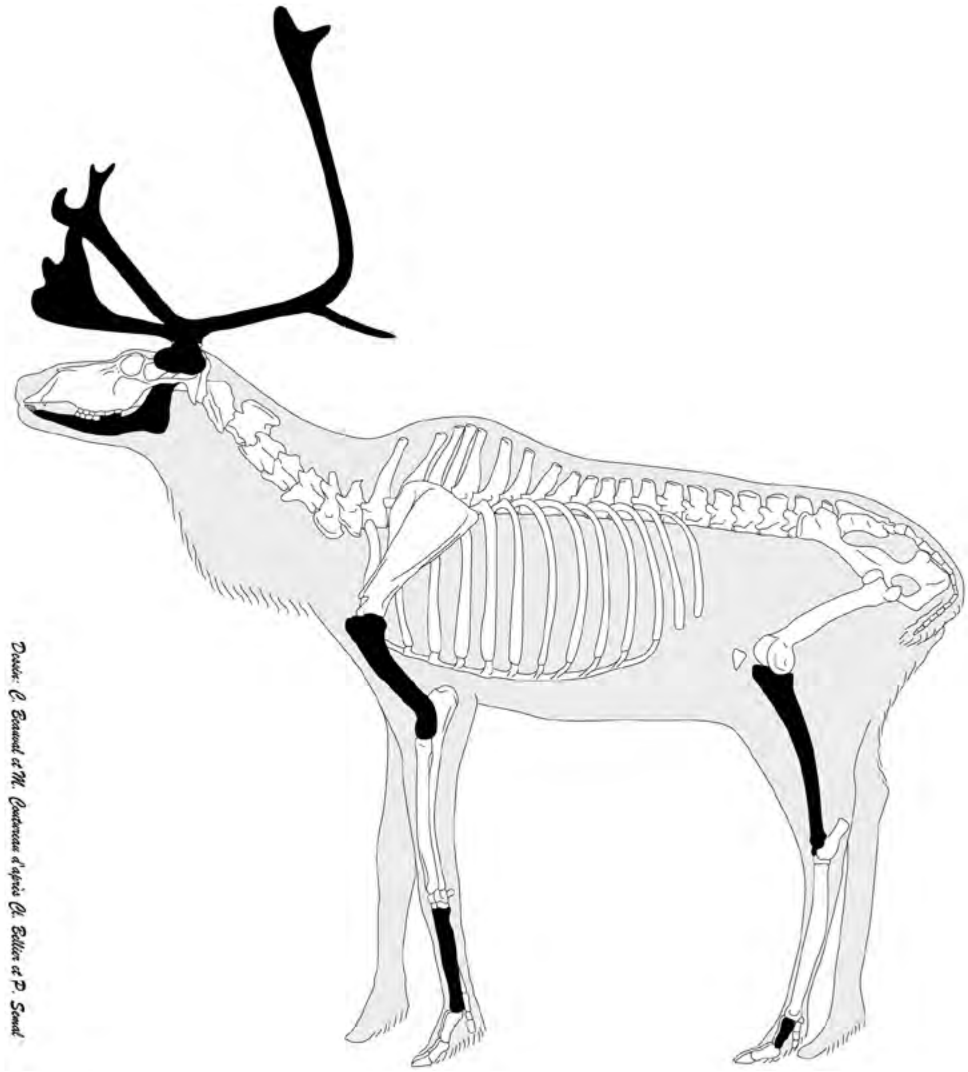

Figure 14. Skeletal preservation of reindeer from Climăuţi II/upper.

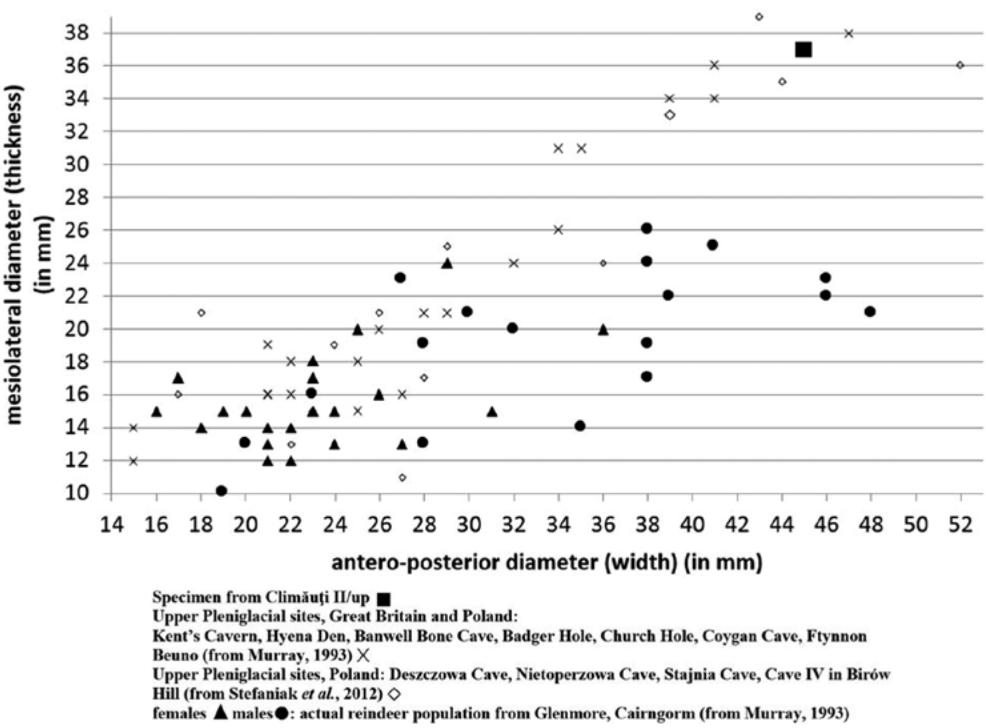

Figure 15. Osteometry of antler basis of reindeer from Climăuţi II/up and specimens of references.

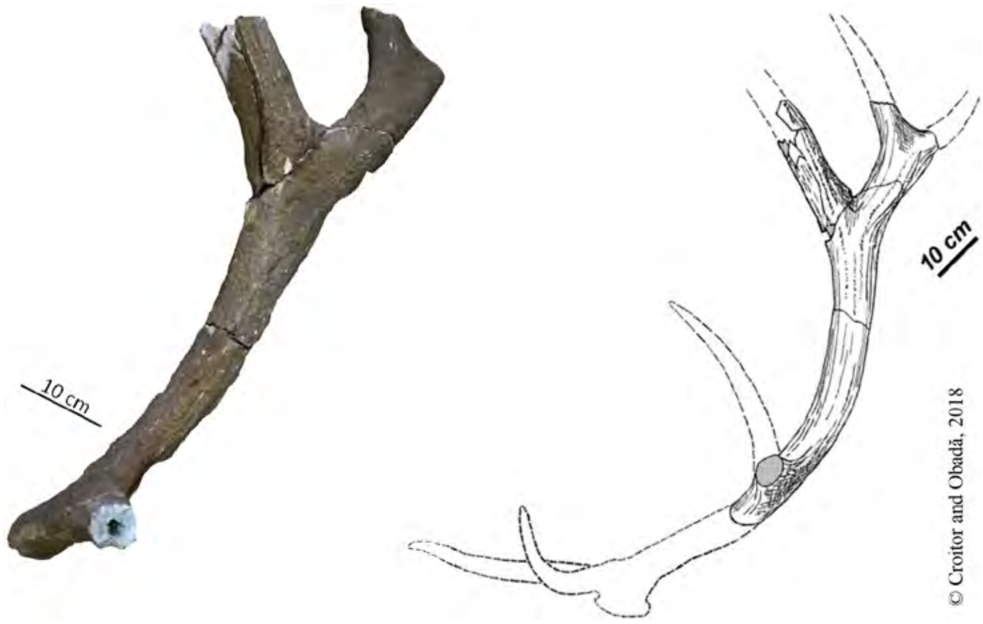

Figure 16. Left antler of red deer from Climăuţi II/up.

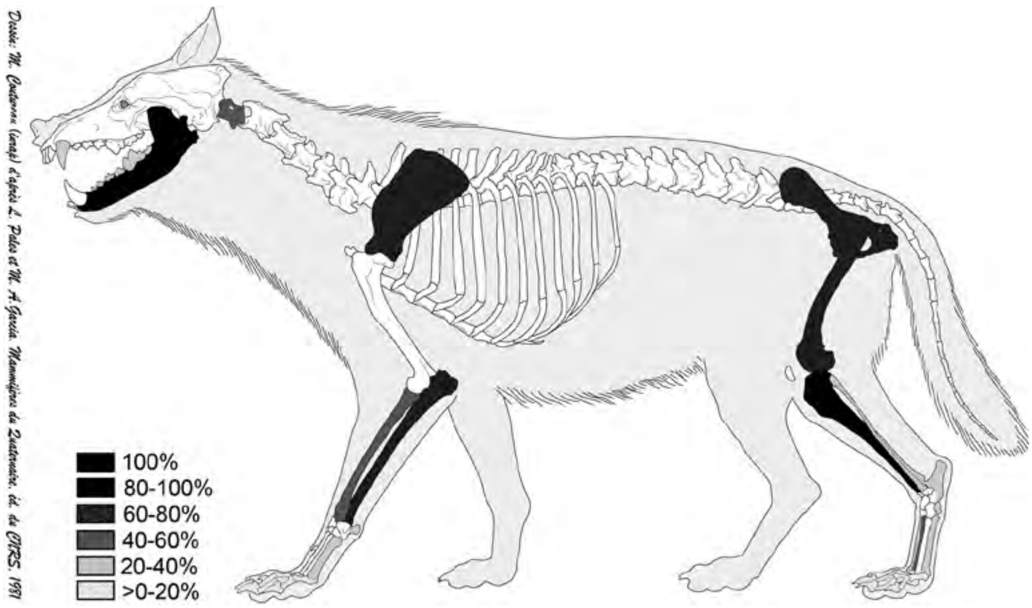

Figure 17. Skeletal preservation by elements in percentage survival (Ps%) of wolf from Climăuţi II/upper.

5.4.2. Horse

Looking at the nutritional values it corresponds to the reverse bulk strategy, the less nutritive parts, more related to marrow consumption (Figure 19).

5.4.3. Bison

Concerning bison we have few elements, but we can purpose tendencies. Looking at the nutritional values it corresponds to the reverse bulk strategy, the less nutritive parts, more related to marrow consumption (Figure 20).

5.4.4. Cervids

Concerning cervids, we have few remains.

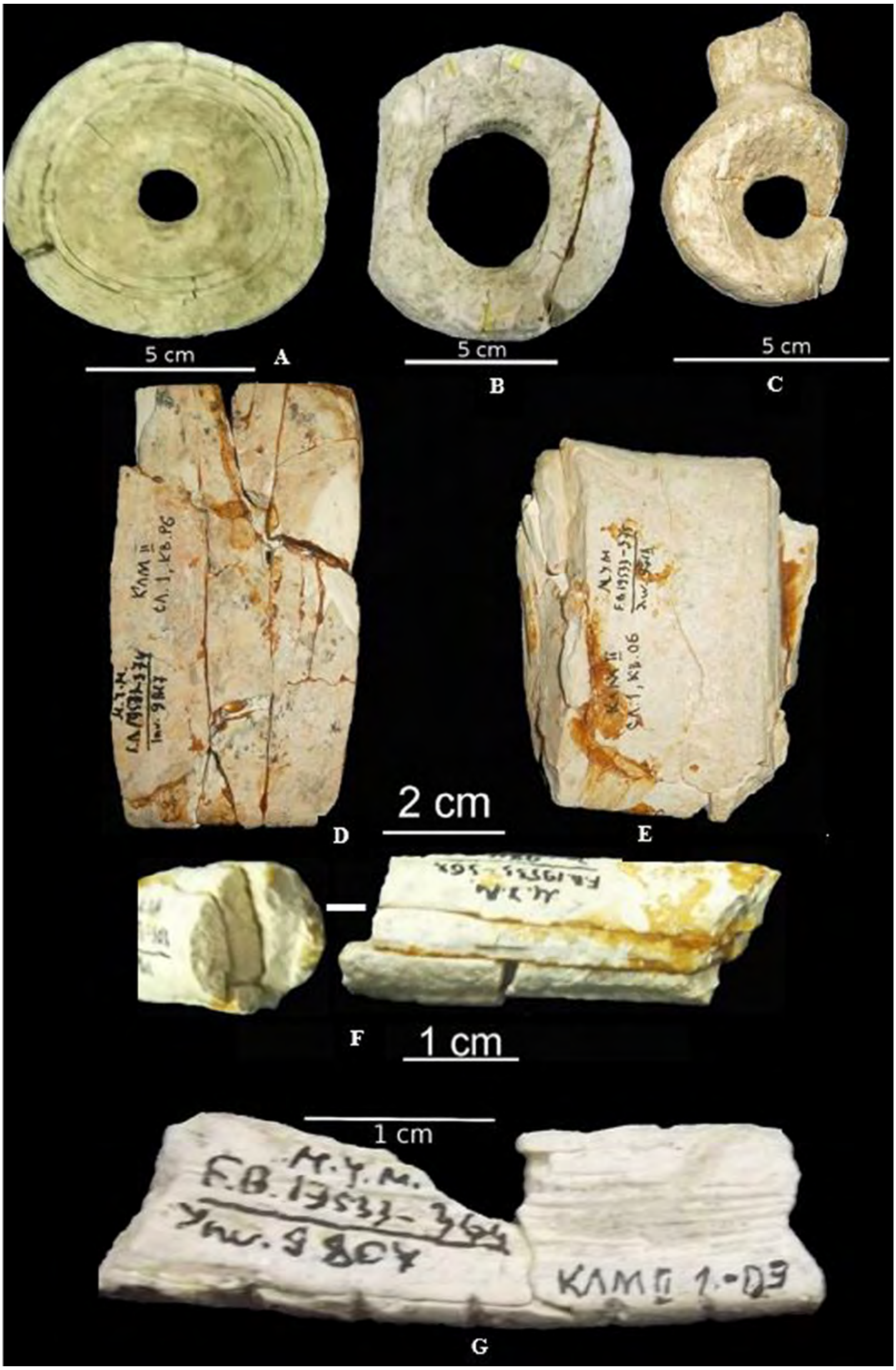

Figure 18. Shaped ivory pieces from Climăuţi II/upper.
A-B-C: ivory rings; D-E: fragments of «bracelets »; F: cone; G: plate.

The surfaces of antlers of red deers are characterized by more plant root marks and ferric and manganese deposits. So they were probably imported on the site. A fragment of antler was shaped: hollowed spongiosa and a circular furrow all around the stem (Figure 21A).

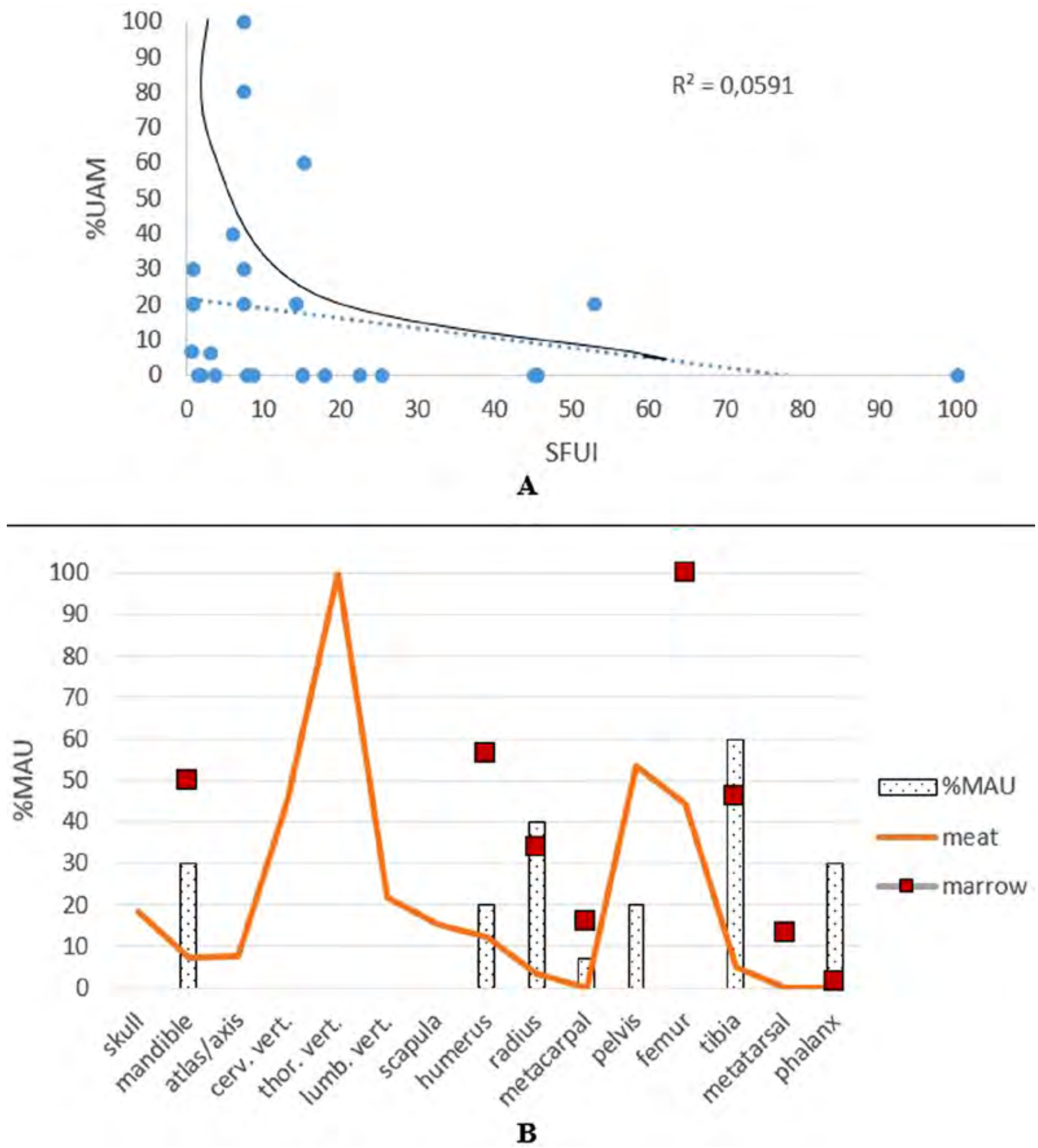

Figure 19. Skeletal preservation of horses related to nutritional values (Outram and Rowley Conwy, 1998; Morin, 2012), from Climăuţi II/upper. A: nutritional values by anatomical segments; B: in%MAU by anatomical elements, related to the indexes meat and marrow.

Another fragment of antler is characterized by series of parallel transversal grooves Figure 21B).

5.4.5. Canids

Two bones of wolf were shaped: a sawn and abraded metapodial and a sawn metapodial with grooves Figure 22).

5.4.6. Large or medium-sized mammal

Three fragments of ribs of large or medium-sized mammal are characterized by modifications (Figure 23). We have to raise that lead pencil marks are present on bones.

The first object (A) is characterized by different modifications. These marks are localized on latero-posterior surface. The first one consists of the presence of a diagonal fracture and a series of notches and grooves. These marks could result from carnivore or anthropogenic activities. Grooves are

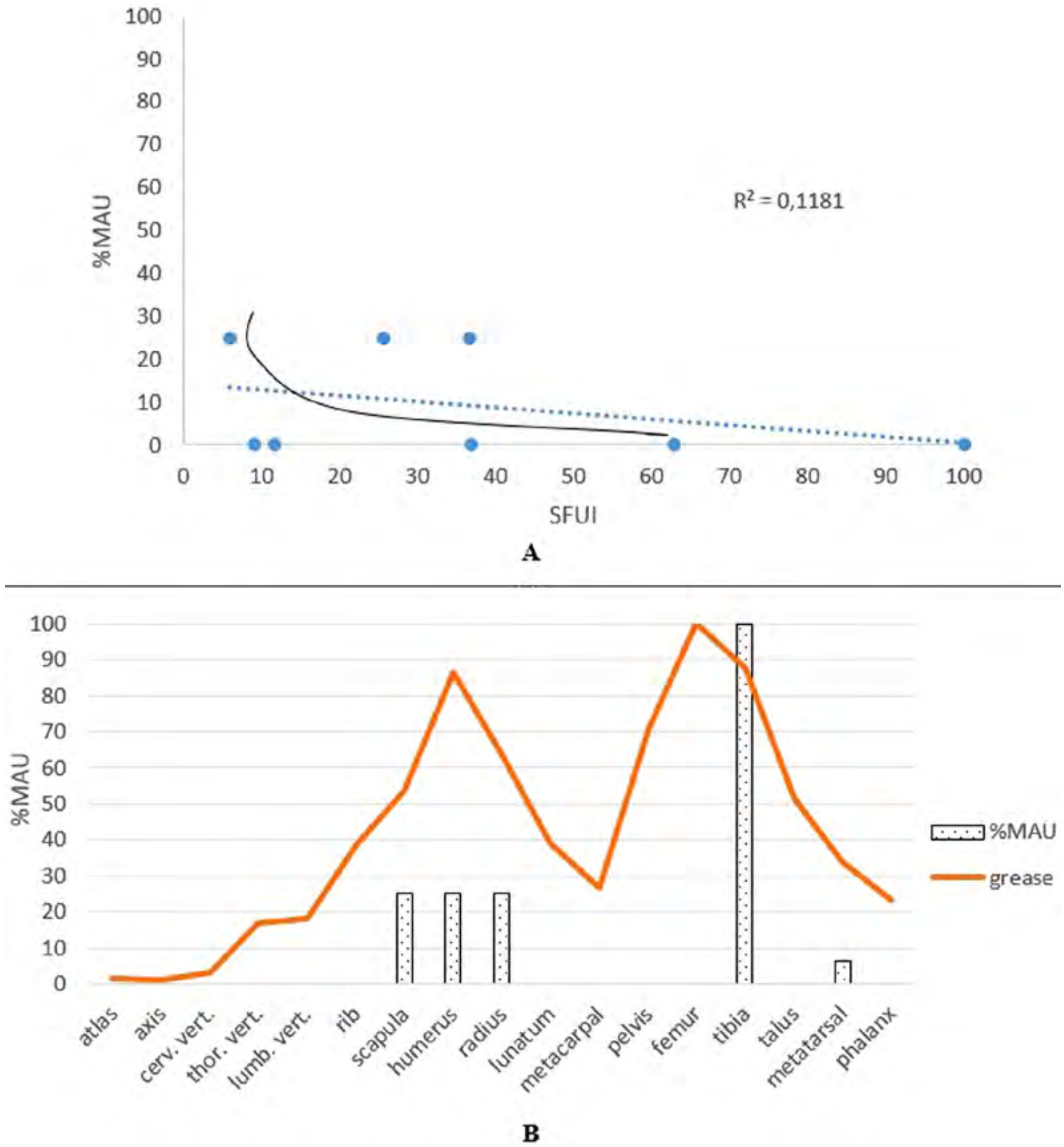

Figure 20. Skeletal preservation of bisons, related to nutritional values (Emerson, 1990), from Climăuţi II/upper. A: nutritional values by elements; B: in%MAU by anatomical elements, related to the indexe grease.

Figure 21. Shaped antlers of cervids from Climăuţi II/upper. A: fragment of shaped red deer antler; B: fragment of cervid antler with grooves.

Figure 22. Shaped bones of wolves from Climăuţi II/ upper. A: sawn and abraded metatarsal V; B: sawn metapodial with grooves.

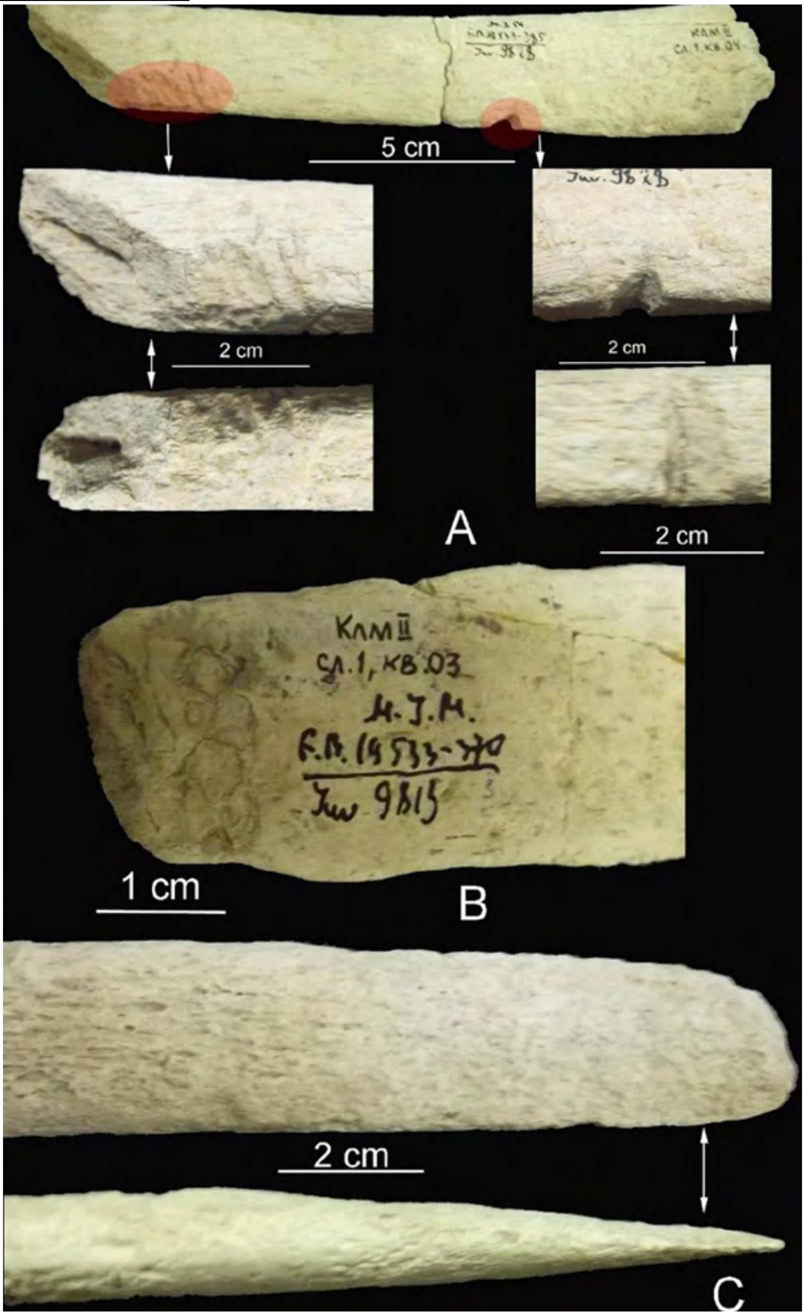

Figure 23. Modified ribs of large or medium-sized mammal from Climăuţi II/ upper.

asymmetric, localized on the edge and only on one side of the rib. Notches are of variable sizes and depths. So these stigmas do not seem to be related to the chewing of a carnivore. In addition, the slices of the grooves are more marked than those generally made by carnivores. It looks like lithic tool impact on relatively grease bone. The second mark is a puncture wound (6 mm width). It does not look like recent damage. This kind of stigmata is not really common on ribs. This is also could result from carnivore or anthropogenic activities on grease bone. Carnivores can make this kind of puncture by gnawing. But generally a unique puncture results from the gnawing on long bone which were fractured and dispersed, not on rib. By addressing the anthropogenic causes, it could result from food or non-food activities, or during slaughtering of the prey. It could be a technical work, as sawing type. However it looks like an immediate damage. Indeed we did not observe any repeated gesture neither abrasion. It could be relied to butchering activities of the carcass. The mark is 'V' shaped but wide, deep and not symmetric, so not similar to a cutmark. From similar cases and experimentations (Churchill *et al.* 2009; Fernández-Jalvo and Andrews 2016; Pomeroy *et al.* 2017) it could be a penetrating lesion, due to object such as stab or projectile. The lack of secondary damages such as radiating fracture lines or crushes tends to show that this lesion was caused by relatively low kinetic energy.

The second object (B) bears notches and the edges were abraded. It is not due to water effect, neither carnivore. It is relied to anthropogenic abrasion and impacts.

The third object (C) was clearly abraded. We can identify it as a lissoir.

5.4.7. Medium or small sized-mammal

Six diaphysis cylinders and fragments of cylinders were sawn and polished, sometimes with grooves (Figure 24). It could be pearls.

5.4.8. Shells and echinoderm

In association with mammal bones we saw the perforated shells and the urchin with grooves (Figure 25).

5.5. Durations of occupation

According to the weight of meat of herbivores and the energy values potentially exploited, the upper level of Climăuţi II is rich (Table 5). It may be the slaughtering of several individuals or, more likely, several hunts that have taken place over a number of years by a relatively large human group.

Figure 24. Diaphysis cylinders and fragments of cylinders of medium or small sized-mammal from Climăuţi II/upper.

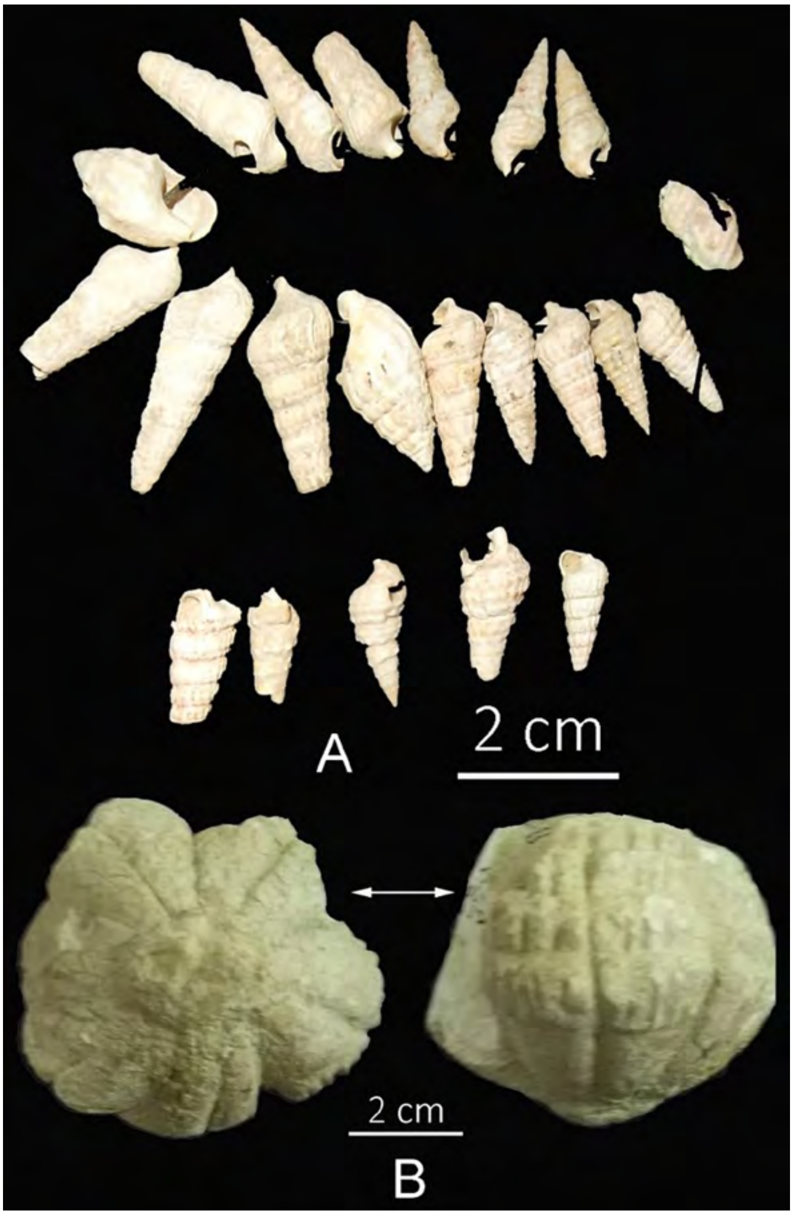

Figure 25. Shells and echinoderm from Climăuţi II/upper.

weight of meat (kg)					
reindeer	horse	bison	TOTAL	mammoth	TOTAL with mammoth
120	950	1920	**2990**	31110	**34100**
estimation of durations of occupation					
number of days for 1 person		number of months for 10 persons		with mammoth	
				days for 1 person	months for 10 persons
4271		**14**		**48714**	**162**
energetic values (Kcal)					
reindeer	horse	bison	TOTAL	mammoth	TOTAL with mammoth
152400	1045000	2016000	**3213400**	62220000	**65433400**
estimation of durations of occupation					
number of days for 1 person		number of months for 10 persons		with mammoth	
				days for 1 person	months for 10 persons
3060		**10**		**62317**	**207**

Table 5. Estimation of weight of meat and energetic values related to durations of occupation, from Climăuţi II/upper.

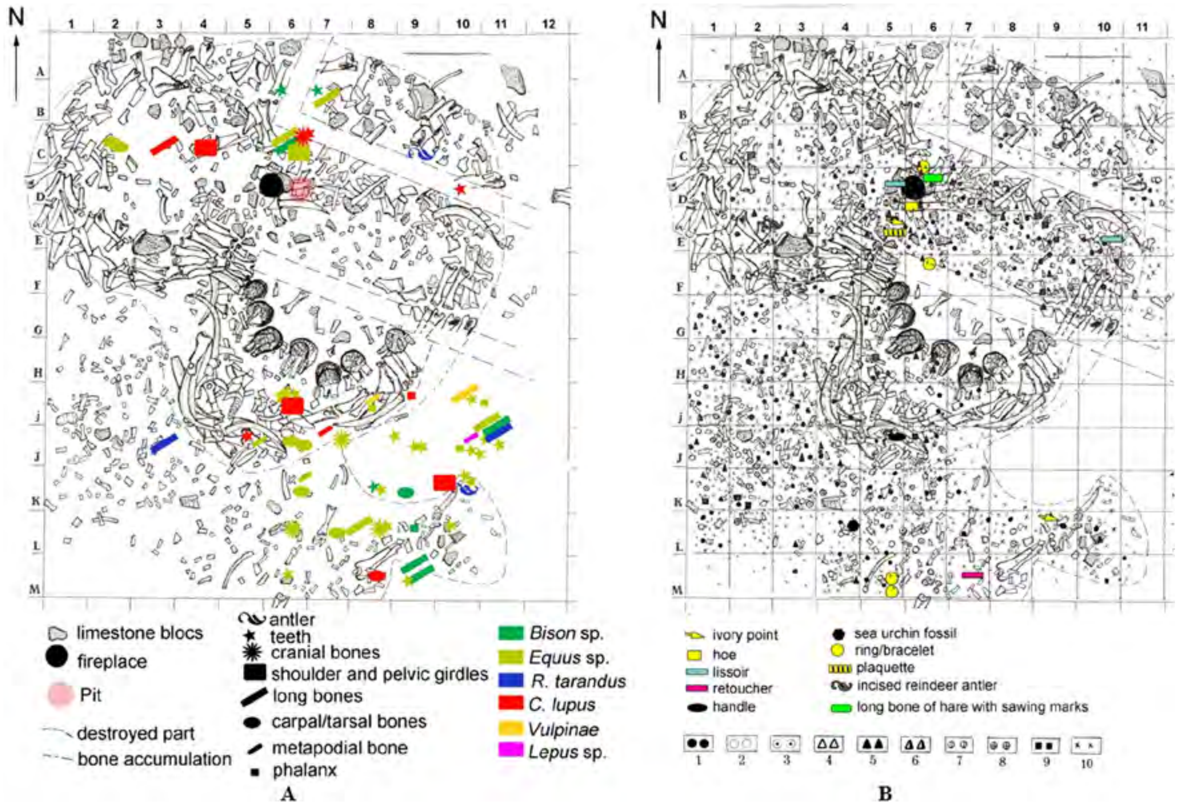

Figure 26. Spatial distribution from Climăuţi II/upper, excavations 1989. A: by type of elements and species (others than mammoth); B: of 'ornaments', boneous and lithic industries; Lithic tools: 1-2: end scrapers; 3: fragments of end scrapers; 4: angle burin; 5: lateral burins on retouched truncation; 6: burins from break; 7: retouched blades; 8: scrapers; 9: nucleus; 10: splinters.

5.6. Spatial distribution

Concerning the spatial distribution of mammoth bones, we have clusters of anatomical elements: skulls, tusks, humerus, tibias, scapulas, femurs (Figure 3), which form a circular accumulation. It is clearly not due to natural processes. So we have an intentional anthropogenic selection and disposition of mammoth bones.

As to other species, some bones are localized in the mammoth bone accumulation and the majority is outside (Figure 26A), probably relied to the treatment of marrow. The osseous industry pieces are located around the fireplace. Lithic nucleus and tools are distributed in this area and to the south of accumulation with more burins in the first and endscrappers in the second, which could reflect different stages of activities, particularly the final manufacturing processes (Figure 26B).

6. Discussion

6.1. Preservation of the assemblage

According to the taphonomic analyses this assemblage was relatively quickly buried, in subsurface with the presence of vegetation, then altered by humidity in relation to active layer of permafrost, mollisol. The whole material seemed to have been accumulated in a relatively short time span.

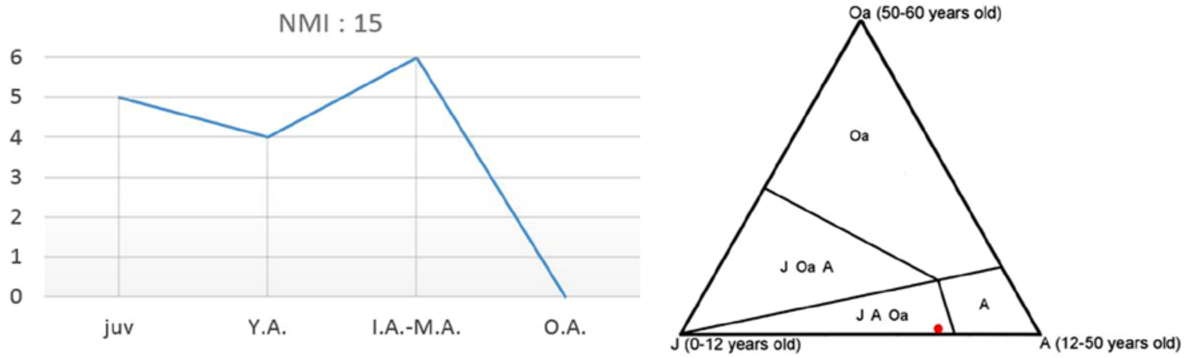

Figure 27. Mortality profile and ternary diagram from the precisely determined age of mammoths from Climăuţi II/upper.

6.2. Acquisition and exploitation of fauna

6.2.1. Mammoth

Although there are less represented, small bones are present. So because we have quite complete skeletons of mammoth, these mammoths died nearby the site. According to the profile of mortality (Figure 27), we have a high representation of adults s.l., with juveniles. Comparing with actualistic data, it could correspond to repeat selective slaughtering. We also identified a young adult male, a mature adults males and females. Knowing that among current populations of elephants three types of social behavior are adopted by elephants (female herds with juveniles, herds of males and solitary adult males) it is unlikely that mammoth of Climăuţi II were in the same place at the same time. So it could correspond to different die-offs.

6.2.2. Large-sized herbivores

Mixt herd(s) of horses were probably hunted. From our study we have a selection of anatomical quarters corresponding to a secondary butchering treatment. This is also the case for bisons.

6.2.3. Cervids

From the skeletal preservation of reindeers, they could have been submitted to the same treatment that for horse and bison.

The surfaces of antlers of red deers are characterized by more plant root marks and ferric and manganese deposits. So they were probably imported on the site.

6.2.4. Wolf

The skeletal preservation of wolves shows that complete carcasses have been bringing back on the site. So they were submitted to different treatment that for herbivores. The presence of a juvenile could correspond to a pack. They could be acquired by active hunting or could be trapped (enclosure) or snared. The tracks taken by the pack can be taking into account. Moreover when in a pack the dominant individuals can be trapped, the rest of the pack remaining in the area and can be hunted. Fur can be used. It has high isothermal capacities and is nonetheless thick and durable. The consumption of meat creates a risk of intestinal parasites. This meat must be cooked for a long time. We know that even it is not common and in high quantity, meat of wolf was sometimes eaten by humans (Lopez 1978; Cherkassov 2012; Steffánson 2004). Bones were used as mobilar support maybe as ornaments or needle cases. Use of wolf bones is rare. It is known in szeletian layer from Buran-Kaya III/C in Crimea (Laroulandie, d'Errico 2004) and the epigravettian site of Eliseevichi 1 (Polikarpovich 1968; Abramova 1995; Demay *et al.* in press) in the Desna valley. Finally, domestication and tame could be possible during this period (Germonpré *et al.* 2015).

6.2.5. Small-sized mammals

Few remains of fox and hare were discovered. These species could have been acquired more occasionally.

6.2.6. Shells and echinoderm

Shells and an urchin were gathered, to be used as ornament and probably for their esthetic characteristics.

6.2.7. Activities of human groups and function of occupations

The archaeological remains from Climăuţi II attest to a variety of activities.

Flint knapping is a major activity, as demonstrated by the local flint exploitation and on-site importation of exogenous materials, the large number of lithic remains and the number of shaped tools. The presence of all the categories of lithic pieces shows that the different steps of the chaîne opératoire were realized on the site.

Then important hunting activities took place. We have highlighted the exploitation of the woolly mammoth that may have been hunted. The different species (mammoth, horse, reindeer, bison) could have been consumed after carcass treatment. Then bones and ivory were used and worked. Ivory work shows an important know-how of this material, with particular techniques.

Lithic tools can be relied to different tasks. Pebbles can be used as hammer for shaping objects. Blades can be used in their raw state or be retouched, to be used in hunting or/and butchering or to make other tools. Retouched flakes can be used for wood, skin, meat and bones works. Scrapers are used to perfect surface aspect. It is also generally agreed that endscrapers were used in the treatment of soft material, such as animal fur. They can also be used by cast percussion on perishables, sush as vegetal or animal origins. Scaled pieces are multi-faceted tools used for plants and any animal material (Bon 2005; Patou-Mathis *et al.* 2005). Burins can be used for grooving, engraving and also to perforate (Audouze *et al.* 1981). Moreover some osseous pieces were identified as *lissoirs*, which could be relied to tanning.

In the excavated area we have only relatively final stages of ivory cutting, lithic works and butchering treatment, so the first stages of the different chaînes opératoires were probably made nearby.

So Climăuţi II/upper could correspond to a base camp probably occupied several times during relatively short time span.

Furthermore this location is a strategic and protected place between river and cliffs near water to hunt mammals.

6.3. Seasonality

We do not have clear data concerning seasonality but we can purpose hypotheses.

According to the birth season and from age of bison teeth determined by Klein-Spinage method we can purpose that these individuals were killed between autumn and spring (Figure 28). So it could

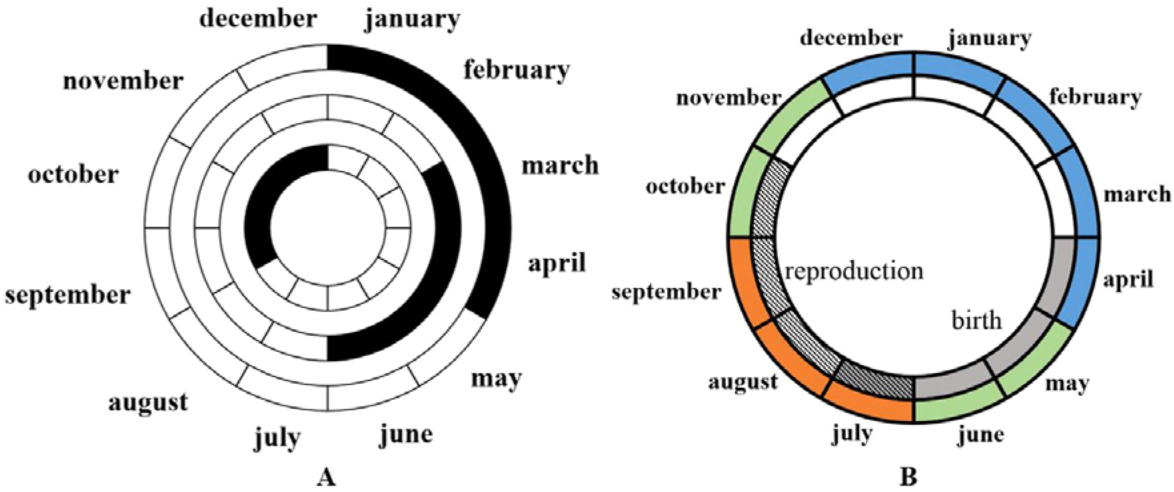

Figure 28. Seasonality of bisons. A: estimation of seasons from individuals from Climăuţi II; B: biological annual cycle of bisons.

correspond, mainly to slaughtering of isolated bison herds, but also to birth season or grouping during the reproduction period. It could also result from different hunts.

From the male non-shed antler of reindeer, we can say he was killed between April and December. So it could correspond to the migrations, to the dispersal or gathering of herds by sex.

6.4. Chronocultural position of the site in the region

Focusing on the Dniester valley sites of the first part of Upper Pleniglacial, we have four open air sites and a rockshelter:

- open air pluristratified sites: Dorochivtsy III (Ukraine) (Kulakovska *et al.* 2008; *et al.* 2015; Demay, Patou-Mathis and Koulakovska 2015), Crasnaleuca-Stanişte/VII (Romania) (Brudiu 1980; Paŭnescu 1999; Cârciumaru, Cosac and Niţu 2004-2005), Raşkov VIII (Republic of Moldova) (Croitor, Covalenco 2011);
- one archaeological layer rockshelter: Ciuntu (Republic of Moldova) (David 1980; Borziac *et al.* 1997; Noiret 2009);
- one archaeological layer open air site: Valea Morilor (Republic of Moldova) (Obadă, Van der Plicht 2010; Obadă *et al.* 2012; Demay, Obadă 2018; Demay *et al.* submitted).

They are generally dominated by relatively short-term occupations, related to local lithic raw material for hunting activities. Reindeer is generally the main game, associated with horse and bison, with few exploitation of Canids. However we don't know if mammoth was included in the diet. But ivory was used as tool and artistic support. It is the case in Dorochivtsy III. Moreover bones of mammoth were used as combustible, as in Valea Morilor. So Climăuţi II is a unique site inthe region with a clear and important status accorded to mammoth by Paleolithic human groups. This could correspond to specific activities of the same human population or to a totally different culture.

7. Conclusions

The zooarchaeological study of bone material permitted to better understand the burial conditions and the human activities in Climăuţi II. We found that this assembly was little affected by sediment movements and have been accumulated in a relatively short time span. The identification of the anatomical representation and the population profiles of mammoths permitted to identify repeated selective slaughtering nearby the site. The woolly mammoth is the main species, probably as important food resources, for ivory and as raw material to build structure. From our study concerning the secondary games, horses, bisons and reindeers, we have a selection of anatomical quarters corresponding to a secondary butchering treatment. Concerning wolves, bones were used as mobile support, which is in fact very rare. Eventually, fox and hare were acquired more occasionally also as red deer antlers were gathered.

The archaeological remains from Climăuţi II attest to a variety of activities, as flint knapping, hunting and butchering activities, also as bone work. So Climăuţi II/upper could correspond to a base camp probably occupied several times during relatively short-termed period. We do not have numerous data concerning seasonality but we can purpose that these occupations took place at least between autumn and spring.

According to the comparisons of the Dniester valley sites of the first part of Upper Pleniglacial, Climăuţi II/upper is a unique site in the region with a clear and important status accorded to mammoth by paleolithic human groups. This could correspond to specific activities of the same human population in the area or to a different culture. This point needs to be further developed in the future by new zooarchaeological analyses of regional sites and comparisons with Eastern European Plain and Central Europe occupations.

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The revision of the Gravettian sequence in the Kostenki-Borshchevo locality in the river Don basin (Russia)

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Abstract

The previous pattern of the Gravettian in the Kostenki-Borshchevo area of the Middle Don basin yielded a two-phase periodization. The early phase was thought to be presented by Kostenki 8/II dated back to ~27 kyr BP uncal. The second phase comprised the Kostenki-Avdeyevo culture (the Eastern Gravettian) sites: Kostenki 1/I, Kostenki 13 и 18, Kostenki 14/I (23-21 kyr BP uncal.) and five typologically particular assemblages altogether being in accordance with the late Gravettian.

New data on the archaeology and absolute chronology obtained from the recent investigations enabled to detail the Gravettian sequence as well as to integrate the local assemblages into general European taxonomy. The main advance was achieved in the defining of the middle Gravettian phase newly dated 25-24 kyr BP uncal. (sites Kostenki 4, Borshchevo 5 and probably Kostenki 9). This cultural complex was associated with the Pavlovian being determined by tools typology and in particular by the series of stone items treated with polishing. It was proposed that along with the Kostenki-Avdeyevo culture the latest phase comprised Kostenki 21/III as the local final Gmelinskaia type Gravettian formerly conjoined together with Anosovka assemblage (Kostenki 11/II).

The latter was attributed to the non-Gravettian. Thus, the Gravettian technocomplex in the basin of the Don acquired a three-part sequence of the early (27-25 kyr BP uncal.), middle (25-24 kyr BP uncal.) and late (23-21 kyr BP uncal.) phases which corresponds to the periodization in Central Europe.

Keywords: the Middle Upper Paleolithic; the Gravettian; material culture; periodization; cultural attribution; the Russian plain

Résumé

Le modèle précédent du Gravettien dans la région de Kostenki-Borshchevo du bassin du Don moyen a permis d'obtenir une périodisation de deux phases. La phase initiale a été pensée pour être représenté par Kostenki 8/II remontant à ~27 kyr BP uncal. La deuxième phase comprenait la culture de Kostenki-Avdeyevo (le gravettien oriental) avec les sites de Kostenki 1/I, Kostenki 13 и 18, Kostenki 14/I (23-21 kyr BP uncal.) et cinq assemblages typologiquement particuliers étant dans l'ensemble en accord avec le dernier Gravettien.

De nouvelles données sur l'archéologie et la chronologie absolue obtenues grâce aux récentes recherches ont permis de détailler la séquence gravettienne, ainsi que d'intégrer les assemblages locaux dans la taxonomie européenne générale. La principale avancée a été réalisée dans la définition de la phase médio-gravettienne, nouvellement datée 25-24 kyr BP uncal. (sites de Kostenki 4, Borshchevo 5 et probablement de Kostenki 9). Ce complexe culturel a été associé au Pavlovien, étant déterminé par la typologie des outils et en particulier par la série d'éléments de pierre traités avec polissage. Il a été proposé que, avec la culture de Kostenki-Avdeyevo, la dernière phase comprenait Kostenki 21/III comme la phase finale locale du Gravettien de type Gmelinskaia, précédemment associé à l'avec assemblage Anosovka (Tenkoski 11/II).

Ce dernier a été attribué au non-Gravettien. Ainsi, le technocomplexe gravettien dans le bassin du Don a acquis une séquence en trois parties des phases ancienne (27-25 kyr BP uncal.), médiane (25-24 kyr BP uncal.) et tardive (23-21 kyr BP uncal.) qui correspond à la périodisation en Europe centrale.

Mots-clés : Paléolithique supérieur moyen ; Gravettien ; culture matérielle ; périodisation ; attribution culturelle ; plaine russe

1. Introduction

Many researchers have made attempts to systematize the Gravettian sites of the Russian plain. For a long time, the Gravettian studies were focused on interpretating the sites of the Kostenki-Avdeevo type. Thus, a number of similar terms almost identical in meaning appeared: 'Willendorf-Kostenki culture', 'Kostenki culture', 'Eastern Gravettian'. These sites lay the foundation for the concept of cultural unity of the Central and Eastern European population, established on the Gravettian basis at the middle Upper Paleolithic. G.P. Grigoriev introduced a concise term for the aforementioned period – 'the Gravettian episode' (Grigorev 1994). Discussion on the status of this community, which encompassed Austria, Moravia, southern Poland in Central Europe, as well as the basins of the Dnieper, Don and Oka in East Europe, has never yielded a definitve understanding of its internal cultural variability and periodization. There exists an even greater range of opinions concerning the interpretation of external archaeological connections and the assessment of the Gravettian dynamics (Bulochnikova 1998). Among the sites that precede the glacier maximum there are those on the Russian Plain which belong to the Gravettian technocomplex, but cannot be classified as part of the Eastern Gravettian in a strict sense. For instance, Molodovo 5/VII on the Dniester, Khotylevo 2 and Pushkari 1 on the Desna, Gagarino on the upper Don, a number of sites with Gravettian layers in Kostenki-Borshchevo region (hereafter referred to as KBR) on the middle Don. In recent years, several new similar sites have been discovered: Borshchevo 5, Troyanovo 4, Ozerovo, etc. (Lisitsyn 2004; Zalizniak *et al.* 2007; Zalizniak & Vetrov 2007; Demidenko 2018).

Kh.A. Amirkhanov in 1998 introduced a classification of the main gravettoid complexes according to the degree of typological proximity (Amirkhanov 1998). The sites are paired on the basis of the leading tool types (shouldered points, leaf-shaped points and Kostenki type knives) and divided into Kostenki-Avdeevo, Khotylevo-Gagarino, Kostenki-Borshchevo and Kostenki-Aleksandrovka groups. However, only Kostenki-Avdeevo sites are considered monocultural in a strict sense. The excessive variability of the inventory of the rest of the gravettoid complexes, even in regard to the leading tools types, does not make it possible to develop a cultural periodization within the East-European community. Which even G.P. Grigoryev refused to work out at the time (Grigorev 1998).

D.Yu. Nuzhny developed a two-stage periodization of the Ukranian Gravettian sites by splitting them into the early stage of 30-26 kyr uncal BP (Mezhigirtsy, Molodovo 5/IX-X, Oselivka 1/III-II, Voronovitsa 1/II) and the late stage of 25-22 kyr uncal BP (Molodovo 5/VIII-VII, Korman 4/VII-VI, Molodovo 1/I, Voronovitsa 1/VI, and Babin 1). D.Yu. Nuzhny determined a distinction between the local complexes and the Kostenki-Avdeevo and Gagarino ones, while also drawing similarities between the Ukranian and the Pavlovian sites of Moravia and Khotylevo 2 on the Desna (Nuzhnyi 2009) at the late stage. Yu.E. Demidenko (Demidenko 2018) also confirms a continuity gap between the two periods of penetration of the early and late Gravettian from Central to Eastern Europe.

M.V. Anikovich proposed that two variations of Eastern Gravettian could have been developing in parallel: 'Willendorf-Kostenki-Zaraisk' and 'Pavlov-Khotylevo-Gagarino' within the rough approximation of 24-16 kyr uncal BP. Apart from that, he substantiated the coexistence of the Kostenki-Avdeevo culture with the Anosovka-Gmelinskaia culture in the KBR (Kostenki 11/II, Kostenki 21/III, Kostenki 5/III) (Anikovich 1998; Anikovich *et al.* 2008). On contrary, Kostenki 4/I, Kostenki 9 and Borshchevo 5/I belong to late gravettoid sites with pronounced Aurignacian features. According to M.V. Anikovich, Kostenki 8/II and Kostenki 4/II stand apart from other Gravettian complexes.

A.A. Sinitsyn made an attempt to assess the Gravettian systematics comprehensively, on the basis of the dominant elements that determine cultural identification. Kostenki 4/II, Kostenki 21/III, Borshchevo 5/I were recognized as the most definite Gravettian', according to the accepted practice (differentiation of blade blanks, presence of the Gravettian points and backed bladelets). Kostenki 11/2 least of all corresponded to the given criteria due to the presence of knives similar to those of Federmesser culture (Anosovka knives). According to A.A. Sinitsyn, the second layer of Kostenki 8 as the earliest Gravettian complex of a Western European or Mediterranean appearance (28-27 kyr uncal BP), does not have cultural continuity with the late Gravettian. A.A. Sinitsyn excluded Kostenki-Avdeevo from the Gravettian sites, since here specific Kostenki tools (shouldered points, Kostenki type knives) are prevalent over the generally Gravettian ones (Sinitsyn 2013). Thus, according to Sinitsyn, the Gravettian on the Middle Don is represented discretely – as a single early manifestation (Kostenki 8/II), followed by three local variations of the late Gravettian. As a result, the researcher rejects the concept of the Gravettian episode as a unifying event in the cultural history of Central and Eastern Europe, since the concept is meaningless without respective eponymous complexes.

K.N. Gavrilov denotes both common and distinguishing features of the Gravettian complexes of Central and Eastern Europe. In particular, he draws attention to the proximity of the needle-shaped micropoints of the Kostenki 8/II complex to microblades with pointed ends, ventrally retouched along the edge opposite to the backed one, found in the 10th layer of Molodovo 5 and at the Dolní Vestonice I and II sites, as well as at the early Gravettian complexes of the Swabian Jura. In the Kostenki 8/II inventory, he emphasizes the presence of both Pavlovian elements (asymmetric trapezia) and Aurignacian ones (carinated scrapers, twisted profile segments).

According to Gavrilov, the sites' unity is combined with their internal cultural variability: in this case the Eastern Gravettian implies the Eastern European Gravettian in a broad sense. The researcher concludes that it is possible to 'assume that the Eastern Gravettian was formed on the Russian Plain due to complex processes in the indigenous population culture combined with the influence or reciprocal contacts with the culture/population of Central Europe' (Gavrilov 2016).

Thus, the KBR sites (Figure 1) are essential in understanding the pan-European specifics of the Gravettian cultures due to the combination of their cultural diversity with a concentrated location within the local area of the Don (Lisitsyn 2014).

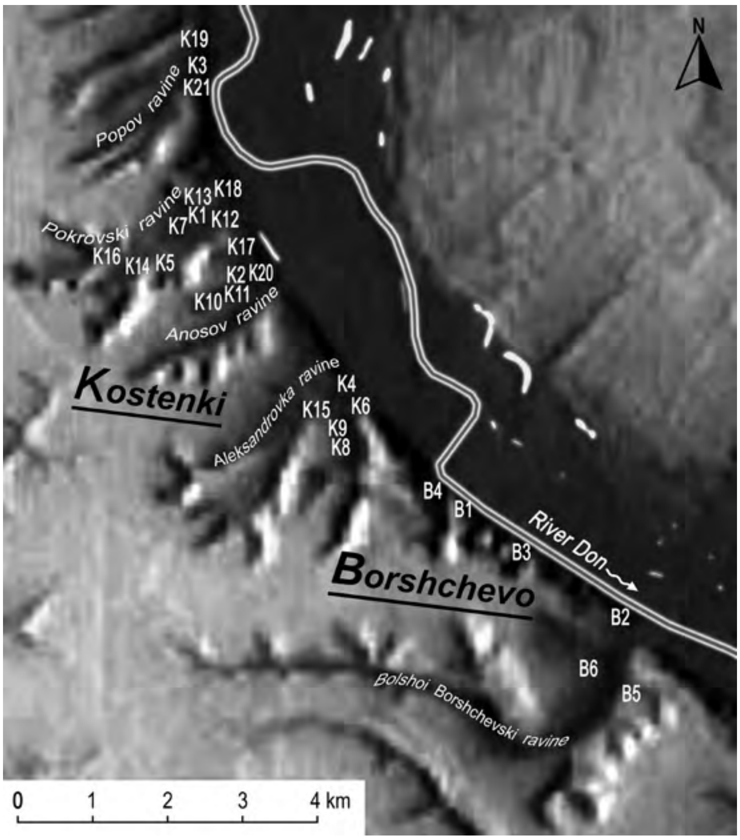

Figure 1. Spatial distribution of the Paleolithic sites in the Kostenki-Borshchevo locality, the Don basin (Russia).

2. The cultural differentiation of the Gravettian in the KBR

Dis*cussion*

Kostenki-Avdeevo culture has always been considered the meaningful core of the KBR Gravettian episode, while the rest of the complexes have been compared to it depending on the degree of their cultural proximity. Apparently, it is the inflexibility of such a construction that led to the fact that no detailed periodization has yet been created for the Kostenkian Gravettian, given a fairly large number of artefacts.

This paper attempts to revise the KBR Gravettian classification in the light of new materials and new 14C datings, which allows us to propose a periodization scheme. Classification of the KBR Gravettian stone industries by culturally separate groups is generally well established, although it needs some adjustment. From my point of view, five separate cultural units can be distinguished.

Telmanskaia complex (Kostenki 8/II)

The complex is represented by a single site – Kostenki 8/II (Telmanskaia site). The second cultural layer was identified in 1950 by A.N. Rogachev and studied in the 1950-1970s on an area of 530 sqm (Rogachev 1957). The finds were discovered in a reduced humified soil with intensive ferruginous and carbonate mineralization. Three clusters of finds could be identified. Two of them are of a round shape and have a hearth in the center, while the third one is oval and has three firepits (Figure 2: A). These clusters are considered to be remnants of light ground dwellings (Paleolit Kostenkovsko-Borshchevskogo raiona... 1982, p. 101). Drawing on the analysis of the flint inventory (n> 23,000), L.M. Litovchenko (Chelidze) proposed to single out a separate Kostenki-Telmanskaia archaeological culture (Chelidze 1968; Litovchenko 1969). Recent research has proceeded with the study of the second cultural layer of this site. Another cluster of finds with two hearths was discovered on an area of 56 sqm, yielding a new collection of artefacts (n> 4000) (Dudin *et al.* 2016).

Kostenki 8/II inventory has a pronounced microlithoid character: the instruments are made on regular thin blades and microblades (Figure 2: B). Backed points are prevalent, as well as burins of all types, including multiple burins, which could be used as cores for microblades. Scrapers are few in number and are represented mainly by simple end scrapers on blades; there are several carinated ones, as well. Among common tools, there are miniature narrow microgravettes, which are intensely backed and have one or both asymmetrical ends ventrally retouched (needle-shaped points). No leaf-shaped points were found. This complex is peculiar due to the presence of 9 trapezia and 14 segments on microblades (Figure 2: B, 3-6, 35-36). Bone tools are represented by awls and lissoirs made of ribs and ivory. Among adornments, the following were found: cylindrical beads made of small bones ornamented by parallel cuts, round double-eyed plaques and various pendants of mammoth tusk.

Artefacts similar ro Kostenki 8/II can be found among the early European Gravettian sites: Grotta Paglicci (layer 23a) in Italy, Geissenklösterle (layer Ic) in Germany, Abri Pataud (layer 5) in France, Willendorf 2 sites (layer 5) in Austria and Molodovo 5 (layers 9-10) in Ukraine. Their 14C age is defined as 31-27 kyr uncal BP (Moreau 2012; Sinitsyn 2013; Gavrilov 2016; Demidenko 2018). According to M.V. Anikovich, layer II of Kostenki 8 was similar to the scarce artefacts found in layer IV of Kostenki 11 and to the Northern point of the same site, so that they could be united into a separate Anosovka-Telmanskaia archaeological culture (Anikovich *et al.* 2008). I believe the available data is insufficient for such a unification, in terms of both stratigraphic and typological context.

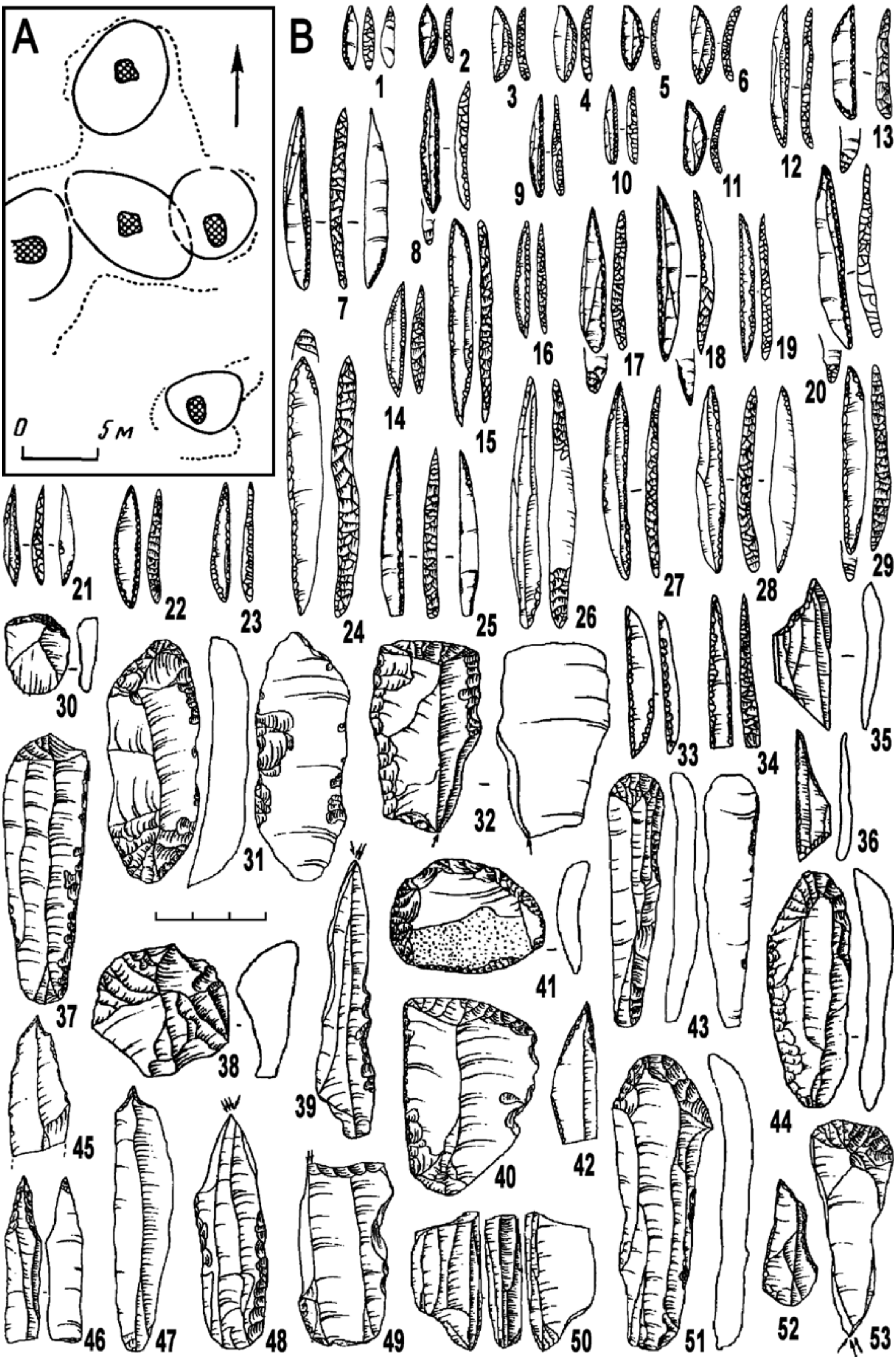

Figure 2. Kostenki 8, cultural layer II: A – contours of dwellings (from: Sergin 1988);
B – the stone assemblage (from: Sinitsyn 2013).

Aleksandrovka complex (Kostenki 4, Borshchevo 5/I, Kostenki 9)

Kostenki 4 (Aleksandrovka) is a two-layer site with both cultural layers (or horizons, according to A.N. Rogachev) containing backed points. In 1927, the site was discovered by S.N. Zamyatnin and was further studied by A.N. Rogachev. The finds were deposited in the loess loam sediments on the first terrace. On the area of over 900 sqm the remains of a settlement consisted of two (northern and southern) long-drawn objects with a number of hearths along the central axis parallel to each other were discovered. Two round objects with a firepit in the center were adjacent to the northern object and partially overlapping it. Subsequently, A.N. Rogachev attributed them to the dwellings (western and eastern) of the upper horizon (Figure 3: A–B). Long objects with multiple hearths were, in turn, associated with the dwellings of the lower horizon. Both layers of Kosteki 4 with dwellings of various types merged along the strike (Rogachev 1955: 19-24).

A.N. Rogachev divided the finds into horizons years after the completion of the excavation, therefore their purity is relative. It is evident when comparing published data. Given the varying size of the collections of the upper (n ~ 14,500) and lower (n ~ 60,000) cultural layers, the anomalous ratio of individual tool types is striking. For instance, the number of burins in a smaller inventory of the upper layer (n = 260) is half as much as their number in the lower layer (n = 158). On the contrary, the number of scrapers in the upper layer (n = 76), is three times lower compared to the lower one (n = 212). All hammer-stones and pestle-stones (n = 43), microblades and micropoints (n = 404), as well as cores on flakes (n ~ 179) are attributed to the upper layer, while blades and points on blades with a vertically retouched backed edge (n = 2604), as well as chisel tools (n = 1210) – to the lower layer.

Peculiarity of the toolkit in each of the Kostenki 4 layers is determined by variations in specific tool types. According to A.N. Rogachev, the upper layer includes micropoints with one straight backed edge and another semi-convex edge and ends ventrally retouched (Figure 3: B, 1-4). He compared these tools with the needle-shaped points from Kostenki 8/II. The second layer of Kostenki 4 includes the Gravettian points, ‘awl-shaped points’ with a dorsally retouched sharp tip and bitruncated backed bladelets. Among the latter, there is a series (n = 25.) of denticulated items (Figure 3: B, 17). It is evident that backed tools are clearly divided into cultural layers assemblages by the blank size (microblades and blades) and the end retouching techniques (ventral and dorsal).

In regard to a series of leaf-shaped points of the upper layer (n = 191), A.N. Rogachev specified a particular group of tools, in which the haft element was designed as a dihedral burin (‘Aleksandrovka points’ – ill. 2: B, 6, 11). Two of them are traced back as drawing knives (Semenov 1957, p.135). M.N. Zheltova determined that no more than ten artefacts could be attributed to the classical points of this type, not taking debitage into account. Concurrently, they are morphologically heterogeneous and multifunctional. At least two artefacts were associated with the lower but not upper cultural layer of the site (Zheltova 2011).

Stone inventory of upper layer of Kostenki 4 can be distinguished from the lower one by the presence of bifacial points (n = 4) (Rogachev 1955, p. 51-54). Possibly the most impressive item is a massive laurel-leaf biface 20 cm in length. The other three are small subtriangular fragments of points or knives bearing typical cutting edge polishing traces (Rogachev 1955, p. 52). One of them is considered a shouldered point, however, its shape and retouching technique have little in common with the Eastern Gravettian points (Figure 3: B, 10).

It should be noted that by their proportions the Kostenki 4 points belong to thick bifaces type, for example, contrary to the same Kostenki-Streletsky points, which show typical features of thin bifaces (Girya 1997, p. 158). The morphologically perfect ‘solutrean’ point of the Aleksandrovka site is represented by a single item, which indicates that bifaces as a whole are an alien element in that stone industry. It could be possibly explained by the fact that the site is located on the

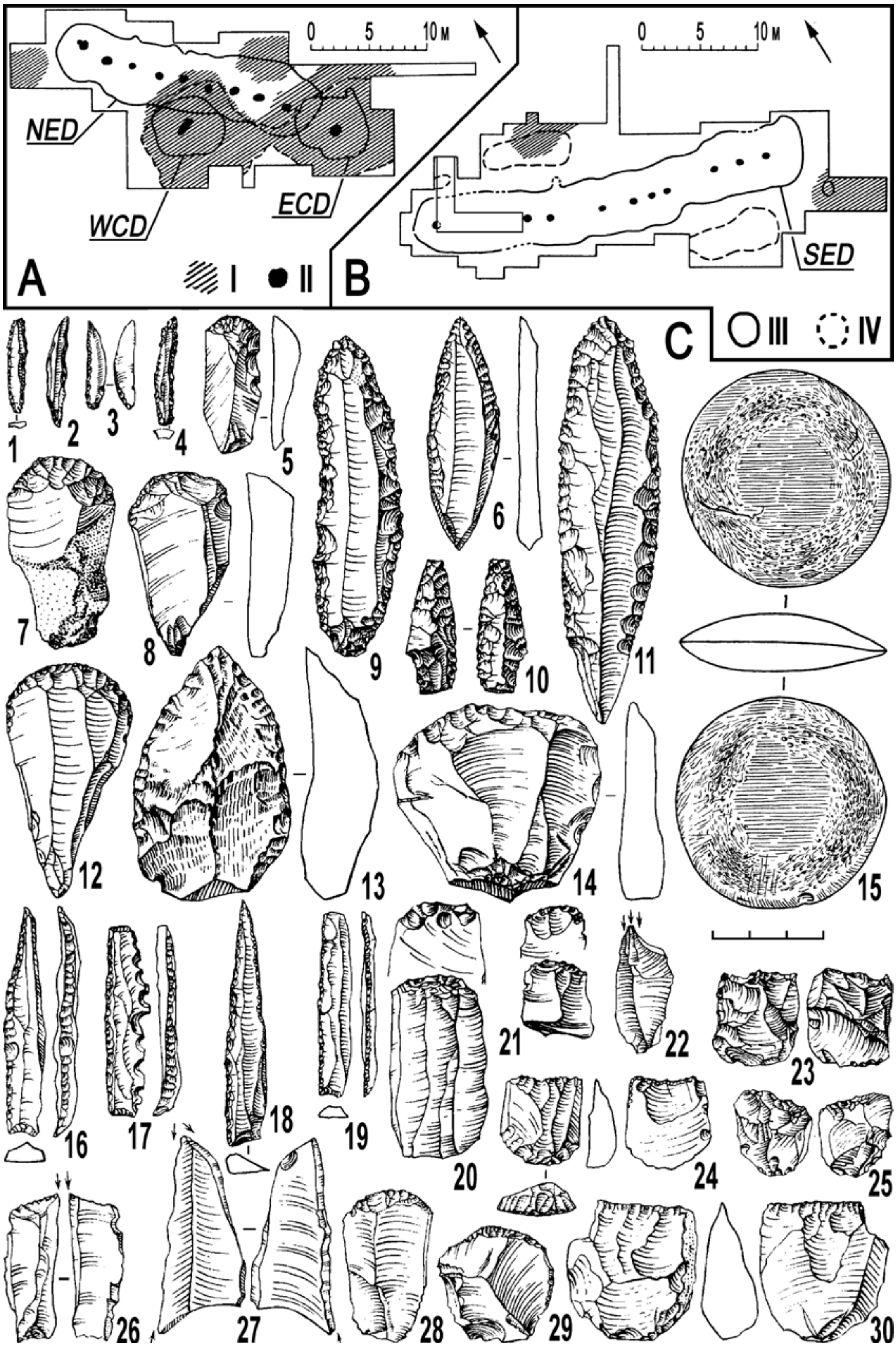

Figure 3. Kostenki 4. A: NED – north elongate dwelling (the lower cultural layer), WCD and ECD – west and east circular dwellings (the upper cultural layer); B: SED – south elongate dwelling (the lower cultural layer). I – extensions of the upper cultural layer; II – hearths; III – contours of dwellings; IV – finds accumulations. C: the stone assemblage: 1 15 – from the upper cultural layer; 16-30 – from the lower cultural layer (from: Rogachev 1955).

same cape as the Bronze Age settlement. Ceramics from this settlement is also included in the Kostenki 4 collection. Massive bifaces are most characteristic of the Aeneolithic or the Bronze Age. Faunal assemblage of Kostenki 4 includes bones of the Holocene animals (wild boar, corsac fox, beaver, red deer), embedded into the Paleolithic horizon as a result of later intrusions (Zheltova & Burova 2014). Other peculiar features of the composition of the finds in Kostenki 4, for example, the extraordinary variety of stone raw materials noted by A.N. Rogachev, can also be explained by the stratigraphic proximity of cultural artefacts of the Bronze Age and the Paleolithic (Rogachev 1955, p. 37).

Finally, Kostenki 4/I materials can be distinguished by the presence of a series of polished objects made of soft stone. These include grinding slabs, quartzite grindstones, slate biconvex discs (Figure 3: B, 15), rectangular billets, 'polyhedral' wands and bullet-shaped points. They are found mainly within round dwellings or nearby, in the northern oblong dwelling. One fragment of a polished tool and 17 slate flakes, possibly connected to the manufacturing of such tools, were found in the southern oblong dwelling, in which, as previously believed, only the lower layer artefacts were found (Zheltova 2013; Zheltova 2014).

Osseous inventory of Kostenki 4 includes awls, lissoirs, wands, points, a mammoth ivory disc. The adornments are represented by double-headed beads, an ivory ornamented fibula with a perforated head, a pendant made on tubular bone pieces and marl pendants. Works of art include four ornamented ivory items, including a schematic anthropomorphic figurine with a dotted pattern, seven schematic zoomorphic marl figurines, an animal head and a fragment of limestone face figurine. Most of these artefacts belong to the upper cultural layer (Rogachev 1955: 78-88, 146-148).

Description of the Kostenki 4 materials shows that the probable intrusion of the Bronze Age artefacts, as well as the composition of the collection made a certain impact on A.N. Rogachev's interpretation of the results of his own work at the Aleksandrovka site (Rogachev 1940; Rogachev 1955: 152-155) . It is evident that dividing the collection into two typologically opposite groups of inventory based on certain culture-determining categories (micro- and macroblanks, core types, hammer-stones and pestle-stones, points and bifaces, chisels, etc.) is outdated.

Ultimately, separating these two cultural layers is possible not through a classification of finds, but through understanding how these artefact types are connected to various types of dwellings — long, with multiple hearths and round, with a single firepit. As M.N. Zheltova demonstrates in her work (Zheltova 2013, 2014, 2015, 2017), neither does establishing such a connection result in a conclusive distinction, nor does it allow to associate one or the other inventory with only one type of dwelling. It is important to note that round dwellings with a single hearth are widespread throughout the Stone Age, while the elongated ones are unique in their size or design. The dimensions of the long southern (32 x 5.5 m) and long northern (23 x 5.5 m) dwellings of Kostenki 4 imply the need to install supports for the roof. However, A.N. Rogachev recorded only four sufficiently deep (15-30 cm) holes in the floor of the southern dwelling, which would have been suitable to dig in support pillars (Rogachev 1955: 89-115); there were no such holes found in the northern dwelling. Both in the elongated and round dwellings, numerous shallow holes were found near the hearth zone and were quite similar. Apparently, understanding the problems associated with the reconstruction of the oblong dwellings, the researcher of this site suggested that they consisted of three joint sections, each with its own roof (Rogachev 1955: 89-113). Nonetheless, by studying planigraphy, M.N. Zheltova (Zheltova 2009) drew a conclusion that the eastern round dwelling of the upper layer was either another section of the northern oblong one or built on its ruins. Thus, the only western round dwelling stands out from the group of dwellings, due to the fact it is located sideways, outside the central axis of the long northern dwelling (Figure 3: A).

I believe it would be more reasonable to consider the Aleksandrovka site as a settlement structure with traces of multiple visits. In the field practice of the Stone Age, determining contours of constructions within settlements with multiple hearths poses a challenge. For instance, in case of the Magdalenian settlements, which were thoroughly excavated, it is extremely difficult to separate such palimpsests containing remains of several light dwellings at once (Leesch & Bullinger 2012). Partial overlapping of dwellings results in complex structures with multiple hearths. Such dwelling sites stretch along the edge of a coastal terrace for dozens of meters, which is consistent with the idea that the KBR Gravettian settlements are connected to the coastal terrains associated with the flood activity of the Don in the Pleistocene (Lisitsyn 2016).

The case of Kostenki 4 is not unique: according to I.I. Razgildeeva (Razgildeeva 2016), the Paleolithic site of Studenoe 2 in the Transbaikal region demonstrates a similar overlapping of dwellings together with an adjacent household zone. Similar to Kostenki 4, there was found a construction stretching parallel to the river bank. Previously it had been considered as an elongated dwelling space with 6 hearths (Konstantinov: 96-110). However, a planigraphic analysis showed that the artefact complexes were associated with separate hearths that had various asynchronous 14C datings.

Thus, stratigraphically and planigraphically merged cultural artefacts of Kostenki 4 belong to a settlement, which contains artefacts of multiple habitation periods of a single culturally unified population. In 1959, at the northern point of the site, excavation led by N.K. Anisyutkin revealed a horizon of finds with materials from the 'lower' cultural layer of Kostenki 4, which included tools characteristic of the 'upper' layer: micropoints, microblades with fine retouching and secondary end cores (Anisiutkin 2006). Types of tools characteristic of both cultural layers of the Aleksandrovka site were identified in the inventory of Borschevo 5/I and Kostenki 9 (Lisitsyn 2011, 2015), where they were also combined together.

Borshchevo 5/I. The site of Borshchevo 5 (studied by the author since 1998) belongs to the ravine cape of the second terrace. The upper Gravettian layer of Borshchevo 5 has bedding levels (Ia and Ib), corresponding to two paleosoils, which are located in the loess loam strata. Layer Ib is deposited in situ, while the overlying Ia shows signs of dislocation along the slope. Approximately 140 sqm were uncovered. A circular accumulation of finds was discovered at the central area of the cape. With a diameter of 5.5m it has the remains of an open hearth in the center, which can be interpreted as the remnants of a light dwelling (Figure 4: A).

The stone inventory of the upper cultural layer (n> 3000) is represented by finds from horizons Ia and Ib, which are comparable in volume. Almost all the artefacts are concentrated within the dwelling, with only single finds outside of it. Composition of the finds of both horizons is identical down to the percentage of the main tool types (Lisitsyn 2015). The industry is lamellar, but not microlithoid (Figure 4: B). Among the secondary treated tools, the following types are prevalent: backed microblades with untreated or transversely ventrally retouched ends, as well as micropoints. The latter are represented by microgravettes and flechettes with a trimmed haft or – less often – tip (Figure 4: B, 8-10, 14, 19). Burins, mainly angular and dihedral ones, are predominant over scrapers. Among other numerous tool types are chisels and massive leaf-shaped points on blades with a retouched contour, sometimes combined with burins.

The complex is peculiar due to the presence of 5 artefacts treated with grinding. An axe and an adze with hammered chopping edge (Figure 4: B, 2-3) were made of silicified dolomite. A heavily damaged biconvex disc (Figure 4: B, 4) and a wand, quadrangular in cross-section and, judging by the traces, used as an anvil with two applied parts (Figure 4: B, 5), were made of slate. Another artefact, made of a concave-convex quartzite oval pebble, was treated with pecking and polished (Figure 4: B, 1). Ground tools are generally similar to those found in Kostenki 4. Ivory tools are scarce: mattocks made of a mammoth rib and tusk, simple awls. Bullet-shaped points were also

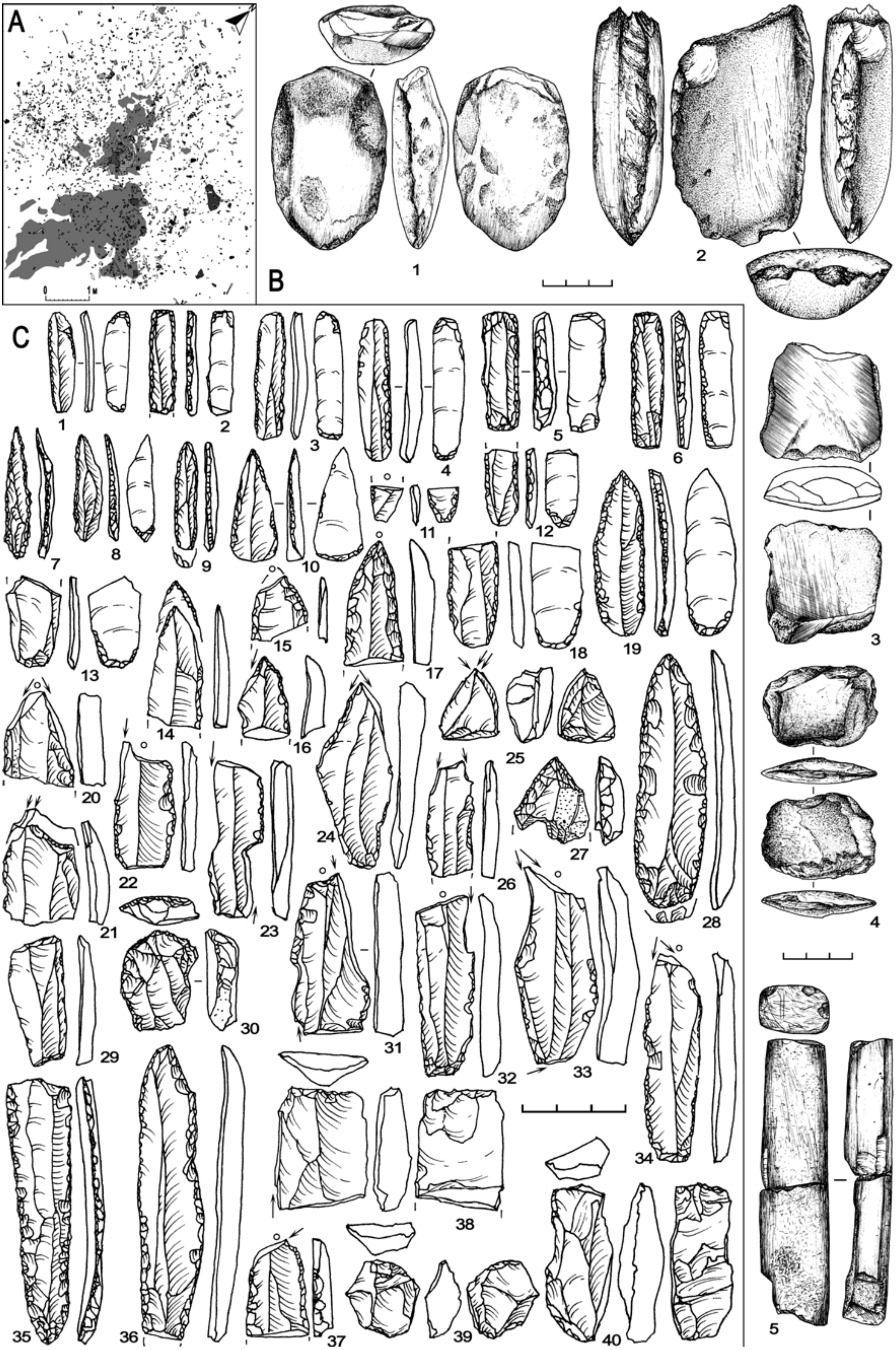

Figure 4. Borshchevo 5, the upper cultural layer. A: accumulation of finds in the dwelling; B: the polished pieces; C: the stone assemblage.

made of a tusk, as well as lissoirs, double-headed beads, two daggers and an anthropomorphic figurine, which is morphologically similar to the Kostenki 4 one (Lisitsyn 2017).

Kostenki 9. Kostenki 9 site, discovered by P.P. Efimenko in 1937, belongs to the cape of the second terrace of the Don, not particularly prominent in the relief. In 1959, A.N. Rogachev discovered a lens of cultural remains with a closed eastern contour, which were concentrated around a cindery hearth in the center (Figure 5: A). It was interpreted as an aboveground dwelling with a diameter of 5-6 m. In 2006-2007, A.V. Popov and A.Yu. Pustovalov uncovered another lens of a cultural layer, belonging to the upper part of loess loam and obtained a small collection of artefacts, including a polished slate disc – fully analogous to the finds from Kostenki 4 and Borshchevo 5 (Figure 5: B, 24).

The main collection of the 1937 and 1959 excavations (n ~ 3000) is published. Almost all of the tools of Kostenki 9 are made on blades and microblades (Figure 5: B), with the exception of a few scrapers on lamellar flakes. The main burin types are angle and dihedral, to a lesser extent the ones on truncation. A series of chisels is found in the collection. Large leaf-shaped points with a marginal retouch along the contour stand out in the assemblage. Backed points are microgravettes made on microblades with a ventrally retouched haft, as well as flechettes similar to the Borshchevo ones. Backed microblades have the shape of elongated rectangles, predominantly with a ventral trimming on the ends.

Apart from the flint artefacts, the assemblage includes fragments of slate tools with polishing traces, two cone-shaped slate wands, subquadrangular cross-section and polished over the entire surface (Figure 5: B, 19-22), as well as a marl zooomorphic piece of unclear morphology (Figure 5: B, 23). Osseous artefacts are scarse: a lissoir made of a mammoth rib and two fragmented ivory wands (Litouchanka 1966).

Cultural remains of Kostenki 9 are typologically similar to Borshchevo 5 and Kostenki 4, which allows us to assume that they belong to the same culture. Another similar trait is the presence of artefacts made of soft stone and treated by polishing (especially biconvex discs). Absence of the Eastern Gravettian markers, that is a series of shouldered points and Kostenki type knives, is also indicative of this.

I believe it is justified to compare sites like Borshchevo 5/I, Kostenki 9 and Kostenki 4/I-II with the Pavlovian culture of the Central Europe, and in particular with the most chronologically recent (25,000-22,000 yr uncal BP) complex – with the upper cultural layer of Milovice 1 site in Moravia (Milovice, site of the mammoth people... 2009).

Milovice has a full range of arfefacts characteristic of Borshchevo 5/I, Kostenki 4 and Kostenki 9, given its greater typological variety. Other late Pavlovian sites (26,000-25,000 yr uncal BP), which are closer geographically, albeit not so remarkable, can also provide analogies to the Milovice finds. Among these are the Gravettian layer of the Kašov site in Slovakia (Novak 2004) and the Jakšice 2 site in Poland (A Gravettian site in southern Poland: Jaksice II 2015: 33-52), 3-4 layers of the Grub-Kranwetberg site in Austria (Nigst & Antl-Weiser 2012) and, possibly, other undated sites of the late Pavlovian (Svoboda 2007; Polanska & Hromadova 2015).

Polishing in production of stone tools is specific to the Aleksandrovka cultural complex, and some similarities in that respect can be drawn only with the Pavlovian sites (Zheltova & Lisitsyn 2017). Generally speaking, production of polished tools is a differentiating factor of the Moravian Gravettian sites (Pavlov, Dolní Vestonice, Przhedmost, Trenčianske Bohuslavice), which distinguishes Pavlovian sites from the rest of the Gravettian complexes. Pavlov 1 has the most exhaustive collection of such tools (Skrlda 1997). Upon obtaining new 14C datings the eponymous Pavlovian site is considered a settlement of recurrent habitation- from the late Aurignacian (31-30 kyr uncal BP) to the early (28-27 kyr uncal BP) and middle Gravettian (26-25 kyr uncal BP) (Svoboda

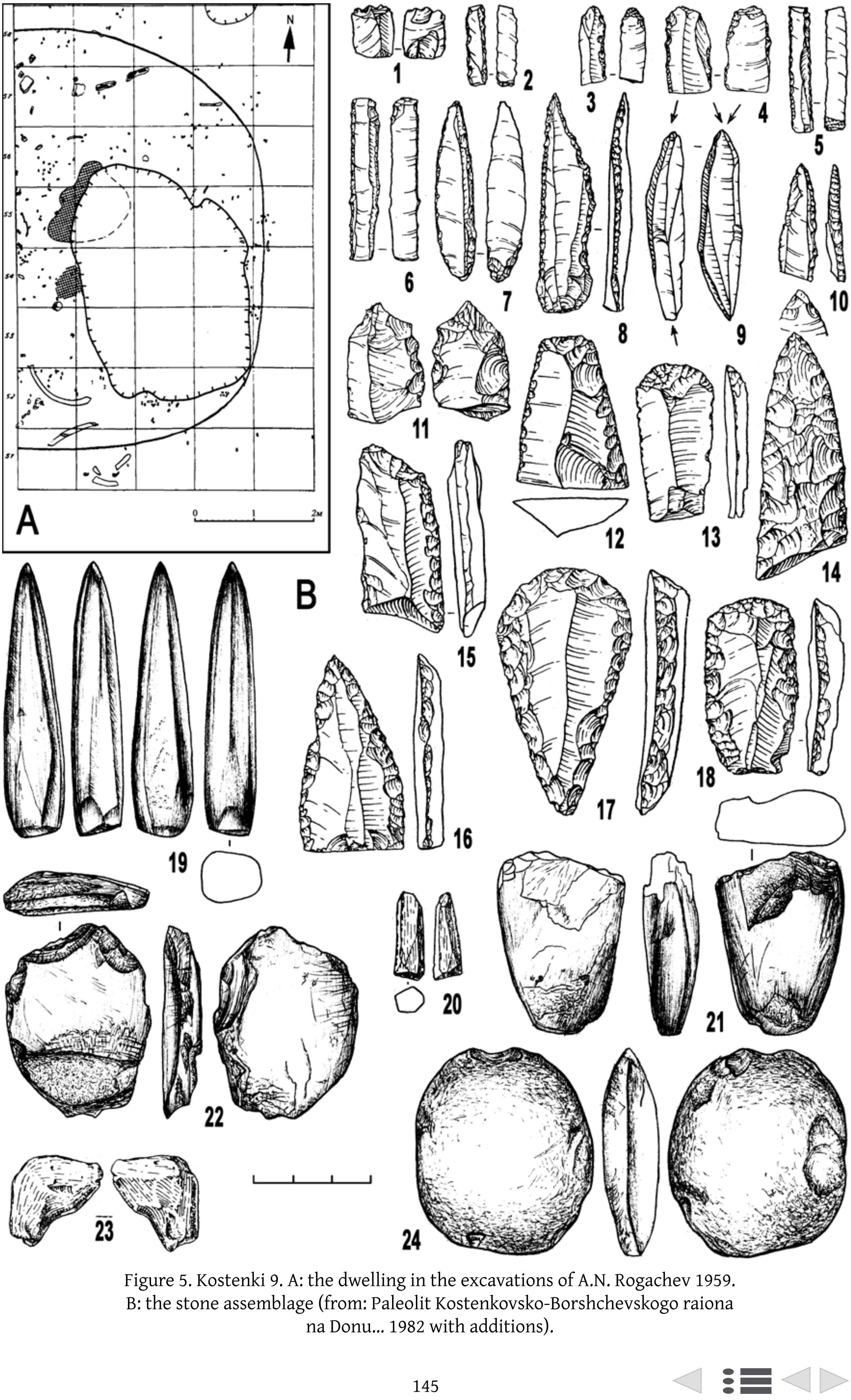

Figure 5. Kostenki 9. A: the dwelling in the excavations of A.N. Rogachev 1959.
B: the stone assemblage (from: Paleolit Kostenkovsko-Borshchevskogo raiona na Donu... 1982 with additions).

et al. 2016) inclusively. In this case, the existence of sites with polished tools in the KBR (25-24 kyr uncal BP) indicates the expansion of the developed Pavlovian to the Russian Plain in the period immediately preceding the late Gravettian migration of the Willendorf-Kostenki population from the Danube (23-22 kyr uncal BP).

Kostenki-Avdeevo (Willendorf-Kostenki) complex
(Kostenki 1/I, Kostenki 13, Kostenki 14/I, Kostenki 18)

All three sites belong to the strata of the second terrace of the Pokrovsky ravine. Traces of long-term settlement were examined, that is, remains of hearths, pits, and dwellings. Apart from that, a child's burial was found in Kostenki 18. The upper cultural layer of Kostenki 1 (Polyakov's site) remains the most abundant of the studied settlements, which have been studied for over 80 years on a total area exceeding a 1000 sqm (Efimenko 1958). There were found the remains of two oval dwelling complexes, parallel to each other, each consisting of numerous hearths located along the central line, as well as pits and dugouts along the outer contour (Figure 6: A). The material culture of the Kostenki-Adeevo sites is has been described in sufficient detail. Therefore, we can confine ourselves to a brief description of the main parameters of the inventory (Figure 6: B).

Tools were made on lamellar blanks, varying from massive ones to miniature microblades. The toolkit can be distinguished by the combination of three tool types: shouldered points, in which the side notch equals 2/3 of the length (both larger and smaller types), Kostenki type knives, and backed microblades — rectangles with transversely retouched ends (dorsally and less frequently ventrally) (Lisitsyn 1998). Bone and ivory inventory is extremely abundant and manifold.

The most characteristic are rib spatulas with anthropomorphic heads, ivory mattocks, various points. Adornments are represented by ornamented diadems, pendants, fibulas (Gromadova 2012). Objects of art include canonical female figurines made of ivory and marl, as well as zoomorphic figurines.

Anosovka complex
(Kostenki 11/II, Kostenki 21/III – dwelling areas)

Kostenki 11 site (Anosovka 2) was discovered by A.N. Rogachev in 1951. It has been intermittently excavated to the present day due to research of Mezin type bone dwellings in the upper cultural layer (Rogachev 1957; Rogachev 1961; Paleolit Kostenkovsko-Borshchevskogo raiona... 1982: 125-128; Popov & Pustovalov 2004; Fediunin 2017). The site is located on the ravine cape of the second terrace.

The second cultural layer has been predominantly examined by testpitting. It is deposited in the middle part of the loess loam and lies in separate clusters. Remains of two dwellings were partially studied (Figure 7: A). The remains of the southern dwelling are an oval lens of 12 x 6.5 m filled with bone char and ash. Inside the dwelling two deepened firepits and ~ 13,500 artefacts were discovered. The northern dwelling was 6x7 m in size, but, as opposed to the southern one, it did not contain ash-carbon mass. The collection from the northern dwelling (partially excavated) amounts to ~ 3000 items. The total number of artefacts from Kostenki 11/II comprises ~ 20,000 items, with 1000 items having a secondary treatement (Popov 1983; Popov 1989; Popov & Pustovalov 2004). Blades with a truncated dorsally retouched end, with a frequent contour retouching along the edges, are prevalent in the toolkit (Figure 7: B, 37-40). Predominance of burins on retouched truncation is a particular feature of this complex. Scrapers are small in numbers and inexpressive; there are also individual cases of treated two-side leaf-shaped points and scrapers of different morphology.

A series of small backed lanceolate points with either dorsal straight or arcuate truncations on one and less often both ends (Anosovka points), gives a peculiarity to the complex. Another peculiarity

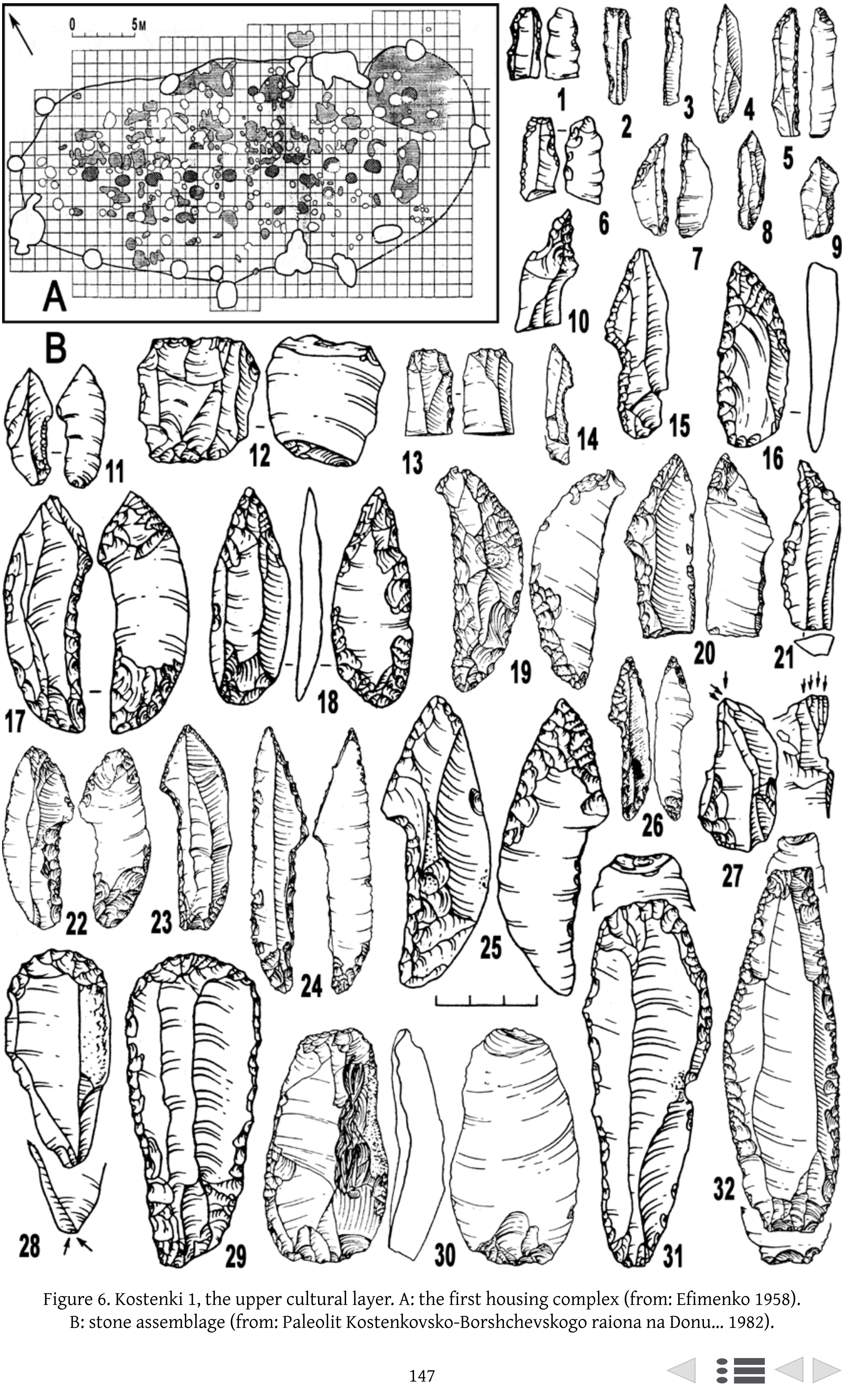

Figure 6. Kostenki 1, the upper cultural layer. A: the first housing complex (from: Efimenko 1958).
B: stone assemblage (from: Paleolit Kostenkovsko-Borshchevskogo raiona na Donu... 1982).

is the small tool size (up to ~ 3 cm) and the blank type: they are made on shortened sub-triangular bladelets and lamellar flakes (Figure 7: B, 1-17). Their dimensions are caused not by the blank standardization, but by an intense edge backing combined with truncation of the point ends. Actually, such tools should be attributed to geometric microliths.

Bone artefacts are represented by two points with heads, which resemble animal faces. Kostenki 11/II complex also features a number of art objects, namely, a series of miniature marl figurines (over 100 items) with a flattened base, some of which are quite recognizable (mammoth, rhinocerous, bison).

The complex does not have comprehensive analogies in the Gravettian industries, but in some aspects, it is similar to various East European sites. Zoomorphic marl figurines in KBR sites remind of Kostenki 1/I, Kostenki 4, Kostenki 9 (Abramova 1961; Rogachev 1961; Anikovich 1983), while backed tools and tools with truncated ends remind of Kostenki 21/III, as well as Pushkari 1 and Klyussi in the Desna region (Sinitsyn 2014a). A specific feature of Kostenki 11/II inventory is the lack of signs indicating microblade blank production combined with mass production of microliths. In this Anosovka complex is similar to the Byki 1 and Byki 7/I-Ia sites in the Seym area with their triangular microliths (the beginning of the late stage of the Upper Paleolithic, 17,000-15,000 yr uncal BP). It should be noted that N.B. Akhmetgaleyeva (Akhmetgaleeva 2015: 181-184) attributes Byki industry not to the Gravettian, but in the Magdalenian cultural cluster. According to the combination of features, the inventory of Anosovka corresponds most fully to materials of Kostenki 21/III. However, surprisingly, these parallels are limited only to some local areas of the latter site and are not represented in others.

Kostenki 21 (Gmelinskaia site) is a site discovered by N.D. Praslov in 1956 on the first terrace of the Don. Total area uncovered in 1950-70s. exceeds 500 sqm. Within the terrace composed of loess-like loams, three cultural layers were revealed, of which the best studied one is the lower one, connected to the Gravettian (Praslov 1964; Paleolit Kostenkovsko-Borshchevskogo raiona ... 1984: 198-209).

Judging by separate finds clusters, six household complexes (I-VI) were determined, spread over ~200 m along the riverside (Figure 8: A). Four of them are thought to be remains of dwellings. Both complex I and the southern complex II, are interpreted as production centers for flint knapping and tool manufacturing. These complexes are interspaced with cultural layer sections having relatively sparse finds. The inventory of Anosovka type is associated exclusively with dwelling features (Figure 8: B).

Remains of dwellings are represented by lenses of ash mass clusters, stone artefacts, bones and ocher (Ivanova 1981). In the plan, they have a circular-oval shape and occupy an area of 10-16 sqmm. Three of them had deepened hearths. Near one of the dwellings (the northern complex), limestone tiles contoured the remains of a structure from the eastern and southern sides. The stone tool collection found in the dwellings (n ~ 2700) amounts to 271 tools. The most numerous and expressive types are backed vertically retouched points and blades (Anosovka points), as well as knife-shaped blades with transverse and oblique truncated ends (Figure 8: B, 1-6). These are followed by burins, including burins on retouched truncation and multiple ones, as well as scrapers. Osseous inventory is represented by fragments of three points and adornments such as oval pendants made of mammoth tusk. Overall, the inventory is identical to the finds of Kostenki 11/II, except for the absence of marl figurines.

Artefacts found in industrial complexes of Kostenki 21/III differ dramatically both from the toolkit found at the site of dwelling and from Kostenki 11/II inventory by the knapping technique, as well as the tools types (Figure 8: B). The collection has pronounced Gravettian features given a large number of microblades and tools on microblades, with shouldered points and numerous

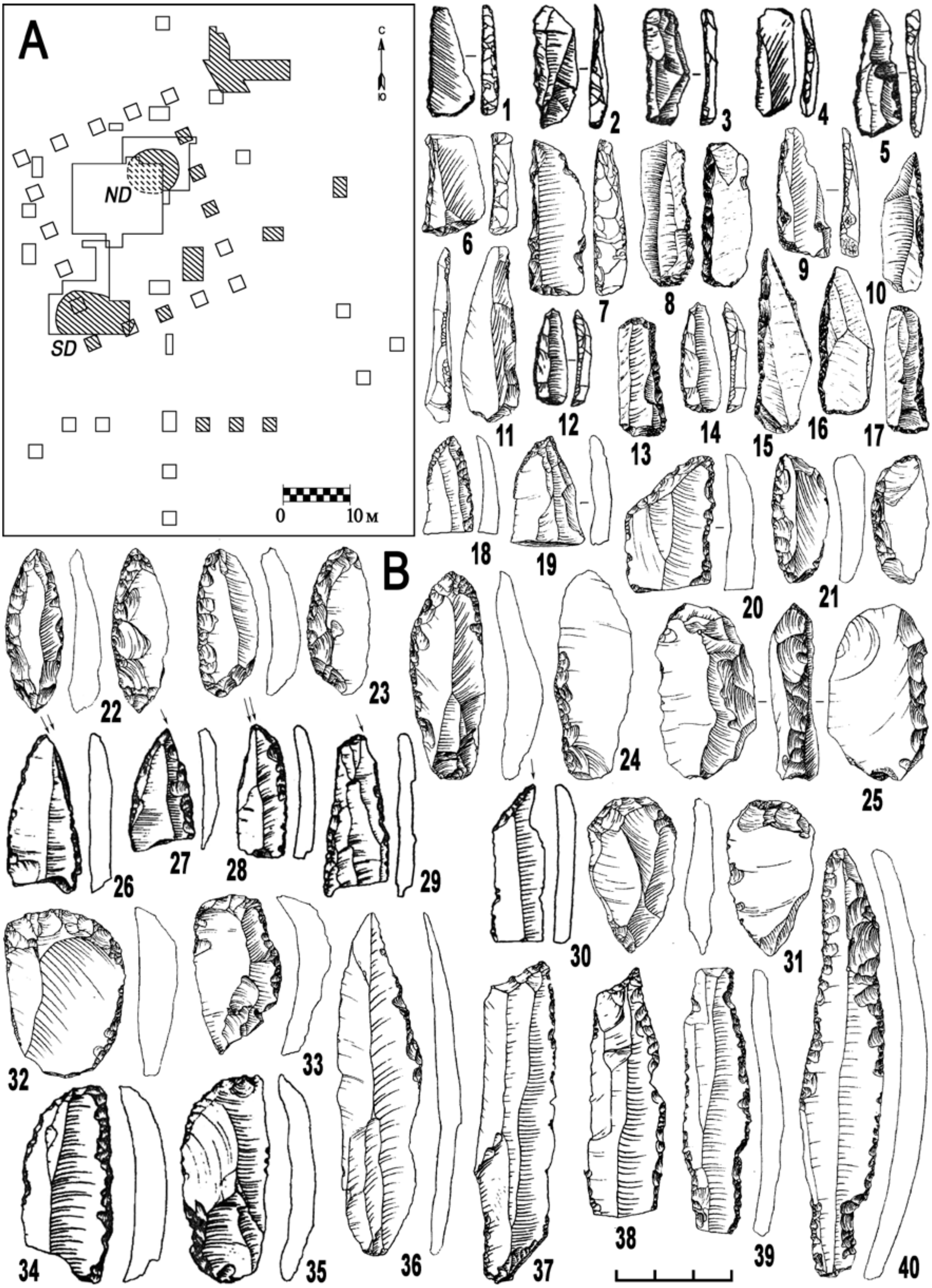

Figure 7. Kostenki 11, the second cultural layer. A: the excavations and testpits scheme. Areas of the cultural reamains spread are hatched. ND – the north dwelling, SD – the south dwelling. B: the stone assemblage (from: Sinitsyn 2013; Popov & Pustovalov 2004).

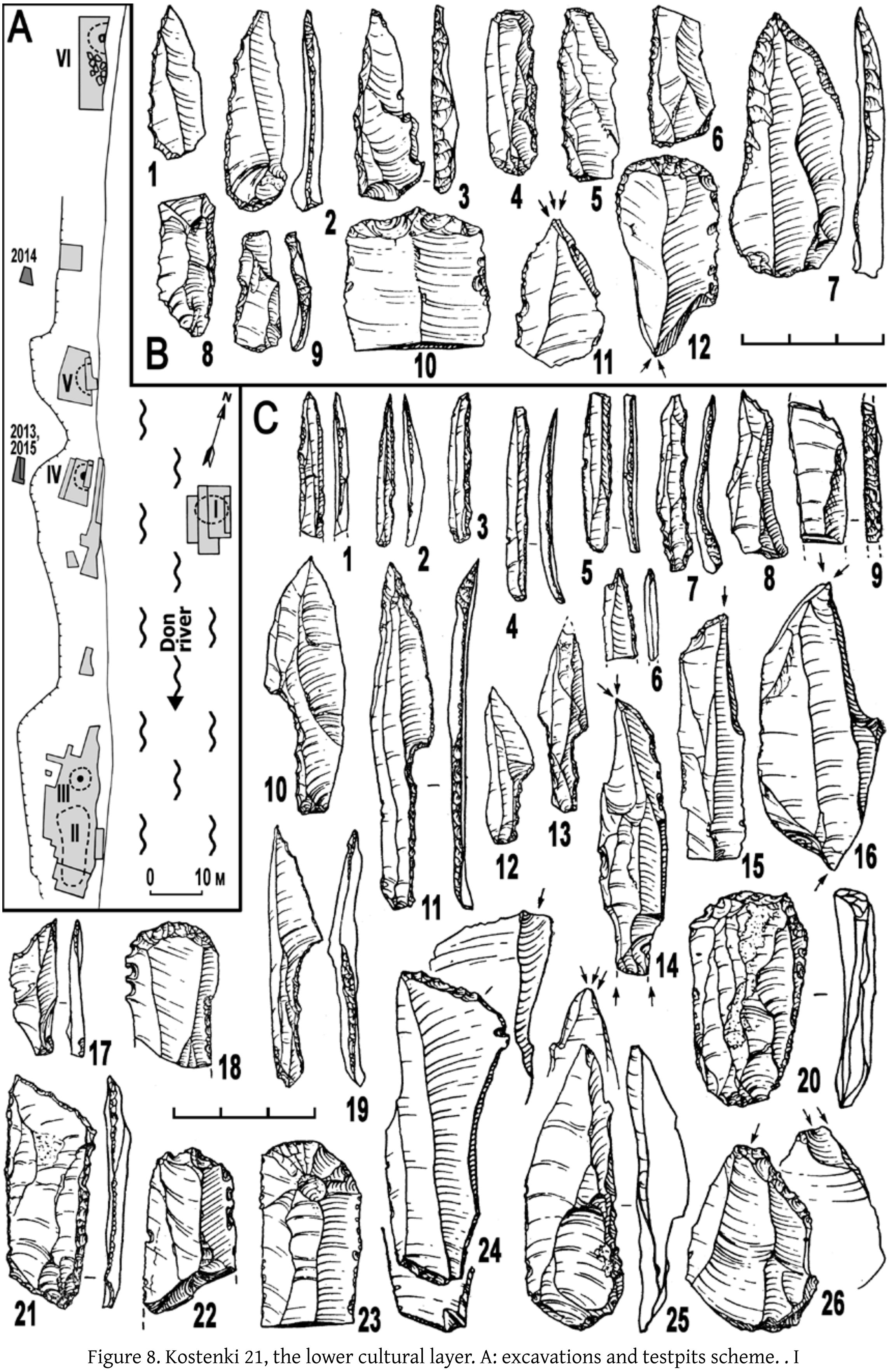

Figure 8. Kostenki 21, the lower cultural layer. A: excavations and testpits scheme. . I II – «manufacturing» complexes, III VI – «housing» complexes. B: stone assemblage of the complex IV. C: stone assemblage of the complex II (from: Paleolit Kostenkovsko-Borshchevskogo raiona na Donu...1982).

ivory and bone tools. According to M.N. Ivanova and N.D. Praslov (Ivanova 1981; Ivanova 1985; Paleolit Kostenkovsko-Borshchevskogo raiona ... 1981, p. 209), such differences can be explained by specifics of activity taking place in dwellings and on tool production areas.

M.V. Anikovich and V.V. Popov united the finds of the second cultural layer of Kostenki 11 with those of the lower layer on the Gmelin site, as well as with the scarce inventory of Kostenki 5/III under the term of Anosovka-Gmelin archeological culture, proposing an alternative interpretation of the typological differences between sites. They believe such differences could be caused by the seasonal character of habitatation – a winter settlement on Kostenki 11/II and a summer settlement on Kostenki 21/III (Anikovich *et al.* 2008: 205-206). From my point of view, such explanation is unsubstantiated, since it is based solely on the presence of bone coal in the dwellings of Kostenki 11/II in contrast to Kostenki 21/ III, where charcoal prevailed.

It should be noted that in Kostenki 21/III the finds clusters of two different cultures were distributed in alternating deposition. Their appearance is not connected to the presence or absence of various household structures of habitation or seasonal character of settlement. Palimpsest cultural layers with separate clusters, left by single- or multi-cultural population groups, are quite common for the Neolithic-Mesolithic sites. The same is true for the KBR at sites of the first terrace of the Don (Kostenki 4, Kostenki 21, Borshchevo 1 and Borshchevo 2). Thus, artefacts of the lower layer of the Gmelin site should be divided into two cultural complexes – Anosovka ('dwellings') and Gmelin ('production sites'). Thus, each of these groups becomes typologically accurate and can be described within a specific cultural and archaeological context.

Gmelinskaia complex
(Kostenki 21/III – production areas)

Kostenki 21/III (Gmelinskaia site) production complexes are characterized by a large area (40 and ~ 80 sqm respectively). These are long lenses of a cultural layer with ash spots and high concentration of finds. At least one open hearth was documented in complex I, while in complex II no hearths were found. Stone tool collections amount to n ~ 7,500 for complex I and n ~ 24,000 for complex II. The number of artefacts with secondary treatment is quite significant (n> 1000).

In production complexes, as opposed to the dwelling sites, the main tool blanks were regular blades and microblades (> 50% of all the items). There are predominantly dihedral burins or burins on retouched truncation found in the collection. Backed points are miniature and are of a microlithoid appearance. Backed microblades have a sharpened or natural end (Figure 8: B, 1-7). Shouldered points (n> 100) make up an expressive category. In contrast to the Kostenki-Avdeevo points, the notch does not exceed half of the blank length (Figure 8: B, 10-13, 19). Bone tools vary – they comprise a series of ivory points, awls, an eyed needle, several flounder-shaped pendants and a pendant made of a reindeer canine tooth. Rare items include an ivory 'shaft straightener' with a fir-tree ornament, as well as an item that is interpreted as a handle. Apart from that, there are two unique engravings of zoomorphic images on stone discs (Paleolit Kostenkovsko-Borshchevskogo raiona ... 1981, p. 208-209).

During the recent work of A.A. Bessudnov, the remains of two more lenses with flint inventory corresponding to the toolkit of 'production centers' were found on Kostenki 21. In my opinion, a wide distribution of Gmelinskaia type finds, including those in the newly unearthed areas, confirms that they are not simply functional, but bear an independent cultural character (Bessudnov 2015).

Parallels to the Gmelinskaia complex can be drawn at Gagarino site on the upper Don (Tarasov 1979). The Gmelinskaia complex is similar to the industry of Gagarino due to a pronounced microlithoid character of flint tools, the use of blades and their fragments to make tools, a combination of burins on retouched truncation and dihedral burins of similar morphology, as well as a series of shouldered points on microblades with the notch taking up half of the blank length.

The same features unite Kostenki 21/III and Khotylevo 2 on the Desna. The Gagarino site has even more common features with the latter one: Kostenki type knives, bone and ivory tools and art objects, including typical female figurines (Gavrilov 2004, 2008, 2016). Differences between the Gmelinskaia and Khotylevo-Gagarino toolkits are mostly negative. For instance, the Kostenki 21/III site has practically no ventral retouching on tools. Some tool types characteristic of the Eastern Gravettian are absent from the toolkit. This difference is also reinforced by the absence of specific bone and ivory items and typical design elements.

Nevertheless, the Gmelinskaia complex is closer to the classic sites of the Eastern Gravettian than any other Gravettian complexes in Kostenki, which are not immediately connected to the Kostenki-Avdeevo culture. In the Gmelinskaia industry, distinguishing feautures are miniature shouldered points, having prototypes in the Eastern Gravettian. In this regard, the Gmelinskaia complex can be seen as a borderline that separates the Gravettian sensu lato from the Epigravettian.

Stratigraphy and geomorphological correlation

The KBR Gravettian sites are associated with the so-called loess-like loam uppermost bed, which completes the local Pleistocene sedimentation column. The only exception could be Kostenki 8/II horizon, enclosed in the horizon of a reduced upper humus stratum, directly covered by loess-like loam. The upper humus stratum is usually compared with the Bryansk paleosoil, and in the KBR it is considered isochronous to 32-28 kyr uncal BP.

However, according to the latest research of Kostenki 8, younger datings of 23.3 and 25.6 kyr uncal BP were obtained for the second cultural layer. Therefore, cautious doubts are being voiced concenring the orthodox view on the age of the enclosing horizon (Dudin *et al.* 2016). I believe the ‘humus content’ can be explained by the presence of washed-out firepits containing charcoal and ash, and not by association with this very stratum. Regardless, it can be argued that the majority of the KBR Gravettian settlements existed during the cold cycle of loess sedimentation corresponding to the final phase of the middle Weichselian glaciation.

Buried soils may be used as additional stratigraphic markers to divide the loess-like bed into parts. Episodes of soil formation, which are associated with the Gravettian cultural layers, have been repeatedly recorded. In particular, up to four ephemeral fossil soils can be distinguished in the Kostenki 14 loess member, of which the two lower ones are associated with Gravettian finds (Sedov *et al.* 2010; Sinitsyn 2015). Two levels of soil formation were recorded on Borshchevo 5, and both contain Gravettian artefacts. At least one distinct paleosoil (the Gmelin one) can be distinguished at the level of the Gravettian layer bedding on Kostenki 1, Kostenki 21 and, possibly, on Kostenki 11 (Paleolit Kostenkovsko-Borshchevskogo raiona na Donu ... 1982, p. 116; Popov & Pustovalov 2004; Hoffecker *et al.* 2016).

3. Chronology and periodization

Over a hundred datings have been obtained on samples from the KBR Gravettian cultural layers. Almost half of them comes from the upper cultural layer of Kostenki 1. Datings on bone samples are prevalent. Existing 14C datings, in average uncalibrated values, determine the period of existence of the KBR Gravettian from ~ 27,000 (Kostenki 8/II) to ~ 21,000 yr BP (Kostenki 21/III). Effectively, in a series of datings, they vary for almost each site, providing an opportunity to demonstrate one’s chronological preferences and choose a specific timepoint accordingly. The most reliable method for development of the Kostenki Gravettian periodization is to examine certain complexes in comparison to the Gravettian sites of other regions and see if they mutually correlate. In accordance with common European ideas on periodization of the Upper Paleolithic, the KBR Gravettian can

Periodization (14C uncal.)	*Cultural attribution*	*Sites / Layers*	*Dates (14C uncal. BP)*	*Related sites*
Early Gravettian (27-25 kyr BP)	***Telmanskaia complex***	Kostenki 8/II	27700±750 (GrN-10509)[1] 27670±270 (OxA-30198)[2] 27620±270 (OxA-30197)[2] 25640±210 (CURL-15797)[3] 24500±450 (GIN-7999)[4] 23340±150 (CURL-15816)[3] 23020±320 (OxA-7109)[4] 21900±450 (GrA-9283)[5]	Grotta Paglicci /23a Geißenklösterle /Ic Abri Pataud /5
Middle Gravettian (25-24 kyr BP)	***Aleksandrovka complex*** ***(Pavlovian)***	Kostenki 4/I-II	25290±210 (OxA-30194) layer I/II [2] 24790±190 (OxA-30193) layer I/II [2] 24710±200 (OxA-30196) layer I/II [2] 23000±300 (ГИН7994) layer I [4] 22800±120(ГИН7995) layer I [4] 20290±150 (OxA8310) layer I/II [6] 14210±70 (OxA-30195) layer I/II [2]	Pavlov 1 Milovice Jaksice 2 Kašov I Grub Kranawetberg
		Kostenki 9	——	
		Борщёво 5/I	25110±200 (OxA-30200) layer Ia [2] 24720±190 (OxA-30199) layer Ia [2] 22500±700 (ГИН-10239)[7] 20000±300 (ЛЕ-6947)[7] 17400±2000 (ЛЕ-5571)[7] 14060±110 (ЛЕ-6809)[7]	
Late Gravettian (23-21 kyr BP)	***Kostenki-Avdeevo complex*** ***(East Gravettian)***	Kostenki 1/I	>45 dates from 24570 to 8700 kyr mainly concentrated 23-22 kyr [8]	Willendorf 2/IX
		Kostenki 13	——	
		Kostenki 18	23440±150 (OxA-X-2666-53) [11] 21020±180 (OxA-7128)[4] 20600±140 (ГИН-8032)[4] 19830±120 BP (GrA-9304)[5] 19300±200 (ГИН-8576)[4] 17900±300 (ГИН-8028)[4]	Kraków Spadzista Moravany
		Kostenki 14/I	22 940 ± 100 (GrA-46676)[9] 22780±250 (OxA-4114)[4] 22500±1000 (ЛЕ-5274)[4] 21 090±220 (AA-91465)[9] 20 730±90 (GrA-46677) [9] 20100±1500 (ЛЕ-5269)[4] 19900±850 (ГИН-8024)[4] 19700±1300 (ЛЕ-5567)[9]	Avdeevo Zaraisk Berdyzh
	Gmelinskaia complex	Kostenki 21/III «production centers»	22860±320 (GrN-24968) [6] 22270±150 (GrN-7363)[1] 22230±100 (GrN-14669) [6] 21780±90 (ГИН-9668) [10] 21260±340 (GrN-10513)[1] 16960±300 (ЛЕ-1043)[1]	Gagarino Khotylevo 2
Epi-Gravettian (≤21 kyr BP)	***Anosovka complex***	Kostenki 21/III «dwellings»		Pushkari 1
		Kostenki 11/II	21800±200 (ГИН-2531)[1] 15200±300 (TA-34)[1]	Byki 7

Figure 9. The periodization and chronology of the Gravettian assemblages in the Kostenki-Borshchevo locality.

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be divided into the early period of 27,000-25,000 yr uncal BP, the middle one of 25,000-24,000 yr uncal BP, and the late one of 23,000-21,000 yr uncal BP. Given a common archaeological context of the identified KBR Gravettian cultural groups with the sites of Eastern and Central Europe, as well as the compliance of datings, we can determine the cultural and chronological succession of these complexes (Figure 9: Table).

Conclusion

Archaeological unity of the Gravettian sites is synstadial in character, which is expressed by common features of inventory and technological basis, and, potentially, by the type of economic adaptation caused by cooling and aridization of the climate. It seems the reasons behind cultural diversity of the KBR Gravettian should be attributed to favorable environmental conditions of this local area to arrange encampment settlements (Lisitsyn 2016).

Taking into account the archealogical context, cultural differentiation of the Kostenki Gravettian takes form of a relatively orderly periodization. Cultural complexes can be distinguished by distinct features of material culture. They are linked to different chronological episodes and have corresponding analogies among the sites of Eastern and Central Europe.

The first manifestation of the Gravettian ~27,000-25,000 yr uncal BP was marked by the emergence of a population group with the Kostenki 8/II industry type in the basin of the Don river. The second wave of settlers (25,000-24,000 yr uncal BP), associated with the Pavlovian, shaped the Aleksandrovka complex belonging to the middle Gravettian. The Gravettian succession in the KBR is completed by the Kostenki-Avdeevo complex (23,000-22,000 yr uncal BP). It is possible that the peak of cooling after 21,000 yr uncal BP led to the emergence of local industries of Anosovka and Gmelinskaia type. The latter largely inherits Gravettian traditions, while Anosovka type belongs to a different line of cultural development.

People of the Gravettian era occupied the Don basin in waves, settling in the tundra-steppe landscape zone, which on the eve of the glacial maximum united the territories of Central and Eastern Europe into a single ecosystem. At the same time, no signs of mixing or hybridization of various generations of the KBR Gravettian may indicate that the waves of these populations followed each other consequently, which leaves open the question if there were any direct contacts between them.

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Industries of the end of Upper Palaeolithic in the south of Russian plain (northeastern Azov Sea region) and the Northern Caucasus

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Abstract

The authors report their comparative analysis of the Upper Palaeolithic sites in Kamennaya Balka, in the northeastern Azov Sea region in the south of Russian plain, which are assigned to the Kamennaya Balka culture, and the Epipalaeolithic sites in the northwestern Caucasus. In both regions, the assemblages are dated to the final of the Upper Palaeolithic, from the Last Glacial Maximum to the end of Pleistocene. The comparison shows numerous analogies between the Epipalaeolithic industry of northwestern Caucasus and the Kamennaya Balka sites, but also indicates important differences between these roughly contemporaneous industries.

Keywords: final Upper Palaeolithic; northern Azov Sea region; north-western Caucasus

Résumé

Les auteurs présentent leur analyse comparative des sites du Paléolithique supérieur de Kamennaya Balka, dans la région nord-est de la mer d'Azov au sud de la plaine russe, qui appartiennent à la culture Kamennaya Balka, et les sites épipaléolithiques du nord-ouest du Caucase. Dans les deux régions, les assemblages sont datés jusqu'à la fin du Paléolithique Supérieur, du dernier maximum glaciaire jusqu'à la fin du Pléistocène. La comparaison montre de nombreuses analogies entre l'industrie épipaléolithique du nord-ouest du Caucase et les sites de Kamennaya Balka, mais indique également des différences importantes entre ces industries à peu près contemporaines.

Mots-clés : Paléolithique supérieur final ; Mer d'Azov septentripnnale ; nord-ouest du Caucase

1. Introduction

In the south-eastern Russian plain, in the northeastern coast of the Sea of Azov, the complex of final Upper Palaeolithic sites in Kamennaya Balka (Figure 1) is studied since the mid-20th century. The first investigator of these sites, M. Gvozdover (1967), noted their similarity with the Imeretian Upper Paleolithic culture in the western Caucasus. For many years, the researchers of the Kamennaya Balka sites (e.g., Leonova, N. 1994; Leonova, N. *et al.* 2015) made comparisons between the assemblages of the Imeretian culture of the Caucasus and the Kamennaya Balka culture. The current state of research in the northeastern Azov Sea region and in the North-Western (NW) Caucasus allows to compare the Upper Palaeolithic industries of these regions in more details.

2. Chronology and characteristics of assemblages in the Kamennaya Balka sites

The final Upper Palaeolithic open-air sites of Kamennaya Balka I, II and III (Tretiy Mys) are located on the high right bank of Don River, near its confluence into the Sea of Azov. At present researchers (Leonova, N. *et al.* 2015) define three stages in the Upper Palaeolithic occupation of this region and

Figure 1. Map showing locations of the Epipalaeolithic sites in the North-Western Caucasus and the Kamennaya Balka sites in the Azov Sea northern coast.

development of the Kamennaya Balka culture. However, due to a bad preservation of bone in the open air sites in this region there is a big problem with precise radiocarbon dating of these stages. Currently, the earliest stage of this industry, which comprises layer 1 in Kamennaya Balka I and layer 3 in Kamennaya Balka II, has a single date of 14,670 ± 105 yr 14C BP (AA-4797) made on charcoal from a hearth in the Kamennaya Balka I site. Layer 3 of Kamennaya Balka II remains undated. The middle stage, comprising layer 2 in Kamennaya Balka II and the lower layer in Tretiy Mys, is dated by about 30 radiocarbon dates made for layer 2 in Kamennaya Balka II to 15/16-17 ka cal BP. The later stage is dated to ca. 13-14 ka cal BP on the basis of geomorphologic and palynological data.

In Kamennaya Balka, the early stage of the Kamennaya Balka culture is represented by the earliest Upper Paleolithic assemblages that are found in the Kamennaya Balka II, layer 3 and presumably in Kamennaya Balka I sites (see Table 1). Researchers of the Kamennaya Balka culture underline that the assemblage from Kamennaya Balka II, layer 3 differs from the later assemblages of this culture known in Kamennaya Balka. The assemblage from layer 3 includes numerous backed pieces made on bladelets and micro-bladelets, indicative backed points similar to Gravette (Figure 2 – 8, 10, 11) and Vachons points (Figure 2 – 1-4, 9, 12). Also, burins on oblique retouched truncation (Figure 2 – 6, 7), end-scrapers (Figure 2 – 14, 15), and truncations on bladelets and small blades (Figure 2 – 5) are characteristic. This assemblage is most similar to the Caucasian Upper Palaeolithic sites; however, it is not published in details.

The middle stage is represented by Kamennaya Balka II, layer 2. The assemblage is dominated by backed pieces (more than 30%; Figure 3 – 13-15) and burins (more than 20%; Figure 4 – 1, 2, 6-8, 12, 13), followed by retouched blades and flakes (11%) and end-scrapers (10%; Figure 4 – 3-5, 9-11). Among backed pieces Vinogradova (2014) defines prevailing quadrangles (60% of total backed pieces), among which so called 'parallelograms' prevail (80%; Figure 3 – 3-12), as well as rectangles (10%; Figure 3 – 1-4) and scalene triangles (5%; Figure 3 – 19-21) are present. Among micro-points comprising about 3%, most points have symmetrical shape, and one or two retouched edges (Figure 3 – 24, 25). Also, there are tools similar to Gravette points (Figure 3 – 22, 23). Angular burins on retouched truncation prevail among burins (Figure 4 – 7, 8), and there are also double (Figure 4 – 6), dihedral (Figure 4 – 13), and multifaceted (Figure 4 – 12) burins. End-scrapers made on flakes (Figure 4 – 10, 11) prevail among end-scrapers. Blades and bladelets with concave truncation are characteristic (Figure 4 – 14-17). Composite tools (Figure 4 – 3, 9), awls, pièces esquillées, and denticilates comprise in total 1-4%.

Fedorovka, Yanisol (Krotova, 1986)	Kamennaya Balka I (Leonova et al., 2015)	Kamennaya Balka II (Leonova et al., 2015; Vinogradova, 2014, Medvedev, 2014)	Tretiy Mys (Leonova et al., 2013)	North-Western Caucasus (Golovanova et al., 2014, Leonova et al., 2014, Leonova, 2014)
Fedorovka, Layers 1 and 2 Yanisol 13–14 kyr		Layer 1 13.5–14 kyr	Upper layer (?), Middle layer 2 13.2–13.6 kyr	Mezmaiskaya, 1-3, hor. 1, 2 Satanay, Kasojskaya, hor. 4, 3 Chigay, layer 5, lower Dvoynaya, layers 6 (?) and 7
	Layer 1 17–18 kyr	Layer 2 15/16–17 kyr Layer 3 18–20 (?) kyr	Lower layer 13.8–14.8 kyr	Kasojskaya, hor. 5, Besleneevskaya, 2B Chigay, layers 10–14 Mezmaiskaya, 1-3, hor. 3-9

Table 1. Chronology of the final Pleistocene assemblages in the Northern Azov Sea coast in comparison to the final Pleistocene assemblages in the NW Caucasus based on calibrated radiocarbon dates (cal BP).

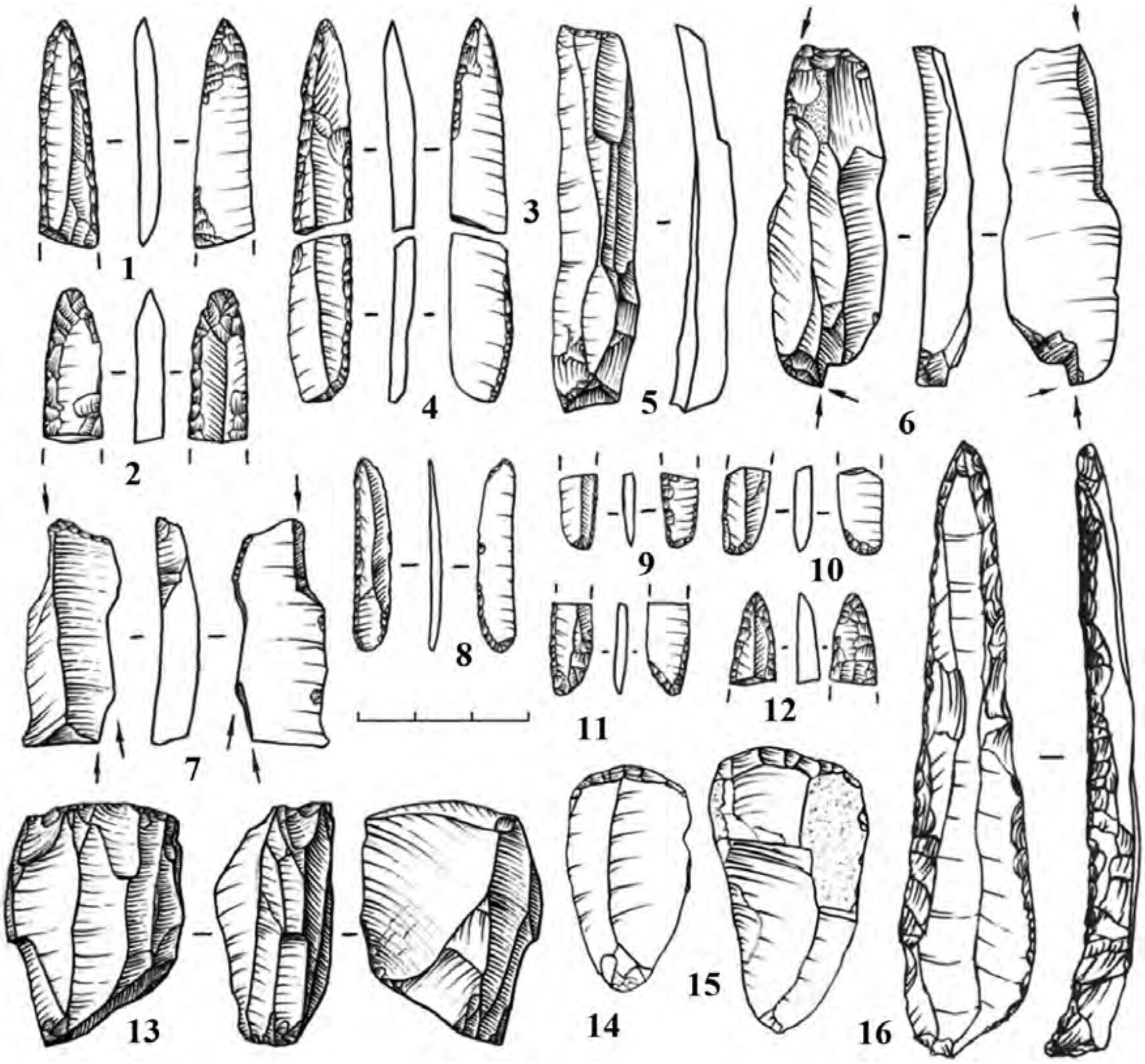

Figure 2. The lithic assemblage from layer 3 in Kamennaya Balka II, representing the early stage (20-18 ka) of the Kamennaya Balka culture. Modified after (Leonova *et al.* 2015: fig. 7). Scale bar = 1 cm.

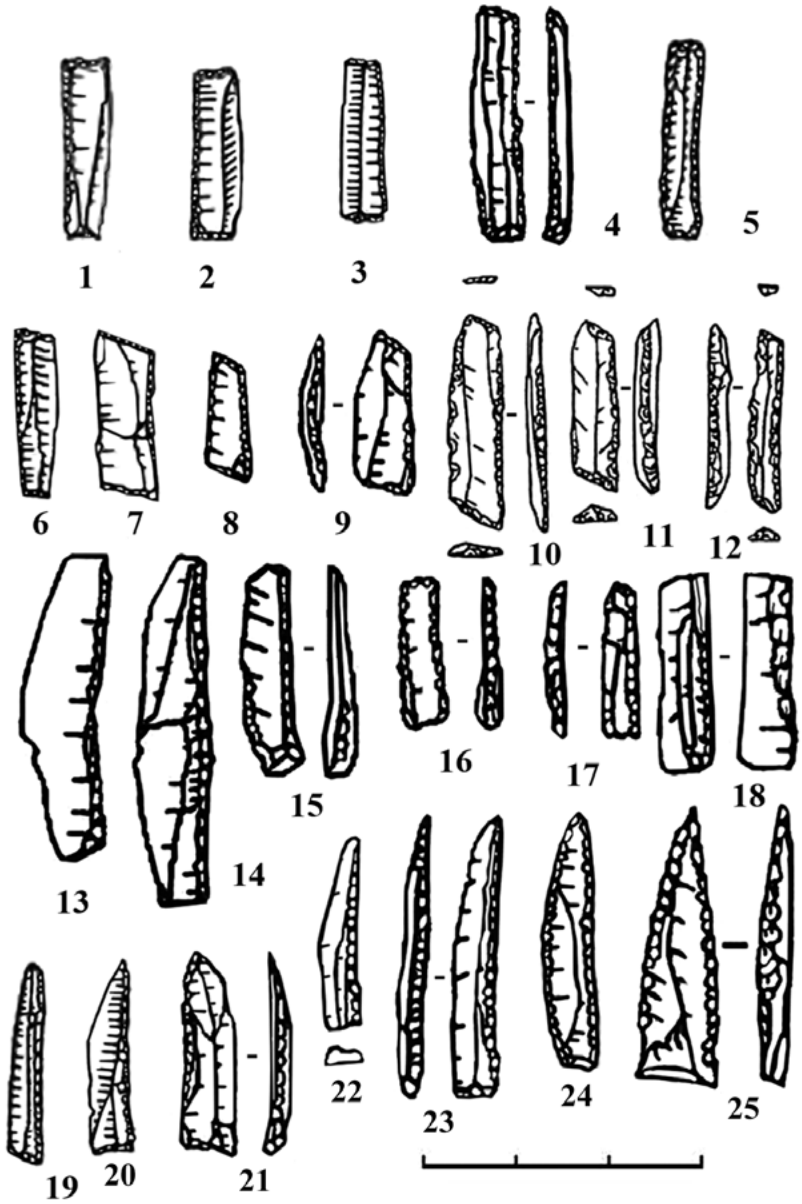

Figure 3. Geometric microliths and retouched tools on bladelets from layer 2 in Kamennaya Balka II (1-9, 13-25) and layer 2 in Tretiy Mys (10-12), representing the middle stage (18/17-16/15 ka) of the Kamennaya Balka culture. Modified after (Leonova *et al.* 2015: fig. 10; Simonenko and Khaikunova 2017: fig. 3; Leonova and Vinogradova 2018: fig. 3). Scale bar = 1 cm.

The personal decorations found in Kamennaya Balka II, layer 2 include only pierced shells of gastropods (Figure 6 – 4). However, bone awls and possible fragments of points with a rounded cross-section (Figure 6 – 1-3) are found in the Tretiy Mys site (lower layer), which is compared with layer 2 in Kamennaya Balka II (Simonenko, Khaykunova 2017).

The latest stage of of the Kamennaya Balka culture is represented by the upper layer in Tretiy Mys and layer 1 in Kamennaya Balka II (Simonenko and Khaykunova 2017). The lithic assemblage from layer 1 in Kamennaya Balka II is characterized by the higher percentage of tools (11.6%) than in layer 2 (6-8%). Burins prevail (23.8%), followed by end-scrapers (18.5%), retouched flakes (15.2%), and backed micro-bladelets (10.7%). Burins on retouched truncation prevail among burins (Figure 5 – 8-10), and there are rare double burins (Figure 5 – 8, 10). End-scrapers on flakes prevail among end-scrapers (Figure 5 – 14, 15, 17), and also there are many double end-scrapers (Figure 5 – 11-13). Denticulates (7.3%), truncations on blades (3.2%; Figure 5 – 7), and rare awls, pièces esquillées and composite tools (Figure 5 – 16) are also represented. Rare points (2%; Figure 5 – 5, 6) are dominated by symmetrical points with one or two edges formed with blunt retouch prevail. Also, there are rare rectangles (Figure 5 – 4), for which ventral retouch of ends is characteristic (Figure 5 – 1, 2).

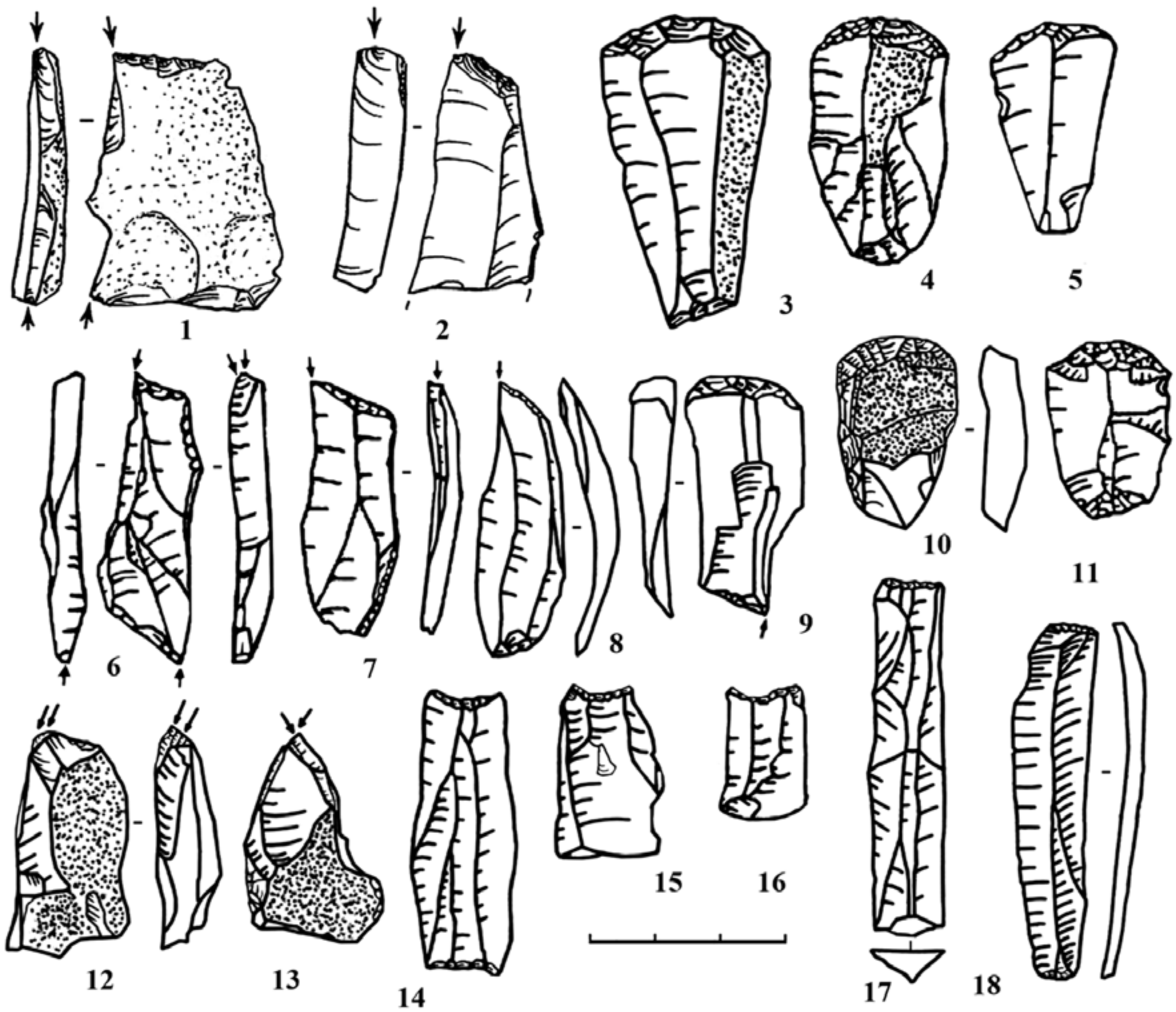

Figure 4. End-scrapers (3-5, 9-11), burins (1, 2, 6-8, 12, 13) and truncations on (14-18) from layer 2 in Kamennaya Balka II (3-18) and layer 2 in Tretiy Mys (1, 2), representing the middle stage (18/17-16/15 ka) of the Kamennaya Balka culture. Modified after (Leonova *et al.* 2015: fig. 10; Simonenko and Khaikunova 2017: fig. 3; Leonova and Vinogradova 2018: fig. 3). Scale bar = 1 cm.

Researchers of the Kamennaya Balka sites underline proximity of the lithic assemblages of all three stages, combining them into the Kamennaya Balka culture, and also note specific characteristics of each stage. Also, the researchers note similarities between the Kamennaya Balka II, layer 2 assemblage, representing the middle stage of the Kamennaya Balka culture, and the Upper Palaeolithic sites located to the west, such as Fedorovka (layers 1 and 2) and Yanisol (Figure 1). The inhabitants of the Kamennaya Balka sites used flint from sources also located 80-150 km to the west from the sites, near the town of Lysogorka and in the Krynka River (a small tributary of Mius River).

3.1 Chronology and characteristics of lithic assemblages in the North-Western Caucasus

In the NW Caucasus, the final of the Upper Palaeolithic is represented by more than 10 sites. We define this period as the 'Epipalaeolithic' by analogy with the Near East, because the Caucasian assemblages dating to this time have numerous analogies, noted by many researchers, among the Epipalaeolithic sites of the Near Easter region. The Epipalaeolithic sites in the NW Caucasus are spread from foothills to the mid-mountain zone in the Kuban River basin (Figure 1). Modern research indicates that the Epipalaeolithic sites of the NW Caucasus are dated in the range from 17 to 10 ka cal BP, based on radiocarbon dates reported for seven sites (Table 2). The Epipalaeolithic

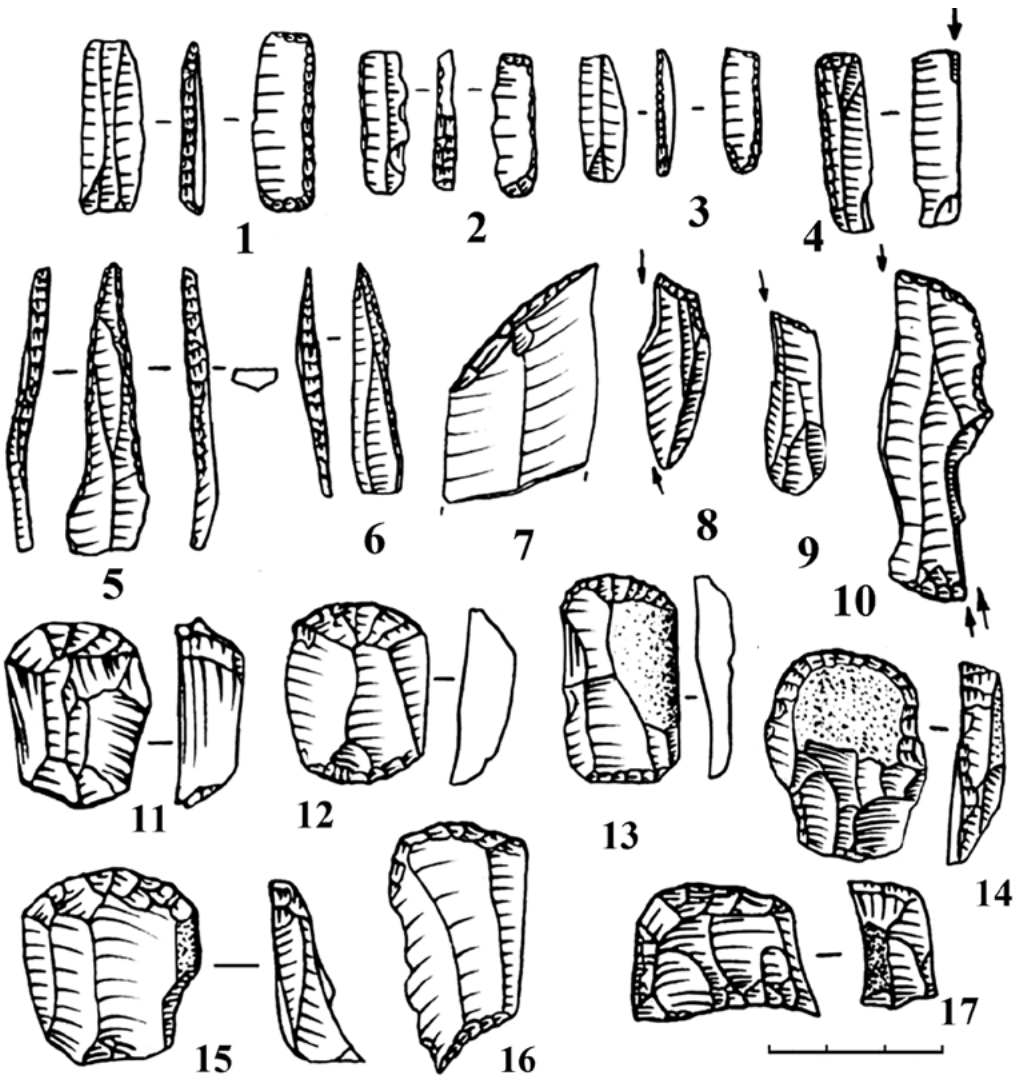

Figure 5. Retouched tools from layer 1 in Kamennaya Balka II, representing the late (15-14/13 ka) stage of the Kamennaya Balka culture. Modified after (Medvedev 2014). Scale bar = 1 cm.

industry of this region is subdivided to the middle (17–13/12 ka cal BP) and late (13/12–10 ka cal BP) stages.

Modern research (Golovanova and Doronichev 2012; Golovanova *et al.* 2014) indicates that the Epipalaeolithic industry of the NW Caucasus is characterized by a highly developed bladelet technology. In factually all Epipalaeolithic assemblages, exept collections from old excavations made without modern excavation techniques, such as water-screening and detailed stratigraphic control, laminar blanks (blades, bladelets and micro-bladelets) prevail over flakes (Table 3). This indicates that the percentage of laminar products and especially the microlithic component (bladelets and micro-bladelets) is greatly influenced by the excavation technique. Also, economic specialization and location of sites relative to raw material sources have to be taken into consideration.

A detailed analysis of micro-blade flaking technology in Mezmaiskaya, layer 1-3 (Nedomolkin 2017, 2019) allows us to draw some preliminary conclusions. The flaking technology is aimed to the production of bladelets and narrow blades with width 5-15 mm from predominantly unipolar and more rare bipolar cores with platform angle about 90°, and using characteristic core trimming elements.

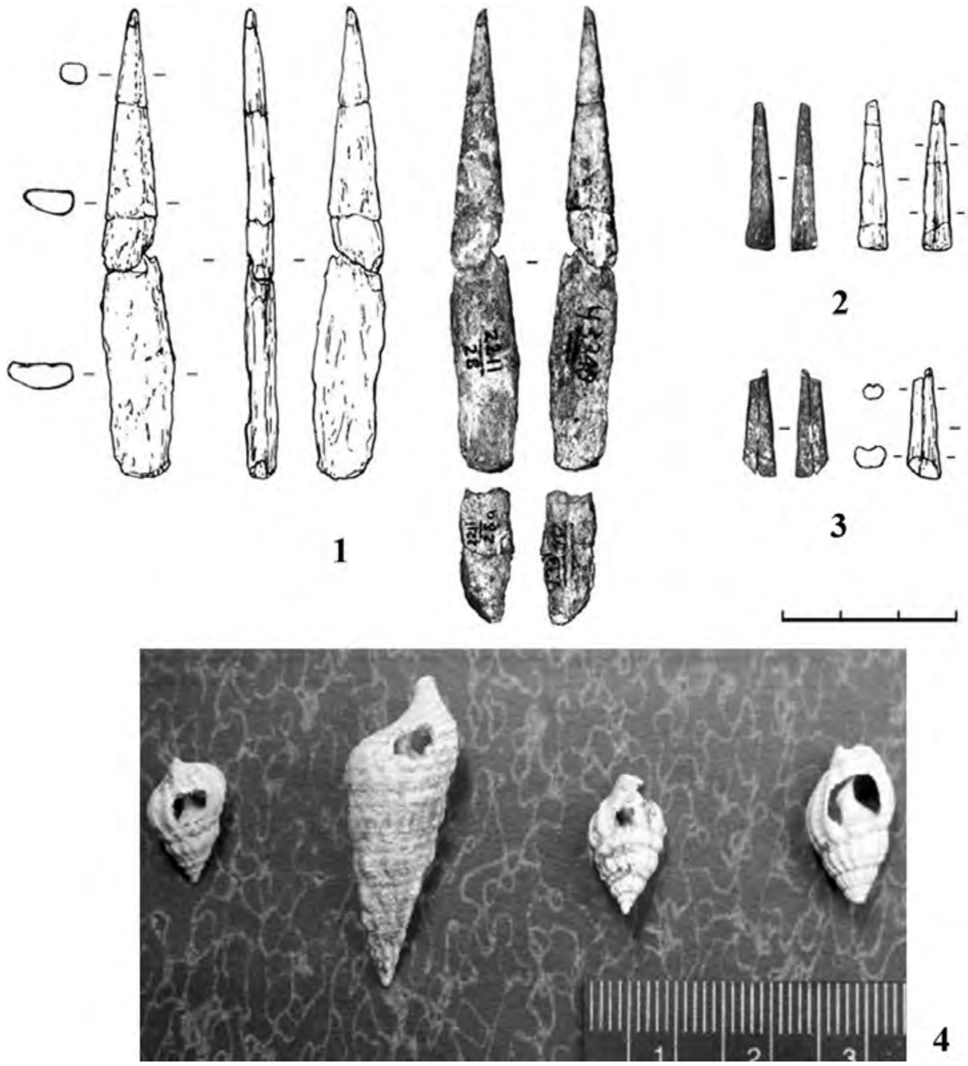

Figure 6. Bone tools from layer 2 in Tretiy Mys (1-3) and pierced shells from layer 2 in Kamennaya Balka II (4), representing the middle stage (18/17-16/15 ka) of the Kamennaya Balka culture. Modified after (Leonova *et al.* 2015: fig. 9; Simonenko and Khaikunova,2017: fig. 1). For drawing scale bar = 1 cm, for photo scale bar = 1 mm.

Analysis of metric and morphological parameters of laminar blanks indicates the predominance of punctiform (32.6%) and flat (62.0%) striking platforms, with width varying from 0.5 mm to 17 mm, although most of the blanks (83%) have width 2-8 mm. The platform depth ranges from 0.4 mm to 6.5 mm, although 75% of the blanks have depth 1-3 mm. Also, the overwhelming majority of the blanks (86%) are characterized by unidirectional parallel removals on the dorsal surface. The blanks with straight profile prevail (61.9%), while blanks with slightly curved profile are more rare (26%). The blanks with triangular (51.3%) or trapezoidal (48.6%) cross-section are almost equally represented. Most of blanks have a feather-like ending (78.5%) and a ventral cornice or 'lip' (62.0%). Also, cornice reduction and abrasion of the edge of the striking platform are defined on 82.6% of the blanks.

Most of the laminar blanks analyzed in Mezmaiskaya, layer 1-3 correspond to the parameters that are characteristic to experimental laminar blanks produced by the pressure technique (see Volkov and Girya 1990; Poplevko 2007; Pelegrin 2012; Pavlenok and Pavlenok 2014). Also, the presence of rare blades with width >15 mm and thickness >6 mm in Mezmaiskaya, layer 1-3 suggests a combination of direct percussion and pressure techniques. In general, the results suggest that in Mezmaiskaya, layer 1-3 the hand pressure technique was used for production of bladelets and

Assemblage	Age ^{14}C (yr BP)	Lab. No.	Method	Calendric Age (yr cal BP)	Source
Mezmaiskaya, Layer 1-3, hor. 1	10400 ± 150	SPb–1117	^{14}C	12255 ± 278	Golovanova et al., 2006, 2014
Mezmaiskaya, Layer 1-3, hor.3	12960 ± 60	GrA–25965	AMS	15782 ± 402	
Mezmaiskaya, Layer 1-3, hor. 9	12953 ± 150	SPb–1215	^{14}C	15773 ± 483	
Mezmaiskaya, L. 1-3	13860 ± 70	GIN–12900	^{14}C	17092 ± 190	
Kasojskaya, L. 4, hor. 1	10400 ± 340	LE–4987	^{14}C	12084 ± 507	Golovanova et al., 2014
Kasojskaya, L. 4, hor. 3	10550 ± 130	SPb–130	^{14}C	12428 ± 222	
Kasojskaya, L. 4, hor. 4	11000 ± 150	SPb–128	^{14}C	12937 ± 142	
Kasojskaya, L. 4, hor. 5	14050 ± 100	SPb–129	^{14}C	17297 ± 229	
Chygai, L. 4 base	9560 ± 100	Ki–13465	^{14}C	10912 ± 167	Leonova, 2014, 2015
Chygai, contact layers 4 and 5	10545 ± 120	LE–8315	^{14}C	12431 ± 215	
Chygai, Layer 5	10300 ± 130	LE–8313	^{14}C	12121 ± 308	
Chygai, layers 4-7	11060 ± 190	LE–8314	^{14}C	13000 ± 186	
Chygai, Layer 9	12983 ± 339	NskA–100	AMS	15716 ± 717	
Chygai, layers 9-13	13250 ± 500	LE–8317	^{14}C	15970 ± 809	
Chygai, Layer 13	13522 ± 4857	NskA–99	AMS	15981 ± 5861	
Dvoinaya, test pit, middle levels	8330 ± 70 8880 ± 60	Ki–14484 Ki–14485	^{14}C	9329 ± 99 9998 ± 129	
Dvoinaya, test pit, lower level	10240 ± 250	Ki–14486	^{14}C	11961 ± 454	
Dvoinaya, Layer 6	8980 ± 280* 10020 ± 160 11830 ± 160	GIN–14704 GIN–14706 GIN–14703	^{14}C	10100 ± 371 11630 ± 291 13761 ± 225	
Satanai, human tibia	9950 ± 500	SPb–254	^{14}C	11531 ± 747	Doronicheva, Golovanova, 2016
Satanai, Layer 2b	11200 ± 110	Ki–14280	^{14}C	13092 ± 142	Aleksandrovskiy et al., 2015
Satanai, hor. 3 (= L. 2b)	11140 ± 100	SPb–132	^{14}C	13040 ±148	Golovanova et al., 2014
Satanai, hor. 4 (= L. 2b)	11200 ± 130	SPb–131	^{14}C	13094 ± 157	
Besleneevskaya, L. 2B	13200 ± 400	SPb–493	^{14}C	15987 ± 689	First pulication
Last Glacial Maximum				25500–18500	

Table 2. Radiometric estimates for the Epipalaeolithic sites
in NW Caucasus.

micro-bladelets, and the direct percussion technique using a soft organic hammer was used for production of large blades. The conclusion about the early appearance of the pressure technique already in the Epipalaeolithic of the NW Caucasus, about 16-15 kyr BP, is supported by finds of flakes and cores with morphological features typical for the pressure technique in some Epipalaeolithic sites in this region (see Es'kova *et al.* 2018).

Assemblage, Age (yr cal BP)	Core types (% to total cores)		Total cores n	Ilam[6]	Laminar blank types (% to total laminar blanks)		Total artifacts n
	Prismatic[1]	Narrow-fronted			Blades	Bladelets & micro-bladelets	
Mezmaiskaya, 1-3 top[2] 12500–12000				78,7	24,1	75,9	339
Mezmaiskaya, 1-3[4] 17300–12000	prevail		21	75,5	18,9	81,1	9881
Kasojskaya, hor. 3-6 12650–12200	prevail		41	61,8	22,8	77,2	3757
Satanai, hor. 3, 4 13250–12900	prevail		136	52,4	44,9	55,1	3351
Dvoinaya, 6, 7 14000–11300	prevail					prevail	>7000[3]
Chygai, 9-14 16500–14600	prevail					prevail	3000[3]
Badynoko, 7.4 15300–14600			13	75,4	3,8	96,2	855
Gubs 1, 2 undated, c. 12900–11700			41	42,0	7,4	92,6	1347
Baranakha 4, 1A c. 14700–12900	+	prevail	19	36,5	35,2	64,8	564
Baranakha 1, undat., c. 14700–12900			8	48,8	46,0	54,0	246
Yavora, undated			7	44,5	49,8	50,2	901

Table 3. The Epipalaeolithic assemblages of the NW Caucasus (technology). Prevailing types of cores and laminar blanks are highlighted. For references see citations in the text. Notes to Table 3:

[1] Including conical cores identified in Dvoinaya, Badynoko; semi-prismatic, semi-pyramidal and semi-conical cores at Badynoko.

[2] The assemblage from Layer 1-3 top at Mezmaiskaya includes artifacts from the uppermost level 1-3/breccia contact horizon and horizon 1 from the 2009 and 2014 excavations.

[3] The total number of lithic artifacts from Dvoinaya Cave and Gubs 5 (Chygai) rockshelter not counts micro-lithics recovered from wet-sieving.

[4] The number of artifacts including tools analyzed in this study from the 2009 and 2014 excavations of Layer 1-3 is indicated in parentheses.

Most of the Epipalaeolithic assemblages in the NW Caucasus contain a large proportion of backed pieces made mainly on bladelets (Table 4). The most important tool groups are points and geometric microliths, although the percentage of these tools varies greatly.

The Epipalaeolithic assemblages in the NW Caucasus are characterized by diverse straight backed points (Table 5), including varieties of Gravette (Figure 8 – 1-5, 7, 8, 10, 11), micro-Gravette (Figure 8 – 9) and Vachons types (Figure 8 – 6, 12-14), all these point types are made mainly on bladelets or micro-bladelets, and rarely on small blades. The Gravette and micro-Gravette points are known in many Upper Palaeolithic sites in the Caucasus, thus representing the tools that define specifics of the Caucasian region through the entire duration of the Upper Palaeolithic–Epipalaeolithic, while Vachons points appear and are wide spread during the Epipalaeolithic. Also, many assemblages include points with retouched symmetrically converging lateral sides (Figure 8 – 17, 18), as well as backed points with obliquely retouched ends (Figure 8 – 15, 16) are noted in some sites.

The presence of rare shouldered points is a characteristic feature of the Epipalaeolithic industry in the NW Caucasus. The most diagnostic point type is the specific shouldered point called the 'Imeretian type' point (Golovanova *et al.* 2014). According to Golovanova and co-author's (2014: p. 221; with some modification), the Imeretian type point can be described as an elongated shouldered point made on bladelet or narrow blade, with an asymmetric and short tang formed by abrupt dorsal retouch on the base, and a tip pointed preferentially from one lateral edge by continuous or partial dorsal retouch. The specimens from the Northern Caucasus include 8 typical points from

Industry, Age (yr cal BP)	Points on bladelets/ blades	Geo-metrics	Backed pieces	Retouched bladelets/ blades*	End-scra-pers	Bu-rins	Other tools	Total tools
Mezmaiskaya, 1-3 top 12500–12000	3 Gravette/micro-Gravette	7 (16.8%)	5 (10%)	3	8	–	20	46
Gubs 1, 2 undated, c. 12900–11700	6 Gravette, 1 Vachons, 1 shouldered	–	12	1/1	7	2	23	54
Kasojskaya, 3-6 12650–12200	14 Gravette, 4 Vachons, 8 shouldered	–	49	12	10	9	50	156
Dvoinaya, 6, 7 14000–11300	Gravette, 1 shouldered	>50 in L.6; 2 in L.7	+	many	prevail	+	?	?
Gubs 7 (Satanai), 3 13250–12900	1 Gravette, 2 shouldered	9	33	18+47 denticulates	74	41	10	235
Baranakha 4, 1A c. 14700–12900	5 Gravette, 2 shouldered, 1 symmetrical	2	17	3	13	4	9	56
Baranakha 1 undat., c. 14700–12900	12 Gravette, 3 Vachons, 2 shouldered	1	5	13+ 3 truncations	13	1	18	71
Mezmaiskaya, 1-3 17300–12900	12.7% of tools: 59 Gravette, Vachons; 5 shouldered	73 (6.7%)	135 (20.9%)	44	55	10	242	623
Gubs 5 (Chygai), 9-14 16500–15000	Gravette	+	many	prevail	?	?	?	?

Table 4. The Epipalaeolithic industry of the Northern Caucasus (typology). For references see citations in the text. Note to Table 4:

* Including truncated bladelets and blades

(+) means the tool type is reported but the number of tools is unknown.

Assemblage, Age (yr cal BP)	Shouldered points		Gravette, micro-Gravette/ Vachons	Symmetrical retouched	Other types	Total
	Imeretian type	Other varieties				
Mezmaiskaya, Layer 1-3 17300–12000	5	–	62 inc. Vachons	2	17	86
Dvoinaya, layers 6, 7 14000–11300	1	–	+/+	+		?
Chygai, layers 9-14 16500–14600	–	–	+/+	+		?
Gubs 7, horizons 3, 4 13250–12900	2	–	2/–	2	–	6
Gubs 1, Layer 2 undated, c. 12900–11700	–	1	6/1	–	2	10
Kasojskaya, horizons 3-6 12650–12200	8	–	14/3	–	–	25
Yavora, undated	–	1	–/2	–	–	3
Baranakha 4, Layer 1A c. 14700–12900	2	–	5/–	3	2	12
Baranakha 1, undated c. 14700–12900	2	–	12/3	–	–	17

Table 5. Distribution of point types in the Epipalaeolithic sites in the NW Caucasus. For references see citations in the text.

Layer 1-3 (all years of excavation) at Mezmaiskaya (Figure 7 – 1-7), 8 points from Kasojskaya (Figure 7 – 8-12), 2 points from Baranakha 4 (Figure 7 – 15, 16), 2 points from Baranakha 1 (Figure 7 – 14) and Dvoinaya Cave, layers 6 – 7 (Figure 7 – 13).

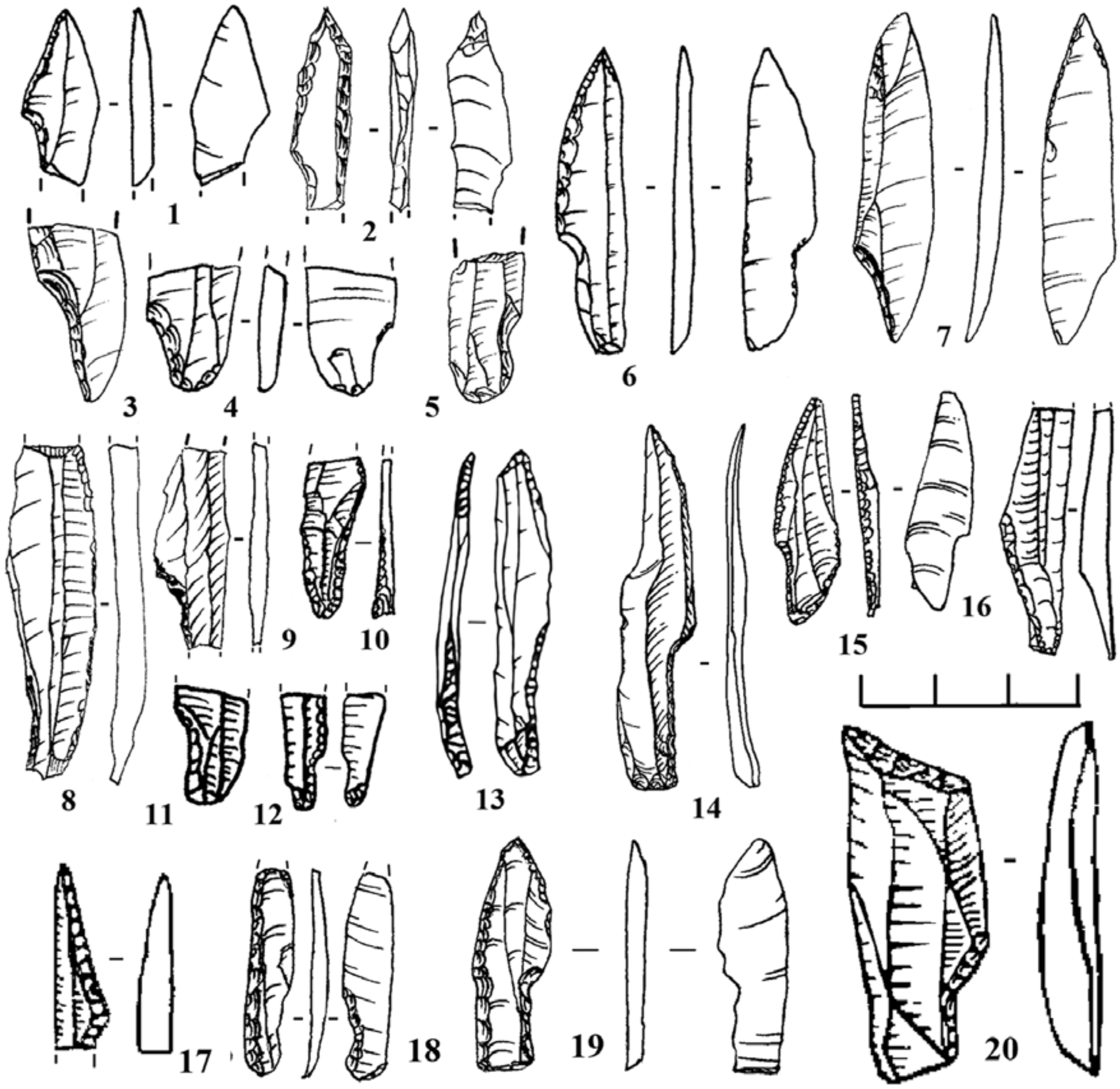

Figure 7. Shouldered points from the Epipalaeolithic sites in the North-Western Caucasus. 1-7 Mezmaiskaya cave, layer 1-3; 8-12 Kasojskaya cave, horizon 3; 13 Dvoinaya cave, layer 7; 14 Baranakha 1; 15, 16 Baranakha 4, layer 1A; 17 Gubs rockshelter 1, layer 2; 18, 19 Gubs rocksheter 7 (Satanai), horizon 3; 20 Yavora. The drawings 1-12, 14-20 – by L. Golovanova; 13 – after Aleksandrova and Leonova 2017: fig. 1. Scale bar = 1 cm.

It should be noted also other special forms of shouldered points, which are found in some assemblages representing the latest stage (12/13–10 ka cal BP) of the Epipalaeolithic in the NW Caucasus. These are two points from Satanai, horizon 3 (Figure 7 – 18, 19). Also, the point from Yavora is similar to Hamburginian points (Figure 7 – 20). The Yavora site has no absolute dates, but the finding of such point suggests possible final Epipalaeolithic age of the assemblage. Also, a point similar to 'pointe á cran Méditerranéenne' (see Demars and Laurent 1992: p. 142-143) is found in layer 2 in Gubs rockshelter 1 (Figure 7 – 17) and also suggests the late age of this assemblage.

This review shows that the backed and retouched points known in the Epipalaeolithic sites in the Caucasus are quite diverse, which can be explained partly by their different ages. Obviously, only new data will allow to define more convincingly peculiarities of these important tool forms in different stages of the Epipalaeolithic in the region.

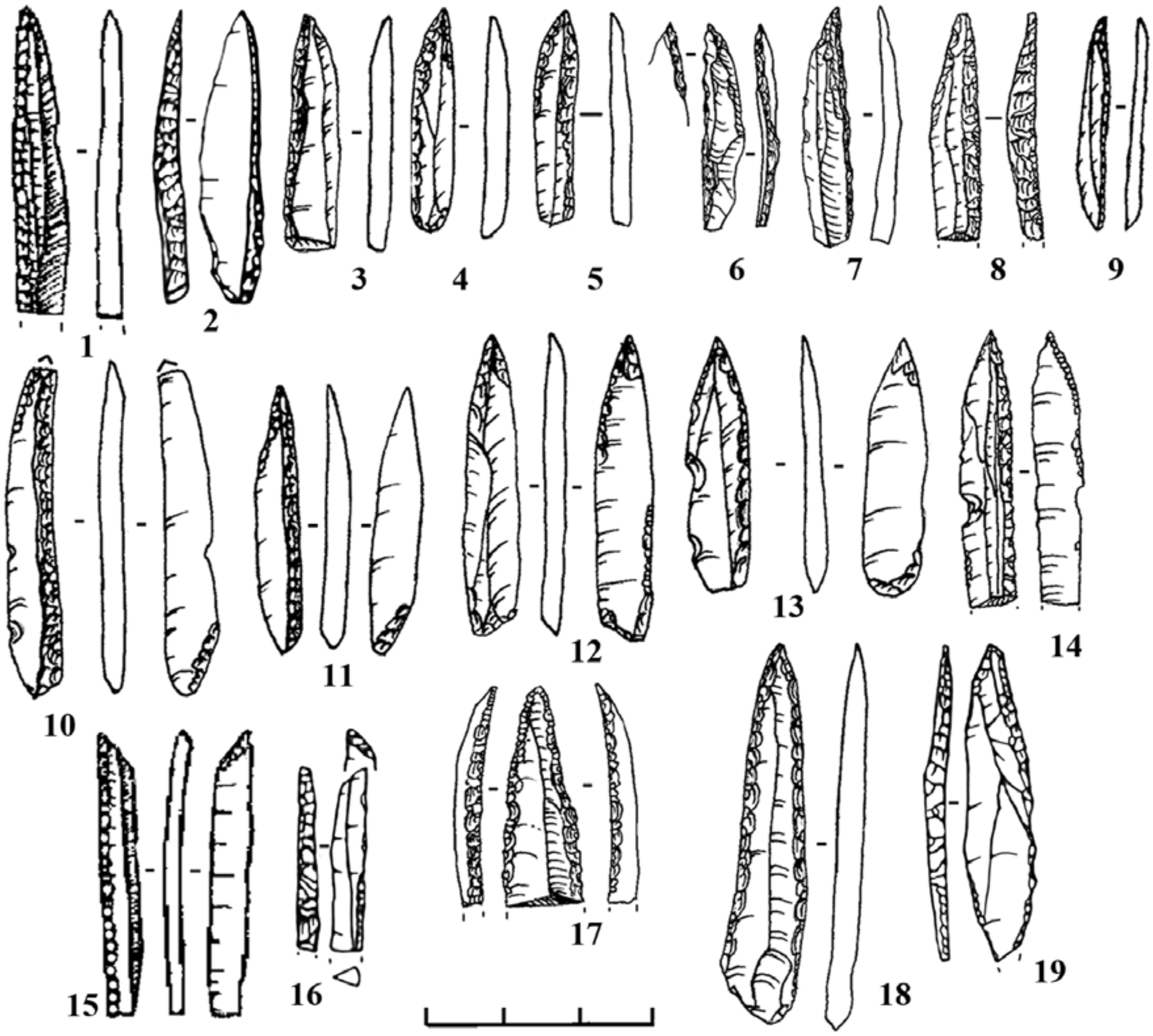

Figure 8. Points from the Epipalaeolithic sites in the North-Western Caucasus. 1, 15 Gubs rockshelter 1, layer 2; 2, 16, 19 Dvoinaya cave, layer 7; 3, 4, 9-13 Mezmaiskaya cave, layer 1-3; 5, 18 Gubs rocksheter 7 (Satanai), horizon 3; 6, 7 Baranakha 1; 8, 14 Kasojskaya cave, horizon 3; 17 Baranakha 4, layer 1A. The drawings 1, 3-15, 17, 18 – by L. Golovanova; 2, 16, 19 – after (Aleksandrova and Leonova 2017: fig. 1). Scale bar = 1 cm.

The Epipalaeolithic industry of Caucasus shows the early appearance of variable geometric microliths, including segments, trapezes, isosceles triangles, scalene triangles, and rectangles (Table 6). Recent studies indicate that the earliest geometric microliths (rectangles and scalene triangles) are found in the Southern Caucasus in layers BII-BIII in Satsurblia cave, which are dated to 24/23–21/20 ka.

In the NW Caucasus, the early stage is not represented at present, and the Epipalaeolithic begins with the middle stage. The most typical types of geometric microliths in this stage are rectangles (Figure 9 – 18-20), scalene triangles (Figure 9 – 22, 23) and lunates (Figure 9 – 1-4). Large segments made on bladelets are also found in assemblages dating to the late stage of the Epipalaeolithic, including Dvoinaya cave, layers 4-6 (Figure 9 – 5-7) and Satanai, horizon 3 (Figure 9 – 8).

The peculiarity of the middle Epipalaeolithic stage in the Northern Caucasus is the appearance of trapezes that are not represented during this period in the Southern Caucasus. These are simple low trapezes made on fragments of bladelets, with oblique truncations on both ends (Figure 9 – 11-14). For example, in Mezmaiskaya such trapezes are found in the lower horizons

Site, unit, age (yr cal BP)	Segment (lunate)	Trapeze	Rectangle	Isosceles triangle	Scalene triangle	Total
Dvoinaya, layers 4, 5 10500–9200	+	+ horned trapezes	–	–	–	?
Gubs 7 (Satanai), Hor. 3 13250–12900	2+1 Helwan	5+1 horned trapeze	–	–	–	9
Mezmaiskaya, L. 1-3 top 12500–12000	1	1 horned trapeze	–	1	–	3
Mezmaiskaya, Layer 1-3 17300–12900	55	7	6	2	–	70
Dvoinaya, Layers 6, 7 14000–11300	>50 in L.6; 2 in L.7	+	+ in L.7	–	+ in L.7	>55
Baranakha 4, 1A undated, c. 14700–12900	1	1	1	–	–	3
Baranakha 1, undated, c. 14700–12900	–	–	1	–	–	1
Yavora, undated	–	–	2	–	–	2
Gubs 5 (Chygai), 9-14 16500–15000	–	–	+	–	+	?

Table 6. Distribution of geometric microliths in the Epipalaeolithic of the NW Caucasus. For references see citations in the text.

9 and 8 of layer 1-3, in the area with well preserved charcoal levels and without evidence of erosional disturbance.

In the late stage of the Epipalaeolithic, low trapezes are also present, alongside with a new type of so called 'horned trapezes' found in the top horizons of layer 1-3 (12,500-12,000 yr BP) in Mezmaiskaya (Figure 9 – 15), horizon 3 (13,250-12,900 yr BP) in Satanai (Figure 9 – 26), and layers 4, 5 (10,500-9,200 yr BP) in Dvoinaya cave (Figure 9 – 16, 17, 25). Also, one Helwan lunate (Figure 9 – 10) is found in Satanai, horizon 3, dated to ca. 13 ka cal BP, and this is the earliest example of this tool known in the Caucasus. However, in the Near East, Helwan lunates appear earlier than in the Caucasus. The earliest Helwan lunates are found in the Natufian layers in el-Wad Terrace (Mount Carmel, Israel) dated to 15 ka (Weinstein-Evron *et al.* 2018) and the Mushabian industry (also in Israel) dated to ca. 17 ka (Belfer-Cohen and Gorring-Morris 2014).

The common feature of all Epipalaeolithic assemblages in the NW Caucasus is the predominance of end-scrapers over burins. In most of the assemblages, simple end-scrapers made on complete and broken blades (Figure 10 – 14-16), sometimes with retouched lateral sides (Figure 10 – 11, 12), are well represented, as well as rare scrapers on flakes (Figure 10 – 10), thumbnail and rounded scrapers (Figure 10 – 8, 9), and more rare carenated scrapers are present. Also, very rare micro-scrapers made on backed bladelets (Figure 10 – 3, 4) are found only in the Epipalaeolithic in the NW Caucasus.

Burins are rare in factually all Epipalaeolithic assemblages in the NW Caucasus. Variable types of burins are represented: angle burins on break, burins on retouched truncation (Figure 10 – 22) and dihedral burins (Figure 10 – 21), and rarer multifaceted (Figure 10 – 20) and double burins.

Also, a characteristic feature of the Epipalaeolithic industry of the NW Caucasus is the appearance of abundant denticulated tools that are virtually absent in the earlier Upper Palaeolithic industry of this region. The denticulated tools are reported in factually all Epipalaeolithic assemblages in the NW Caucasus (Figure 10 – 18, 19), but the percentage of these tools varies greatly. Apparently, this variation may be partly related to economic specialization of some sites. For example, a very low percent of denticulated tools in th Baranakha 4, layer 1A and Yavora sites may be explained by that both are open-air sites, which were likely used as seasonal or short-term hunting camps in high mountains.

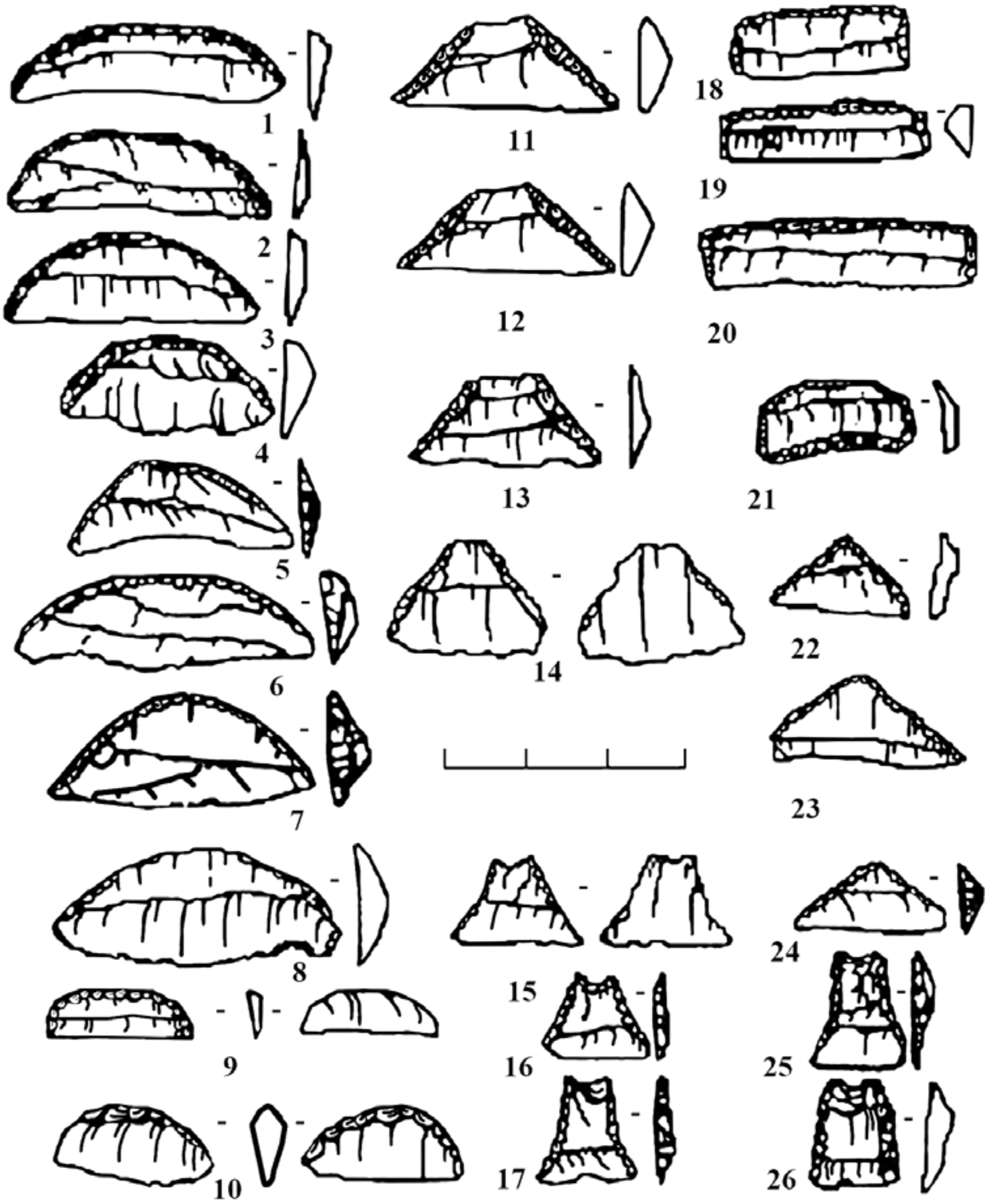

Figure 9. Geometric microliths from the Epipalaeolithic sites in the North-Western Caucasus. 1-3, 11-15, 18, 22, 23 Mezmaiskaya cave, layer 1-3; 4, 21 Baranakha 4, layer 1A; 6, 7 Dvoinaya cave, layer 6; 8-10, 26) Gubs rocksheter 7 (Satanai), horizon 3; 5, 16, 17, 24, 25) Dvoinaya cave, layers 4-5; 19 Yavora; 20 Dvoinaya cave, layer 7. The drawings 1-5, 8-15, 18, 19, 21-23 – by L. Golovanova; 6, 7 – after (Aleksandrova and Leonova 2017: fig. 2); 5, 16, 17, 24, 25 – after (Leonova and Aleksandrova 2012: fig. 3); 20 – after (Aleksandrova and Leonova 2017: fig. 1). Scale bar = 1 cm.

Most of the Epipalaeolithic assemblages also contain other tool types, of which the most common are oblique truncations on bladelets (Figure 10 – 5, 7) and rarely on blades (Figure 10 – 6). Also, very rare bladelets with ventral retouch and composite tools (Figure 10 – 13, 17) are found.

3.2. Organic artifacts and personal ornaments in the Epipalaeolithic of the NW Caucasus

A significant advance of recent research is the discovery of a rich and varied set of bone tools, decorated bone artefacts and personal ornaments in the Epipalaeolithic assemblages postdating the LGM in the NW Caucasus (Golovanova *et al.* 2014). Bone points and awls are the dominant groups of bone tools in all sites (Table 7).

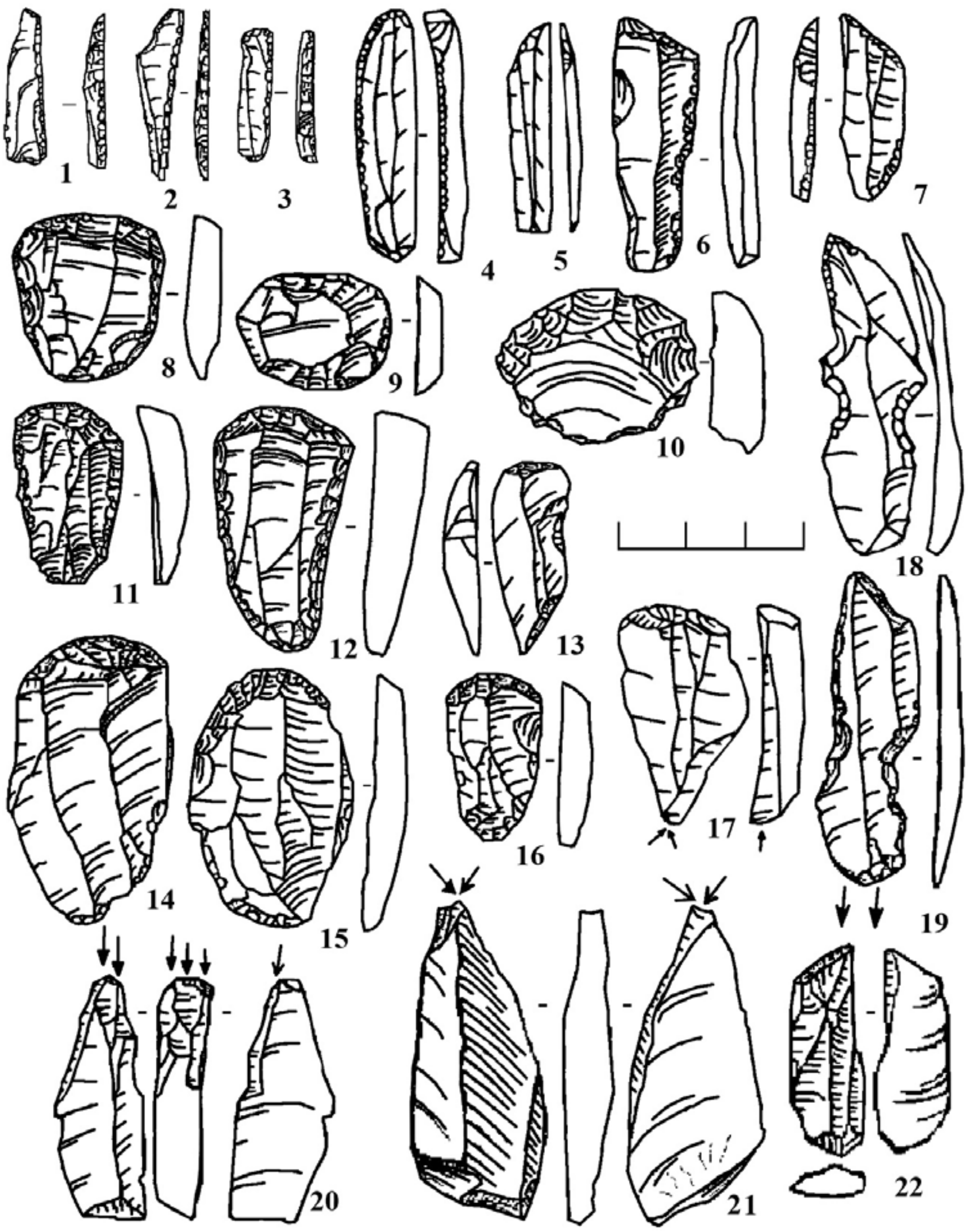

Figure 10. Retouched tools from the Epipalaeolithic sites in the North-Western Caucasus. 1, 3, 7, 9, 10, 14-16, 19, 20 Mezmaiskaya cave, layer 1-3; 2, 21) Kasojskaya cave, horizon 3; 4) Dvoinaya cave, layer 7; 5) Dvoinaya cave, layers 4-5; 6) Baranakha 1; 8, 12) Gubs rockshelter 7 (Satanai), horizon 3; 11) Baranakha 4, layer 1A; 13, 17) Gubs rockshelter 5 (Chygai), layers 10-14; 18) Dvoinaya cave, layer 6; 22) Yavora. The drawings 1-3, 6-12, 14-16, 19-22 – by L. Golovanova; 4, 18 – after (Aleksandrova and Leonova 2017: figs. 1, 2); 5, 13, 17 – after (Leonova and Aleksandrova 2012: figs. 1, 3). Scale bar = 1 cm.

Bone points. In Layer 1-3 at Mezmaiskaya Cave, all points are fragmented. There are 5 fragments of points with rounded cross-sections (Figure 11 – 3), and 4 fragments have flat-convex cross-sections (Figure 11 – 15). One point has two engraved incisions converging at the tip (Figure 11 – 14).

In horizon 9 of Layer 1-3 at Mezmaiskaya, there is also found a burnt fragment (37 x 11 x 10 mm) of bone point with two longitudinal deep grooves cut from two sides of the tool for mounting of microliths (Figure 11 – 16). The horizon has a radiocarbon date of 12,953 ± 150 14C BP (SPb-1215)

Industry/ Chronology (yr. cal BP)	Bone/antler tools			Decorations and ornamented pieces				Total
	point/ awl	needle	other	tooth	bone/ stone	shell	other	
Dvoinaya, 4, 5 10500–9200	4 w/ groove		1	few	-/1			?
Kasojskaya	2					3		2+3
Gubs 1, layer 2	1							
Dvoinaya, 6, 7 14000–11300	+	1		3	2/-	>10	parallel cuts	>20+ shells
Gubs 7, hor. 3, 4 13250–12900	few		+	1			bone fibula	?
Mezmaiskaya, 1-3 17300–12000	10/5, one w/ groove	8	12	4		many	parallel cuts	50+ shells

Table 7. The Epipalaeolithic industry of the NW Caucasus (organic artifacts and decorations). For references see citations in the text.

on wood charcoal, indicating the calendric age between 15,290-16,256 cal BP (68% range). This artifact is the oldest composite tool made from bone that is found in the Caucasus. This discovery suggests that usage of bone tools for mounting of lithic microliths appears in the region at about 16-15 ka cal BP, in the middle Epipalaeolithic. Also, a fragment of bone smoother made from a flat bone, heavily smoothed from one side (Figure 11 – 4), and 10 other bone tools are found in Layer 1-3 of Mezmaiskaya cave.

In the Epipalaeolithic level (horizon 3) of Layer 4 at Kasojskaya Cave, only two bone artifacts were found (Golovanova *et al.* 2014). They include a fragment of unfinished bone tool, probably point, and the tip fragment of point with rounded cross-section. The Epipalaeolithic assemblage from Layer 2 in Gubs 1 rockshelter includes only one published bone awl and probably a few bone points or awls (see Amirkhanov 1986) that are not published.

In Dvoinaya Cave, bone tools found in the upper layers 4-5 include an intermediate tool made from antler, four fragments of bone points with grooves, two of which have diagnostic impact fractures (Figure 11 – 17). In the lower layers 6 and 7, organic artifacts were found mostly in Layer 7 (Leonova El. 2014, 2015). In Layer 6, they include only a few fragments of bone points or awls. In Layer 7, a small fragment of bone artifact (probably point) has three parallel cuts made by a stone tool (Figure 11 – 13). In Gubs 5 (Chygai) rockshelter, bone tools were found in layers 8-14 (Leonova E. 2014, 2015). A small fragment of tool (probably point) made from antler is found in layers 10-14.

Ornamented bone points. In layer 7 in Dvoinaya Cave, it is found a large (11.2 cm in length) point made of long bone, slightly curved in profile, which is ornamented with three sets of short parallel incisions (from 42 to 45 incisions in each row) made by a stone tool along the entire length of the bone point (Figure 11 – 9). The specimen has a rounded cross-section at its distal tapered part and an oval cross-section at its basal part. In Mezmaiskaya, a complete (10.4 cm in length and 0.6 cm thick) double-pointed point with a weakly damaged base was found in 1993 in eroded sediments of lens Y, which was excavated near the cave wall and contained mixture of prevailing materials from Layer 1-3 with later (Holocene age) materials. The point (Figure 11 – 8) has a weakly curved profile, oval cross-section, and 16 rhythmic parallel cuts going across the tool. The point from Mezmaiskaya is similar to the point found in Dvoinaya Cave and appears to originate from the Epipalaeolithic Layer 1-3.

While many bone artifacts found in Gubs 7 (Satanai) rockshelter lack excavation horizon provenience (see Golovanova *et al.* 2014), most of them most likely originate from the Epipalaeolithic Layer.

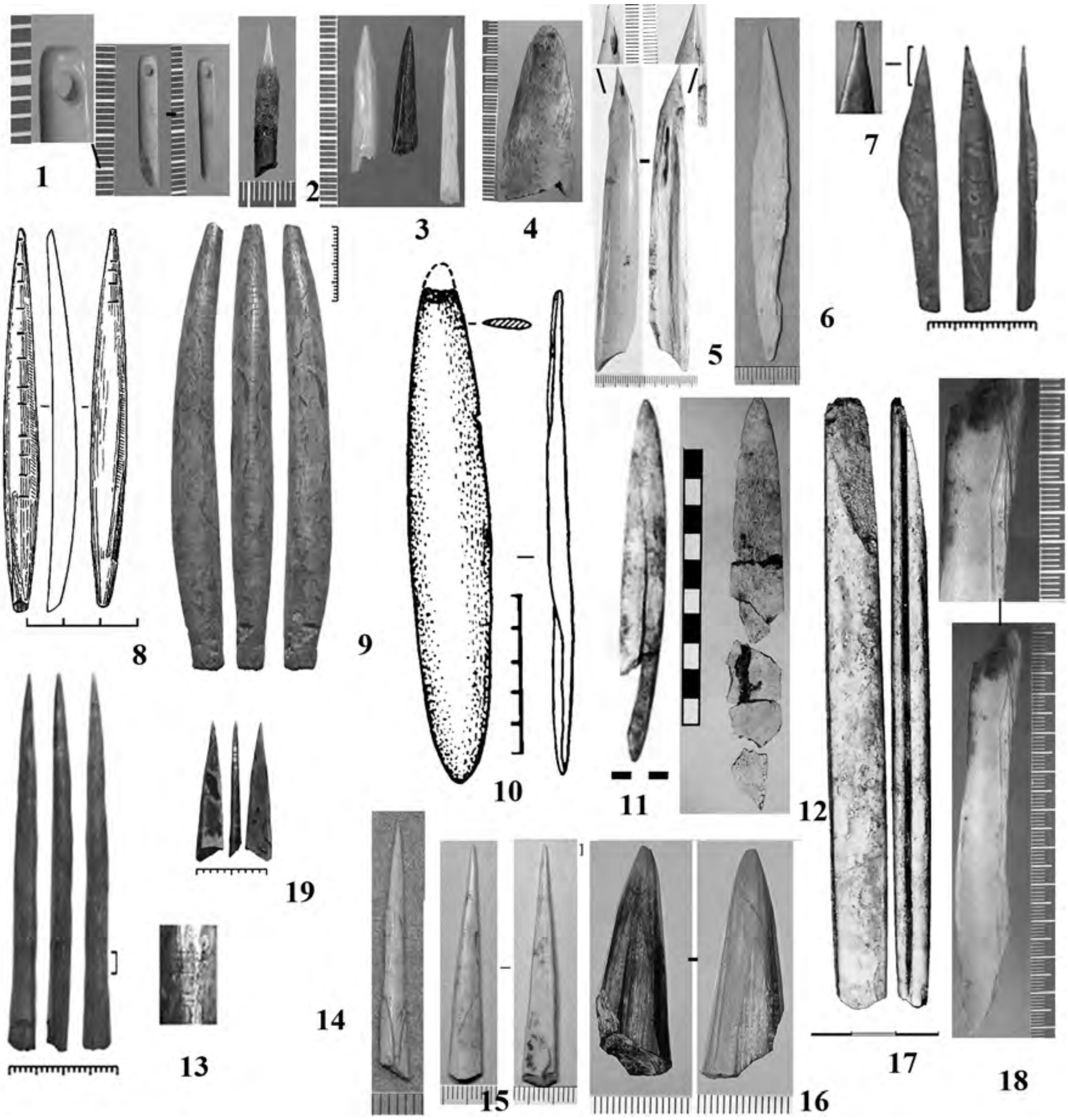

Figure 11. Bone tools from the Epipalaeolithic sites in the North-Western Caucasus. 1-6, 14-16, 18 Mezmaiskaya cave, layer 1-3; 8 Mezmaiskaya cave, lens Y; 7, 9, 13, 19 Dvoinaya cave, layer 7; 10-12 Gubs rockshelter 7 (Satanai); 17) Dvoinaya cave, layers 4-5. The photos 1-6, 11, 12, 14-16, 18 and drawing 8 – by L. Golovanova; drawing 10 – after (Amirkhanov 1986: fig. 23); photos 7, 9, 13, 17, 19 – after (Leonova and Aleksandrova 2012: fig. 2; Leonova 2014: fig. 2; Leonova *et al.* 2017). For images 1-7, 9, 13-16, 18, 19 scale bar = 1 mm; for images 8, 10-12, 17. Scale bar = 1 cm.

The bone artifacts include 11 projectile points (Figure 11 – 10-12). The bone points from Satanai represent the largest series of such tools ever found in a single Upper Palaeolithic–Epipalaeolithic site in the Caucasus. These bone tools were found nearby of human remains that likely represent a destroyed intentional human burial (see Amirkhanov, 1986, Doronicheva and Golovanova 2016). The human remains were directly dated to ca. 10.8-12.3 ka cal BP (68% range; Table 2). Basing on the exeptional preservation, unusually large amount of these artifacts, and their association with a probable intentional human burial, one can suggest that the bone points from Satanai may represent the artifacts that were specially placed together with the deceased, and which consequently may represent the oldest example of the 'burial inventory', known so far in the Caucasus.

Bone awls. In Layer 1-3 in Mezmaiskaya, there are found 5 bone awls, including two complete awls (Figure 11 – 5, 6) and two awl fragments, one of which is made from a flat bone. A micro-awl (Figure 11 – 2) is close in size to bone needles; however, only the tip of this tool is completely modified and polished while the base is unworked. In Dvoinaya Cave, bone awls (6 pieces) predominate in Layer 7 (Figure 11 – 7). All bone awls bear traces of wear (multiple linear striations and intensive polish) that indicate their use for working hide.

Bone needles. Of the 8 needle fragments found in Layer 1-3 in Mezmaiskaya cave, the basal fragment (Figure 11 – 1) has an eye heavily polished from use. In layer 7 in Dvoinaya Cave, there are two fragments of a needle-like point or a very large needle. Also, a bone needle with a broken eye was found in layers 8-14 in Gubs 5 (Chygai) rockshelter (Leonova 2014, 2015).

Pendants. In layer 1-3 in Mesmaikaya, there are 3 pendants made from caprid incisors (Figure 12 – 1-3), one of which has a suspension hole made with biconical drilling from both sides, and two pendants have broken suspension holes. One pendant is badly burned and has a suspension hole drilled from two sides (Figure 12 – 4). In Gubs 7 (Satanai) rockshelter, there is one pendant made from a horse incisor, with a slotted and then drilled suspension hole (Figure 12 – 7). In Dvoinaya Cave, a stone pendant with a suspension hole, which is made from a small flat pebble (Figure 12 – 9), and a tooth pendant with a broken suspension hole (Figure 12 – 8) are found in layers 4-5. In Layer 6, there are two pendants made from teeth ungulates, with holes for hanging, one of which has suspension hole drilled from two sides (Figure 12 – 5). The personal decorations found in Layer 7 include one pendant made probably from the upper incisor of a large predator (probably, cave bear), with hole for hanging drilled from two sides (Figure 12 – 6).

Beads. The personal decorations found in Layer 7 in Dvoinaya cave include two flat rounded stripe-beads made of bone, with a suspension hole in the center (Figure 12 – 11). In the lowest horizon of layer 1-3, it is found a bead made from a bird bone (Figure 12 – 12); its ends are cut off and the surface has traces of planing.

Shell beads. Numerous stripe-beads made from pierced shells of small terrestrial gastropods, Helicidae gen., Succinidae gen. (Succinaea sp.), and Pupillidae gen., are also present in Layer 1-3 at Mezmaiskaya. While most of these shells are broken into small or very small fragments, there are numerous complete shells with pierced holes (Figure 12 – 14). In the Epipalaeolithic level (horizon 3) of Layer 4 at Kasojskaya Cave, there are found three pierced shells (Figure 12 – 13) that are complete analogs of pierced shell beads from Layer 1-3 at Mezmaiskaya. In Dvoinaya Cave, more than 10 pierced beads made from shells of the river mollusc Theodoxus fluviatilis were found in layer 7 (Leonova, E. 2014).

Other decorations and ornamented artifacts from bone. In layer 1-3 in Mesmaikaya, one large long bone fragment (108 mm in length) has a linear engraving (Figure 11 – 18). Engraved lines are also present on two bone points. An unusual bone tool, which has the awl-like main part with a rounded cross-section, and the flat and rounded end, was found in Gubs 7 (Satanai) rockshelter. The tool was interpreted as barrette or 'fibula' (Figure 12 – 10).

3.3. Procurement of lithic raw materials in the Epipalaeolithic of the NW Caucasus

In Mezmaiskaya Cave, a petroarchaeological study (Doronicheva *et al.* 2013) indicates that a local bad quality Jurassic flint, which sources are known 2-3 km from the site, comprises only 2.8% of the lithic artifacts analyzed from the Epipalaeolithic Layer 1-3. Most artifacts are made from various high-quality flints transported from distant sources, mainly from Shakhan (21.2%) and Besleneevskaya (21.9%), located 30–40 km and 50-60 km from the site, respectively. The analysis suggests that knapping and production of tools made from these flints were partly performed in the site.

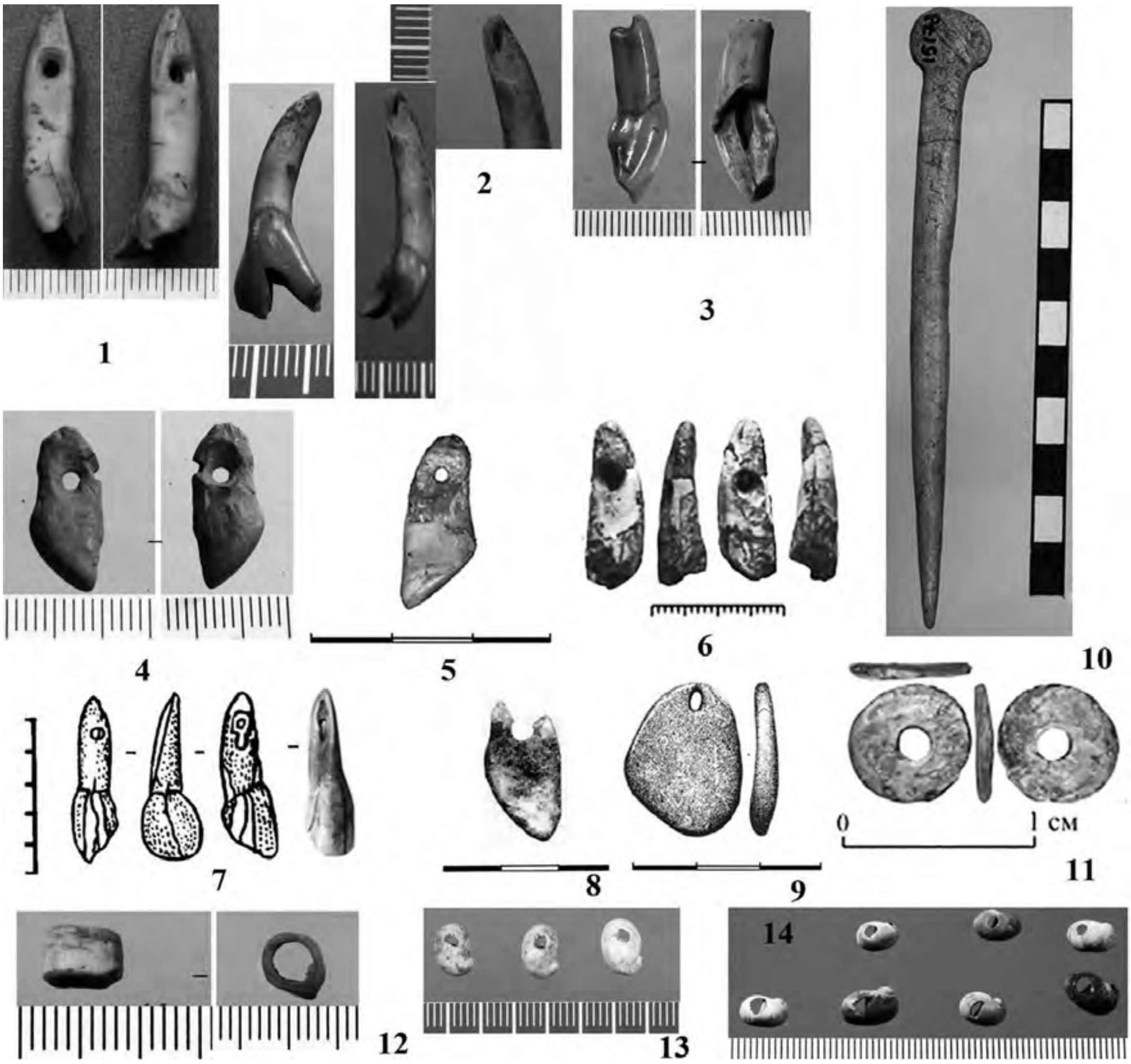

Figure 12. Personal decorations from the Epipalaeolithic sites in the North-Western Caucasus. 1-4, 12, 14 Mezmaiskaya cave, layer 1-3; 5 Dvoinaya cave, layer 6; 6, 11 Dvoinaya cave, layer 7; 7, 10 Gubs rockshelter 7 (Satanai); 8, 9 Dvoinaya cave, layers 4-5; 13 Kasojskaya cave. The photos 1-4, 7, 10, 12-14 – by L. Golovanova; 5, 8, 9 – after Leonova and Aleksandrova 2012: fig. 2; Leonova 2014: fig. 2; 6, 11 – after (Leonova *et al.* 2017); drawing 7 – after (Amirkhanov 1986: fig. 23). For images 1-4, 6, 12-14 scale bar = 1 mm; for images 5, 7-11. Scale bar = 1 cm.

Obsidian artifacts in Layer 1-3 at Mezmaiskaya comprise only 0.1-0.4% of the assemblages from different years of excavation. A trace element analysis (Doronicheva and Shackley 2014) indicates this material was procured from the Chikiani source (~450 km to the southeast), in southern Georgia, and from the Baksan (Zayukovo) source (~250 km) in the North-central Caucasus. The prevalence of chips and microchips (62.5%) suggests on-site tool production, although obsidian tools are extremely rare finds. No cores or cortical flakes from obsidian were found.

In the Epipalaeolithic sites known in the Gubs River valley, including Gubs rockshelter 1 (Layer 2), Gubs 7 (Satanai) rockshelter (horizon 3), Kasojskaya Cave (horizon 3), Gubs 5 (Chygai) rockshelter and Dvoinaya Cave, the majority of lithic artifacts are made on local Jurassic flint. The assemblages contain artifacts indicating all stages of onsite knapping and production of tools, including cores, CTE, primary flakes, flakes with cortex, chips, as well as numerous blades, bladelets, and microbladelets. Also, special petroarchaeological research of lithic collection from ly. 2 at Gubs 1 rockshelter show that 13.5% at the assemblage were made from Besleneevskaya high-quality Cretaceous flint, that sources are located 20-30 km from the site (Doronicheva *et al.* 2013).

In Kasojskaya cave, obsidian artifacts include one Gravette point in hor. 3, blade fragment in hor. 2 and CTE in hor. 5. The last two originate from the Zayukovo (Baksan) obsidian source (~250 km; Doronicheva *et al.* 2019). One flake is found in the Gubs 7 rockshelter, hor. 4. Also, a few small artifacts from obsidian were found in Chygai and very rare obsidian artifacts were found in Dvoinaya Cave (Leonova 2014, 2015). Sources of these obsidian artifacts are not identified yet.

In the Epipalaeolithic Layer 1A in the Baranakha-4 site, most artifacts are made from local raw materials (Doronicheva *et al.* 2013): chert (27%; 300-400 m) and flint (24%; 5-6 km). However, these low quality raw materials were used only for on-site production of flakes, but were not used for production of laminar blanks and retouched tools. Also, in Layer 1A, humans actively exploited high quality flints (45%) from the Akhmet-Kaya source located about 30-50 km from Baranakha-4.

The Besleneevskaya site is notable for that it is located only a few hundred meters from the Besleneevskaya sources of the highest quality flint known in the NW Caucasus. In this source, large nodules of transparent, red, and multi-colored flints occur in the limestone bedrock. A petroarchaeological study suggests that the Epipalaeolithic humans mainly visited the Besleneevskaya site for on-site knapping of the local high-quality flint.

In general, the results of petroarchaeological research (Doronicheva *et al.* 2013; Doronicheva *et al.* 2019) indicate that the Epipaleolithic humans in the NW Caucasus exploited diverse sources of high-quality flint, and significantly intensified exploitation of high-quality raw materials (flint and obsidian) from distant sources, especially the high-quality flint from the Besleneevskaya and Akhmet-Kay sources, in comparison to the Upper Palaeolithic humans of this region. The results also indicate that the Epipalaeolithic humans in the region had access to raw materials from regions located far to the east (central Northern Caucasus) and south (north-western Lesser Caucasus). This suggests extensive social and trade networks that expanded from the northwestern part of the Lesser Caucasus (Chikiani obsidian area) in the south to the northwestern Caucasus (Mezmaiskaya and other sites) in the north, and to the Baksan (Zayukovo) obsidian source area in the north-central Caucasus in the east.

3.4. The Epipalaeolithic industry of the NW Caucasus: conclusions

The results of modern research of the Epipalaeolithic industry in the NW Caucasus that are briefly reported above suggest that:

1. The Epipalaeolithic industry of the NW Caucasus shows development of the micro-blade technology, which resulted in the appearance of the hand pressure technique. This allowed to produce laminar blanks that were thinner and more straight in profile.
2. The tool inventory is characterized by numerous tools made on bladelets and micro-bladelets, including simple backed pieces, as well as Gravette and micro-Gravette backed points, with addition of Vachons backed points that appear during this period and are quite abundant in some sites. Also, some multilayered sites show decrease of the percentage of backed tools towards the end of the Epipalaeolithic.
3. The most important Epipalaeolithic innovation is the appearance of geometric microliths. The percentage and diversity of these tools increase towards the end of the Epipalaeolithic.
4. The appearance of variable shouldered points is one more important Epipalaeolithic innovation. Also, points similar to Hamburginian points and 'pointe á cran Méditerranéenne',

which are typical of the final Palaeolithic in Europe, are found in some sites probably dating to the final stage of the Epipalaeolithic in the NW Caucasus.

5. The Epipalaeolithic industry of the NW Caucasus is also characterized by new advances in organic technology and changes in personal decorations. These innovations include among others a new technique of bi-conical drilling from two sides and a new style of decoration using pierced shells of terrestrial molluscs. Also, the bone tools decorated with sets of numerous parallel cuts, which are found in Dvoinaya and Mezmaiskaya caves, reflect change in the style of ornamentation of bone artifacts. In addition, a fragment of bone point with cut grooves, which is found in horizon 9 of layer 1-3 in Mezmaiskaya, indicates that the earliest composite bone tools with grooves made for mounting of lithic microliths appear in the Epipalaeolithic of the NW Caucasus at ca. 16-15 ka cal BP.

4. Discussion and conclusions

Recent studies significantly contribute to our understanding of cultural development of industries dating to the final of the Upper Palaeolithic in the NW Caucasus and the northeastern Azov Sea region. Comparing the industries of these two regions, it should be noted that the assemblages from layer 3 in Kamennaya Balka II and Kamennaya Balka I, which represent the earliest stage of the Kamennaya Balka culture (see Leonova *et al.* 2015), are most similar to the Epipalaeolithic industry of the NW Caucasus. This proximity is expressed primarily in the common microlithic character of the lithic assemblages, predominance of backed tools in the tool sets, and presence of Vachons points with ventral thinning in both regions.

In comparison to the NW Caucasus and the northeastern Azov Sea region, the earlier appearance of geometric microliths is currently reported during the early Epipalaeolithic in the Levant (about 23-20 ka cal BP; Goring-Morris *et al.* 2009; Bar-Yosef and Belfer-Cohen 2010; Belfer-Cohen and Gorring-Morris 2014) and in the Southern Caucasus (about 25/24 ka cal BP in Satsurblia cave in west Georgia; Pinhasi *et al.* 2014). In the Levant, geometric microliths are well developed during the second stage, defined as the 'middle Epipalaeolithic' and dated to 18-14.5 ka cal BP. They are especially characteristic to the Geometric Kebaran (ca. 17.5-15 ka cal BP), and include not only variable trapeze-rectangles, but also triangles, trapezes, rectangles, and asymmetric trapezes. In the Mushabian industry, dated to the middle Epipalaeolithic, the geometric microliths comprise triangles, lunates, as well as the oldest Helwan lunates (dated ca. 17 ka) that are found so far in the Levant and elsewhere.

The early Epipalaeolithic stage is not represented in both the NW Caucasus and the northeastern Azov Sea region, like in Europe. In the NW Caucasus, northeastern Azov Sea region, and southern Europe the Epipalaeolithic begins with the middle stage (ca. 18-14 ka cal BP), when variable geometric microlithic tools appear and widely spread in these regions.

The late Epipalaeolithic (14/13-10 ka cal BP) sites in the NW Caucasus are characterized by a large diversity of geometric microliths, as well as the appearance of Helwan lunates and horned trapezes. It should be noted that during the same time period the simple low trapezes appear also in the Crimea (about 14 ka cal BP; Man'ko 2010; Biagi 2016). Also, the oldest horned trapezes in the Crimea are dated to ca. 10 ka cal BP in layer 3 in Shan-Koba. This data suggests a kind of cultural relationship between the human groups that inhabited the NW Caucasus and Crimea during the final Pleistocene – early Holocene.

Similarly, in the northeastern Azov Sea region, the assemblages dating to the period between 17-15/14 ka cal BP are characterized by diversity of geometric microlithic tools. However, the most typical forms of geometric microliths in the Kamennaya Balka sites are parallelograms that are not found in either the Northern or Southern Caucasus. Also, rare rectangles and scalene triangles are present in all regions.

The shouldered points typical of the Epipalaeolithic industry in the Caucasus are also characteristic to different final Palaeolithic industries in Europe, although these tools are not characteristic to the Epipalaeolithic industries in the Levant. In Europe, shouldered points are represented by very diverse types, but all of them are different from the Imeretian type shouldered point, which is typical to the Epipalaeolithic of the Caucasus. In the Kamennaya Balka sites shouldered points are not defined. The researchers report symmetrical points formed by abrupt retouch. Similar points are known in the Epipalaeolithic in the NW Caucasus, where bladelet points are more variable.

There are also differences between the Epipalaeolithic assemblages in the NW Caucasus and the Kamennaya Balka sites in the character of bone industry. While similar bone points with a rounded cross-section are found in both regions, the Epipalaeolithic assemblages of the NW Caucasus have yielded numerous and variable bone tools that have no analogs in the Kamennaya Balka sites, including bone points with a plano-convex or flat cross-section, awls, smoothers, points with a groove, and bone points ornamented with sets of short parallel incisions made by a stone tool along the entire length of the bone points. However, these differences may be partly related to a bad preservation of bone in the open-air sites of Kamennaya Balka.

Also, the character of personal decorations is different between these two regions. In the Kamennaya Balka sites, only pierced shells of gastropods are found. In the Epipalaeolithic assemblages in the NW Caucasus there are known numerous shell beads made from variable pierced shells of small terrestrial gastropods, Helicidae gen., Succinidae gen. (Succinaea sp.), and Pupillidae gen., in layer 1-3 in Mezmaiskaya cave, or from pierced shells of the river mollusc of Theodoxus fluviatilis in Dvoinaya Cave. In addition, the Epipalaeolithic assemblages of the NW Caucasus have yielded variable other personal decorations, including pendants made from teeth of unglulates, bead made of a small longbone of bird, and rounded flat stripe-beads.

The study of lithic raw material procurement strategies indicates wide contacts between the Epipalaeolithic population of the NW Caucasus and the neighbouring regions of the Caucasus, including the central part of the Northern Caucasus and the south-western region of the Southern Caucasus. However, the transportation of lithic raw materials from sources located in the northeastern Azov Sea region to the Epipalaeolithic sites of the NW Caucasus is not defined at present. Preliminary results of the study of lithic raw material procurement in the Kamennaya Balka sites indicate transportation of lithic raw materials from sources located 50-150 km north-west from the sites, although a more detail modern level research is necessary for more precise conclusions abouth the lithic raw material procurement strategies in the region during the final Upper Palaeolithic.

Finalyzing this discussion we would like to emphasize that the data available today indicates that the northeastern Azov Sea region and the NW Caucasus are related to specific cultural entities that formed in each region during the final Upper Palaeolithic. However, modern data also suggests that the final Upper Palaeolithic industries of both regions may have a common genesis.

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Part II

Session XVII-6

Lithic raw materials procurement during the upper Palaeolithic from Eurasia. Traditional approaches and contributions from the Archaeometry

Foreword

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Since the last decades, the study of lithic raw materials used by Palaeolithic groups has become an indispensable tool for better recognising their lithic procurement strategies. The analysis of the exploited rocks has allowed determining the frequented territories by past groups and is essential to determine their mobility strategies.

Studies focusing on lithic raw materials recovered at Palaeolithic sites range from macroscopic approaches just using a binocular magnifier or jointly with petrographic studies to geochemical analyses with the use of large devices.

In the UISPP-Paris Congress, the XVII.6 session entitled Lithic raw material procurement during the Palaeolithic from Eurasia. Traditional approaches and contributions from the Archaeometry focused on different methods to characterize lithic artefacts from several Palaeolithic sites from Eurasia as a means of better determining past human mobility. Several approaches were presented, providing in this volume some examples.

E. Doronicheva and colleagues present in their chapter Procurement and exploitation of lithic raw materials in the Middle Palaeolithic of the North-Central Caucasus preliminary results obtained from petrographic and geochemical analyses from the Middle Palaeolithic site at Saradj-Chuko Grotto, which is the only Middle Palaeolithic stratified site known in the Zayukovo (Baksan) obsidian source area, in North-Central Caucasus (Russia). They have employed X-Ray Spectral Fluorescent Analysis as well as petrography to obtain the mineralogical and geochemical composition of several dozens of geological and archaeological flint artefacts.

A. Eixea and colleagues in their chapter entitled First data on the characterization of siliceous raw materials and the catchment areas from Cova de les Malladetes (Barx, Valencia) present the first lithic raw material analysis results from the Gravettian level IX from Cova de les Malladetes (Valencia, Spain). After new survey works to identify chert sources, they have employed macroscopic analyses through a binocular microscope that have been completed by Energy-Dispersive X-Ray Fluorescence (ED-XRF) and X-Ray Powder Diffraction (XRD).

T. Pereira and colleagues present in their chapter, which is entitled Raw material procurement at Abrigo do Poço rock shelter (Central Portugal) new data about the human occupations at Abrigo do Poço. The site has an Epipalaeolithic occupation overlying a Solutrean occupation. In their study, they have focused on the analysis of the Upper Palaeolithic occupation, that seems to have been based on the exploitation of a small chert outcrop located right above the site. For analysing the samples, they have employed macroscopic studies joined to geochemical analyses through portable X-Ray Fluorescence (p-XRF).

Finally, the chapter presented by M. Sánchez de la Torre and colleagues entitled Multi-method study of a Pyrenean lithological tracer and its presence in the Magdalenian of Cova del Parco and Forcas I rock shelter (NE Iberia) presents a multi-method study of the Montgaillard-Montsaunès chert type, that outcrops in the northern Pyrenees and its presence in the Palaeolithic levels from Cova del Parco and Forcas I rock shelter. The analysis has been done using macroscopic, petrographic and geochemical analyses by Energy-Dispersive X-Ray Fluorescence (ED-XRF), Laser Ablation Inductively Coupled Plassma Mass Spectrometry (LA-ICP-MS) and Particle Induced X-Ray Emission (PIXE).

Procurement and exploitation of lithic raw materials in the Middle Palaeolithic of the North-Central Caucasus (Preliminary results)

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Abstract

Here we present data on lithic raw material exploitation, obtained from petrography and geochemical analyses, and the examination of an archaeological collection from the Middle Palaeolithic at Saradj-Chuko Grotto, the only MP stratified site known in the Zayukovo (Baksan) obsidian source area, North-Central Caucasus, Russia. From 2016 an excavation was undertaken and new artefacts and datations were obtained. At the same time, a field survey in the region has permitted also to collect information about the geology and geomorphology of obsidian-bearing deposits. The petrographic and chemical analysis, using XRF has allowed to determine the chemical composition of obsidian and flint. Among 6 main regional sources, The origin of flint seems to be local and the main obsidian source is the Zayukovo one.

Keywords: flint sourcing; obsidian; XRF; Saradj-Chuko Grotto; Middle Palaeolithic; North-Central Caucasus

Résumé

Here we present data on lithic raw material exploitation, obtained from petrography and geochemical analyses, and the examination of an archaeological collection from the Middle Palaeolithic at Saradj-Chuko Grotto, the only MP stratified site known in the Zayukovo (Baksan) obsidian source area, North-Central Caucasus, Russia. From 2016 an excavation was undertaken and new artefacts and datations were obtained. At the same time, a field survey in the region has permitted also to collect information about the geology and geomorphology of obsidian-bearing deposits. The petrographic and chemical analysis, using XRF has allowed to determine the chemical composition of obsidian and flint. Among 6 main regional sources, The origin of flint seems to be local and the main obsidian source is the Zayukovo one.

Mots-clés : flint sourcing ; obsidienne ; XRF ; Grotte de Saradj-Chuko ; Palaeolithique moyen ; Caucase Centre-Nord

1. Introduction

The north-central Caucasus—the defined geographic region located between the highest Caucasian volcanic mountain peaks of Elbrus (5642 m asl) and Kazbek (5034 m asl) is notable as the area producing the only obsidian source (called Baksan or Zayukovo) known from the Northern Caucasus (Shackley *et al.* 2018) that was actively exploited from the Middle Paleolithic to the historical period (e.g., Nasedkin & Formozov 1965; Le Bourdonnec *et al.* 2012; Chataigner & Gratuze 2014; Doronicheva & Shackley 2014; Frahm *et al.* 2014, 2016; Tuboltsev 2017; Asheichyk *et al.* 2018; Biagi & Nisbet 2018; Shackley *et al.* 2018; Doronicheva *et al.* 2019).

Figure 1. Simplified map showing main stratified Middle Paleolithic sites in the Northern Caucasus. Triangles are for cave sites, and squares are for open-air sites. Legend: 1-2 – Ilskaya I-II open-air sites, 3 – Matuzka cave, 4 – Mezmaiskaya cave, 5 Hadjoh-2 open-air site, 6-8 – Monasheskaya and Barakaevskaya caves, and Gubs I Rockshelter, 9 – Besleneevskaya-1 open-air site, 10 – Baranakha-4 open-air site, 11 – Saradj-Chuko Grotto, 12 – Weasel cave, 13 – Tinit-1 open-air site.

The character of the MP industry in the north-central Caucasus still largely remains unclear mainly because of the lack of stratified MP assemblages (Figure 1). This situation existed until the recent time, despite the fact that some Mousterian artefacts made from local obsidian had been collected on modern surfaces of river terraces near the town of Zayukovo in the 1970s (Liubin & Beliaeva 2009) and efforts of several other research groups inability to find stratified MP sites in this region.

In 1981 N. Hidjrati discovered a stratified multi-layered MP site in Weasel Cave, located in the eastern part of north-central Caucasus; in the Kazbek Mount area (Hidjrati *et al.* 2003; Faulks *et al.* 2011). The top group of layers 5-11 contains typically Mousterian, non-blade, non-Levallois industries. Most artifacts are made from micro-quartzite. For layer 5, three radiocarbon dates were obtained, in the range of 39-41 ka cal BP. For layer 7 a single AMS date is c. 49 ka cal BP. The middle group (layers 12-21) were dated from 70 to 250 ka. The faunal assemblage and pollen indicate the age of layers 12-14 from 70 to 128 ka. Layer 18 is dated by a single $^{39}Ar/^{40}Ar$ estimate to c. 200 ka. According to Hidjrati, a Levallois Mousterian industry is represented in Layer 18, with Levallois tools on blades, including Levallois points. Many artifacts are made from local flint, and other types of raw materials (e.g., andesite) were rarely used (Faulks *et al.* 2011). According to other research (Golovanova, Doronichev 2005; Golovanova 2015), layers 12-14 represent a laminar Levallois Mousterian industry, which has analogies in the Zagros Mousterian industry in the South-Eastern Caucasus and Zagros mountains.

Our field surveys in 2016 led to the discovery of the first stratified MP site in the Elbrus region and near the Zayukovo (Baksan) obsidian source area (Doronicheva *et al.* 2017). The site, called Saradj-Chuko Grotto, is located only ~6 km from known obsidian sources. A unique petroarchaeological methodology developed for raw material analysis of lithic collections from archaeological sites is used in the research. In Saradj-Chuko Grotto, predominantly obsidian and in lesser degree flint are the main lithic raw materials used for tool manufacture. We report data on lithic raw material exploitation, obtained using petrographic and geochemical analyses, and study of the lithic assemblage from the Middle Palaeolithic layer 6B at Saradj-Chuko Grotto.

2. Materials and Methods

Saradj-Chuko Grotto is located ~70 km north-east of the highest Caucasian volcanic mountain peak of Mount Elbrus (5642 m asl) and about 4 km south of the town of Zayukovo in the Baksan river valley (Terek river basin), close to known obsidian sources. The cave is situated in a deep (up to 200 m), terraced and forested valley of the Fanduko (or Saradj-Chuko; Figure 1) river, a small tributary of the Baksan River, ~35 m above the river, with an area of over 300 m^2. The entrance opens to the south-east.

In 2016, a 1 per 1.5 m test excavation led by E. Doronicheva was undertaken in Saradj-Chuko Grotto to examine the stratigraphy of deposits. This resulted in the discovery of 24 stone artefacts, most of which are made from obsidian and two tools produced from light grey flint. The assemblage includes one core, 8 flakes, 8 tools made on flakes, 5 fragments, and 2 chips. The tools comprise 3 simple side-scrapers, 2 Mousterian points, and 3 tool fragments (Doronicheva *et al.* 2017).

A Multi-disciplinary research in Saradj-Chuko Grotto began in 2017. A small (4 x 2 m) excavation was dug next to the 2016 test excavation. Excavations on the area of 8 m^2 revealed 11 layers. The richest occupational level (about 200 lithic artefacts per square meter) is Layer 6B. Layer 6B is a dark brown loam with rare small pebbles of ignimbrite and tuff, 30-40 cm thick. The layer lies within a slight inclination to the west. Besides numerous stone artefacts, abundant charcoal pieces and fragments of animal bones are found in this layer.

In 2017-2018, we obtained several radiocarbon dates. For layer 6B two dates indicate the age >40,000 yr BP. This suggests that the age of layer 6B is beyond the limit of radiocarbon dating, and other methods of absolute dating should be used for the Middle Palaeolithic sediments of Saradj-Chuko grotto. While results of radiometric (ESR) dating are pending, the results of pollen analysis suggest the early Middle Palaeolithic age (probably MIS 5) of the lithic industry from Layer 6B in Saradj-Chuko (Doronicheva *et al.* 2019).

In 2016-2018, we undertook specific field surveys in the Zayukovo (Baksan) obsidian source region, as well as in the Baksan River valley and valleys of its small tributaries in order to collect newer information about the geology and geomorphology of obsidian-bearing deposits in the region. Four main outcrops of obsidian within the Zayukovo (Baksan) area were identified, sampled, and studied, called Zayukovo 1-4 (Shackley *et al.* 2018). We collected 39 obsidian source samples from the outcrops. One of these outcrops was discovered near the Hana-Haku-1 flint outcrop (Figure 11).

Obsidian varies in form and colour. Elemental analyses indicate a single homogeneous composition of Baksan obsidian (Shackley *et al.* 2018). For this study 14 obsidian artefacts from ly. 6B (Table 4) were analysed using the ThermoScientific *Quant'*X EDXRF spectrometer in the Geoarchaeological XRF Laboratory, Albuquerque, USA (http://www.swxrflab.net/; Shackley 2011). Both trace elements and oxides were acquired (Table 4). All archaeological samples are analyzed whole. The data from the WinTrace software were translated directly into Excel for Windows software for manipulation and on into SPSS for Windows for statistical analyses when necessary. In order to evaluate these quantitative determinations, machine data were compared to measurements of known standards during each run (Table 4). USGS RGM-1 rhyolite standard was analyzed during each sample run for obsidian artifacts to check machine calibration. Also, in 2016-2017, we conducted field work in the North-Central Caucasus, in the Elbrus region, for survey and study of the regional flint sources, which could be used during the Palaeolithic. Five flint sources were discovered (Figure 2: A). The search and study of raw materials that could be used in the Palaeolithic, is an important step in the methodology of petroarchaeology. Exploration is carried out using geological maps developed by the All-Russian Geological Research Institute (VSEGEI) named after. A.P. Karpinsky for the regions of the Russian Federation, as well as data from the portal http://www.onegeology.org/portal/home.html. In areas where there are rocks that may have contained flint, prospecting was conducted to search for deposits. The outcrops were recorded using a Garmin navigation device and mapped. A series of samples was collected from each source. The data from these sources were introduced into a database created for stone raw material sources in the North-Central Caucasus.

Flint primary deposits are present in the limestones of Jurassic and Cretaceous ages, covered from above by thick strata of volcanic deposits (Figure 2: B). We found primary outcrops of light grey Cretaceous flint in the Hana-Haku and Shtauchukua river valleys (right tributaries of the Baksan river), and outcrops of Jurassic dark grey and black flint near the village of Bedyk in the Baksan valley. Primary outcrops of Jurassic black flint were also found in the Chegem river valley, and presumably Cretaceous pink flint of different colours found in the river alluvium in the Kamenka river valley. At Shatauchukua-1 we collected samples at several points, and marked as 'Shtauchukua-1-1' and 'Shtauchukua-1-2'.

In 2017-2018 we have carried out 40 petrographic and 34 geochemical analyzes of samples from these five flint outcrops in the Elbrus region. The results are represented in this paper (Tables 1, 3 and Figures 3, 4 and 8). A petrographic analysis of flint samples was performed in the Laboratory of Geochemistry of Environments named after Fersman at Herzen State University in St. Petersburg, Russia. The petrographic study of the flints was made on thin sections under a polarizing microscope POLAM-111, with a magnification of 65x and higher. According to the petrographic studies, micromorphological characteristics of flints have been identified. All petrographic descriptions of samples from deposits are accompanied by photographs.

The chemical composition of flint and composition of trace elements were determined by X-Ray Spectral Fluorescent Analysis, using the Spectroscan MAX device. This method of analysis is one

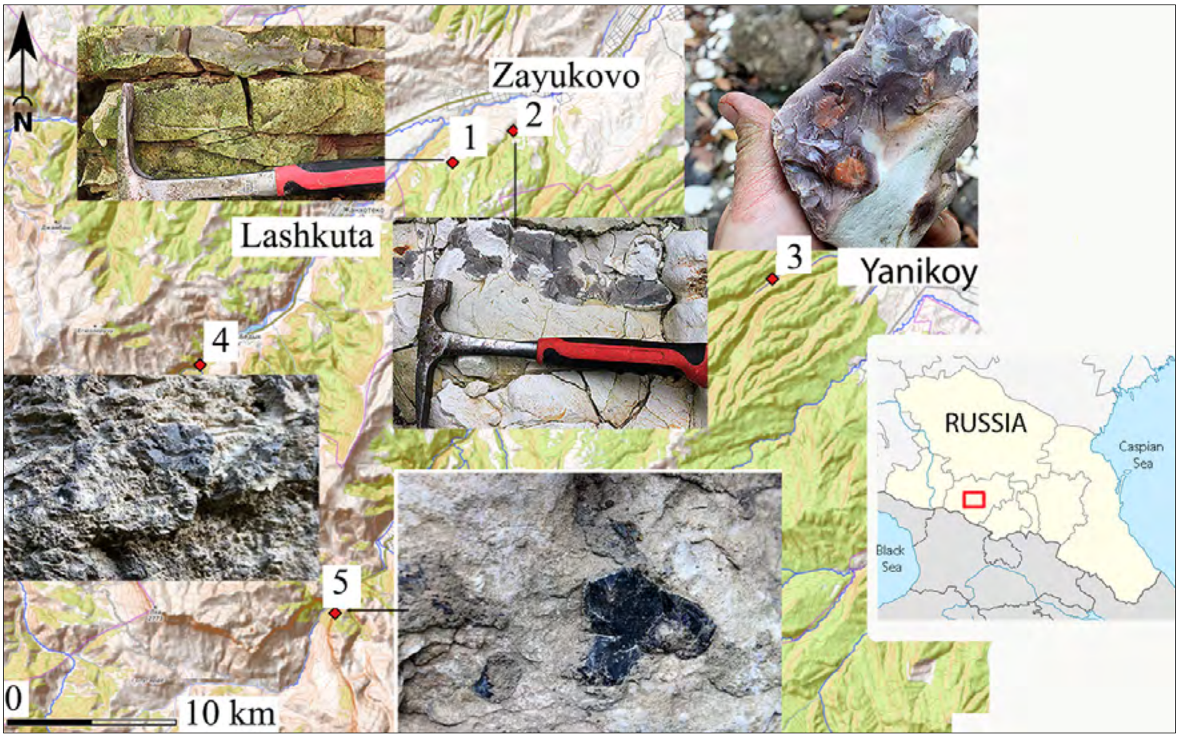


Figure 2. The Elbrus region, North-Central Caucasus, Russia. Location of the studied flint sources. Legend: 1 – Shtauchukua-1-1 and Shtauchukua-1-2, 2 – Hana-Haku-1 outcrop, 3 – Kamenka-1 alluvial source, 4 – Baksan-1 outcrop, 5 – Chegem-1 outcrop.

of the most effective because it allows you to compile complete and reliable information about the elemental composition of samples in a relatively short period of time. X-ray fluorescence method refers to the instrumental methods for determining the elemental composition and allowing you to determine the composition of elements in the range from Be to U at a concentration of from units of parts per million (ppm) to 100%, regardless of the form of the substance. Spectroscan-MAX GV, on which the measurements were made, is a non-destructive testing instrument. The final data reflect the concentration of such elements as V, Cr, Fe, Co, Ni, Cu, Zn, Sr, Pb, Rb, Ba, La, Y, Zr, Nb, As, as well as the oxides of TiO_2, MnO, CaO , Al_2O_3, SiO_2, P_2O_5, K_2O, MgO, Na_2O in percent by weight.

To date, the collection of samples from the North-Centre Caucasus consists of 50 etalon samples. They add the Lithotheque of flint samples from the whole Northern Caucasus, which is created since 2007 and today consists of more than 700 samples that are stored in St.-Petersburg.

3. Results

3.1. Characterization of the regional flint sources

According to geochemical and petrographic studies, several groups of flint samples from various outcrops, which are characterized by a specific mineralogical and geochemical composition, can be distinguished:

Shtauchukua-1-1. The flint is light grey in colour with white carbonate crust. Composition: microcrystalline quartz (80%), concentric-zonal chalcedony (10%), separate inclusions of carbonate (5%) replacing microfossils and filling cracks, and inclusions of organogenic silicic skeletons of marine organisms (foraminifera) replaced by hydrogoethite (5%). Figure 3: 1-2.

The geochemical composition is characterized by high proportion of Zn (zinc) and Ba (barium). Average content of SiO_2 (82.63%) and Al_2O_3 (0.8%). Table 1.

Shtauchukua-1-2. The flint is light grey in colour with white carbonate crust. Composition: microcrystalline quartz (70%), inclusions of carbonate replacing microfossils and filling cracks (10%), concentric-zonal chalcedony (10%) replacing foraminifera, and inclusions of organogenic silicic skeletons of marine organisms (foraminifera) replaced by hydrogoethite (5%). Figure 3: 3-4.

The geochemical composition is characterized by high proportion of Cu (copper), Zn (zinc), and Sr (strontium). Average content of SiO_2 (83.37%) and Al_2O_3 (0.5%). Table 1.

Hana-haku-1. The flint is light grey in colour with white carbonate crust. Composition: microcrystalline quartz (80%), separate inclusions of carbonate replacing microfossils (13%), concentric-zonal chalcedony (5%) replacing foraminifera, and inclusions of organogenic silicic skeletons of marine organisms (foraminifera) replaced by hydrogoethite (2%). Figure 3: 5-8.

The geochemical composition is characterized by high content of Cu (copper), Ba (barium), Sr (strontium), and Zr (zirconium). Average content of SiO_2 (82.31%) and Al_2O_3 (0.57%). Table 1.

Kamenka-1. The flint is pinkish-beige and grayish-brown in colour. Composition: microcrystalline quartz (68%), concentric-zonal fibers of chalcedony (15%) replacing foraminifera, a large number (about 10%) of silicic skeletons of marine organisms (foraminifera, spicules), some replaced by thin-grained hematite (5%), separate inclusions of carbonate replacing microfossils (2%). Figure 3: 9-10.

The geochemical composition is characterized by high content of Cu (copper) and P_2O_5 (phosphates). Average content of SiO_2 (85.42%) and Al_2O_3 (0.69%). Table 1.

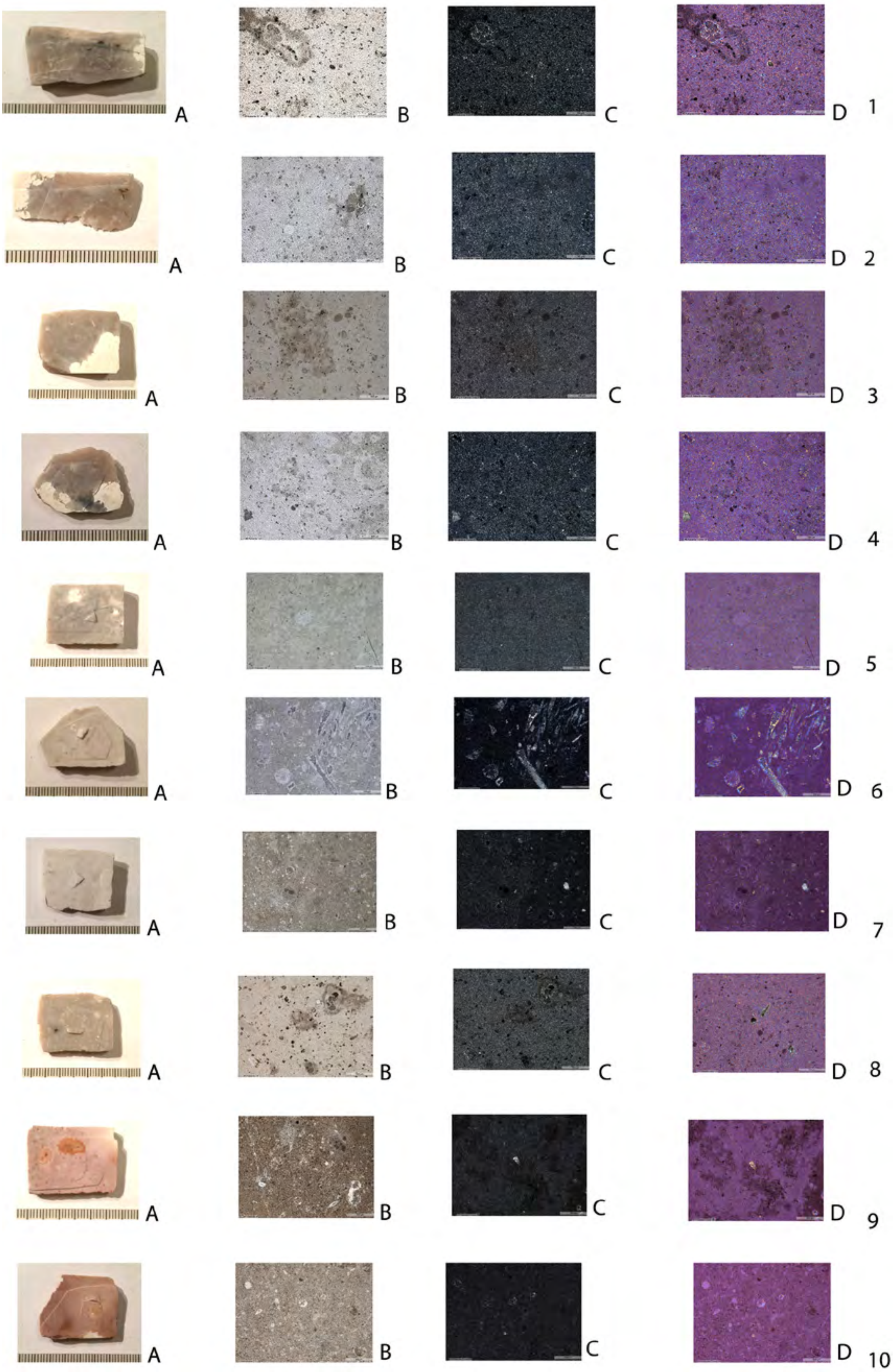


Figure 3. Petrographic study of samples from flint sources: 1-2 – Stauchukua-1-1, 3-4 – Shtauchukua-1-2, 5-8 – Hana-haku-1, 9-10 – Kamenka-1. A – a sample, B – a macrograph without analyzer, C – In polarized light, D – In polarized light with a quartz plate. Scale 500 mkm.

Source sample	TiO2	MnO	Fe.	Cu	Zn	Sr	CaO,	Al2O3,	SiO2,	P2O5	K2O,	Rb	Ba	Zr	Na2O	Nb
	%	%	%	ppm	ppm	ppm	%	%	%	%	%	ppm	ppm	ppm	%	ppm
Shtauchukua-1-1	0,06	0,003	0,3	21	12	63	0,2804	0,851	94,2	0,01	0,17	3,47	114	7,55	0,05	n/o
Shtauchukua-1-1	0,05	0,002	0,41	918	90	386	n/o	n/o	11,2	0,01	n/o	4,88	540	n/o	0,05	10
Shtauchukua-1-1	0,06	0,006	0,32	35	5	77	0,4157	0,848	78,1	0,01	0,188	3,8	254	n/o	0,05	3
Shtauchukua-1-1	0,05	0,003	0,28	7	5	49	0,3923	0,611	74,3	0,01	0,105	4,88	n/o	6,97	0,05	n/o
Shtauchukua-1-1	0,05	0,003	0,3	17	5	69	0,2295	0,858	88,5	0,007	0,163	4,36	67	9,02	0,1	n/o
Shtauchukua-1-1	0,06	0,002	0,29	18	12	57	0,3315	0,786	82,8	0,018	0,147	5,1	n/o	5,96	0,05	n/o
Shtauchukua-1-1	0,07	0,012	0,36	261	5	222	0,0665	0,317	37,8	0,01	n/o	n/o	467	n/o	0,05	n/o
Shtauchukua-1-2-	0,07	0,01	0,34	195	5	175	n/o	0,289	45,6	0,01	n/o	n/o	160	n/o	0,05	n/o
Shtauchukua-1-2-	0,05	0,007	0,36	27	5	127	0,1449	0,551	54,5	0,112	0,048	4,57	1	n/o	0,05	2
Shtauchukua-1-2-	0,06	0,007	0,44	984	98	459	0,05	n/o	7,8	0,01	n/o	4,14	121	n/o	0,05	18
Shtauchukua-1-2-	0,06	0,005	0,32	8	2	56	0,1565	0,878	81,5	0,01	0,212	1,91	90	10,2	0,05	2
Shtauchukua-1-2-	0,05	0,004	0,28	7	5	47	0,2512	0,885	86,7	0,01	0,172	3,85	161	7,26	0,05	n/o
Shtauchukua-1-2-	0,05	0,003	0,32	7	10	51	0,2625	0,832	81,2	0,074	0,192	4,49	168	9,11	0,05	n/o
Hana-haku-1	0,08	0,009	0,42	611	19	363	n/o	0,149	22,8	0,01	n/o	2,98	291	n/o	0,05	5
Hana-haku-1	0,06	0,011	0,36	92	5	220	0,4948	0,547	63,1	0,01	0,082	6,64	146	n/o	0,05	n/o
Hana-haku-1	0,07	0,005	0,42	598	15	393	0,05	0,107	20,6	0,01	n/o	7,62	486	n/o	0,05	1
Hana-haku-1	0,05	0,003	0,3	7	5	93	0,1386	0,807	95,8	0,06	0,154	2,05	93	0,65	0,05	n/o
Hana-haku-1	0,06	0,004	0,33	18	5	69	0,3352	1,035	95,5	0,01	0,243	6,99	138	7,24	0,05	n/o
Hana-haku-1	0,05	0,005	0,29	38	5	132	0,2206	0,474	65,1	0,01	0,018	1,94	18	n/o	0,05	n/o
Hana-haku-1	0,05	0,003	0,29	14	3	92	0,1337	0,84	92,3	0,01	0,165	6,36	90	10,1	0,3	n/o
Hana-haku-1	0,05	0,001	0,3	4	8	67	0,1586	0,996	98,7	0,01	0,199	5,9	70	9,55	0,04	n/o
Hana-haku-1	0,06	0,007	0,35	13	5	113	0,1885	0,954	87,8	0,079	0,219	2,93	131	1,38	0,05	n/o
Hana-haku-1	0,06	0,009	0,32	7	5	138	0,5184	0,488	56,7	0,01	0,035	n/o	498	n/o	0,05	n/o
Kamenka-1	0,05	0,003	0,33	7	9	95	0,1052	0,864	96	0,016	0,163	4,1	46	7,14	0,05	1
Kamenka-1	0,05	0,003	0,35	21	7	83	0,2059	1,014	99,8	0,01	0,227	4,43	169	5,5	0,05	n/o
Kamenka-1	0,05	0,004	0,35	18	5	94	0,1223	0,803	81,8	0,01	0,122	3,13	62	3,87	0,05	2
Kamenka-1	0,05	0,006	0,32	6	5	58	0,119	0,794	77,5	0,01	0,171	4,45	11	0,07	0,05	n/o
Kamenka-1	0,05	0,002	0,34	11	7	98	0,1054	0,849	97,4	0,033	0,134	3,98	146	4,57	0,05	n/o
Chegem-1	0,04	0,008	0,34	22	15	54	2,88	1,15	78	0,034	0,36	11	131	33	<0,2	8
Chegem-1	0,06	0,033	0,45	14	48	318	46,055	1,19	19	n/o	0,474	7,408	n/o	8,74	4,32	8,88
Chegem-1	0,03	0,006	0,38	30	<5	54	4,11	0,94	69,9	0,03	0,3	6	146	32	<0,2	7
Baksan-1	0,04	0,007	0,33	46	<5	29	1,77	1,13	83,6	0,028	0,37	10	79	29	<0,2	8
Baksan-1	0,07	0,016	0,45	345	n/o	271	1,4184	0,312	32,5	n/o	n/o	1,068	20	n/o	3,18	9,79
Baksan-1	0,11	0,049	0,69	86	18	197	31,462	1,384	27,8	n/o	0,34	10,12	53	7,3	1,21	7,33

Table 1. Geochemical characterization of flint samples from the studied flint sources.

Baksan-1. The flint (or silicified limestone, because the% of silica is quite low) is light beige in colour.

Composition: quartz-chalcedony (45%), with secondary development of calcite crystals (50%), a large number of organogenic silicic skeletons of marine organisms (foraminifera, spicules), single grains of goethite (10%). Cement with some crustification consists of carbonate. Figure 4: 1-3.

The geochemical composition is characterized by a high content of Ba (barium). Average content of SiO_2 (97.28%) and Al_2O_3 (0.79%). Table 1.

Chegem-1. The flint (or silicified limestone, because the% of silica is quite low) is striped, brownish-brown in colour. Composition: quartz-chalcedony (45%), with secondary development of carbonate

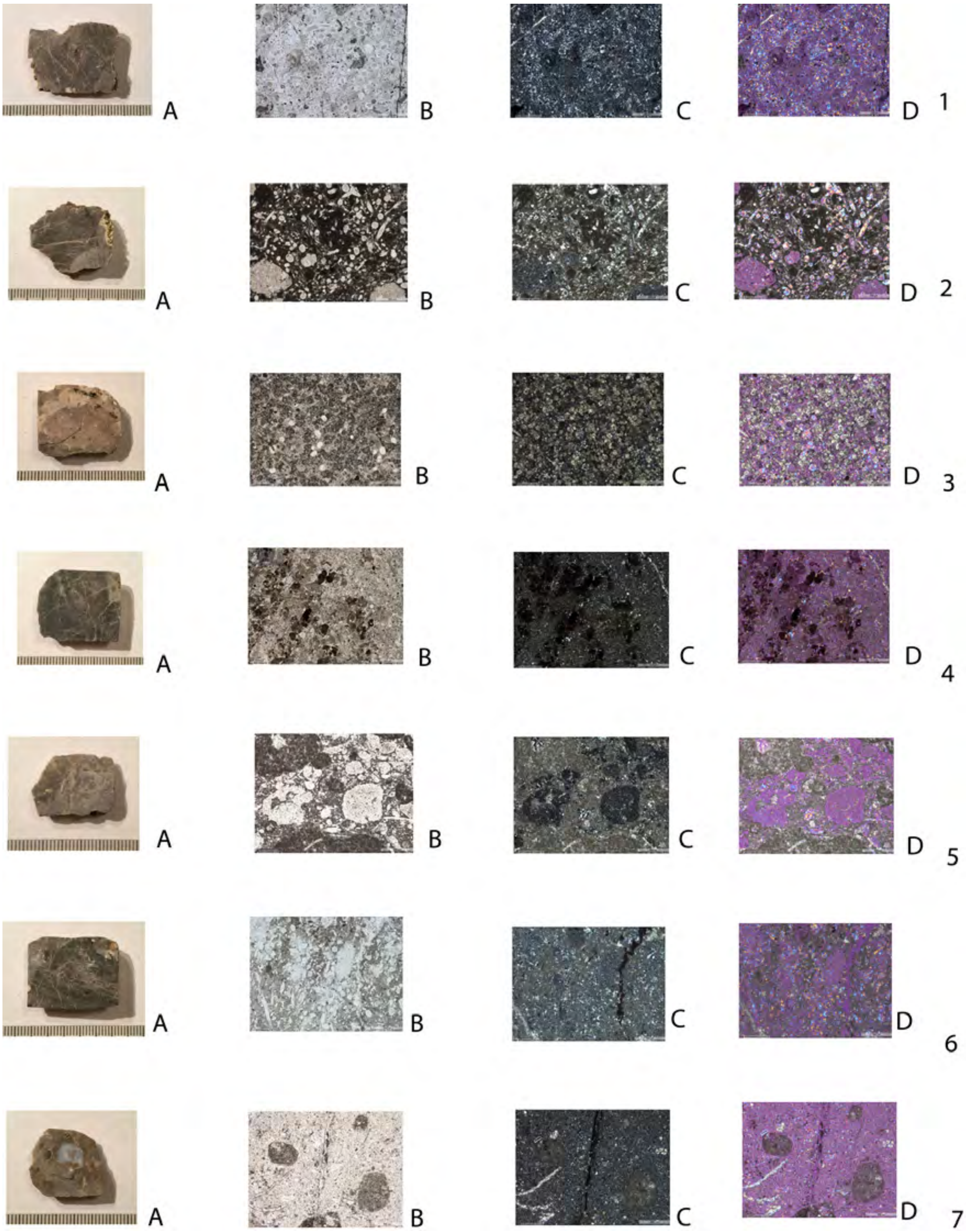


Figure 4. Petrographic study of samples from flint sources: 1-3- Baksan-1, 4-7 – Chegem-1.
A – a sample, B – a macrograph without analyzer, C – In polarized light,
D – In polarized light with a quartz plate. Scale 500 mkm.vv.

(50%) replacing microfossils (foraminifera, spicules) and crystal calcite developed in cracks, a large number (about 10%) of organogenic silicic skeletons of marine organisms (foraminifera, spicules) replaced by chalcedony, and fine-grained goethite (5%). Cement with some crustification consists of carbonate. Figure 4: 4-7. The geochemical composition is characterized by a high content of CaO (11.6%) associated with the high carbonate content. Average content of SiO_2 (83.55%) and Al_2O_3 (0.9%). Table 1.

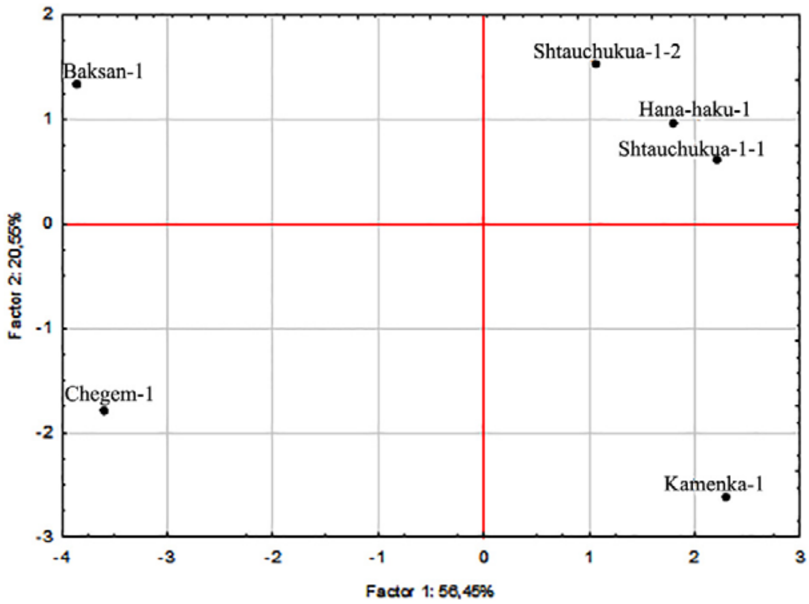


Figure 5. Location of the studied flint outcrops in the space of the first two main components.

According to preliminary data, the chemical composition of flint from the Shtauchukua-1-1 and Shtauchukua-1-2 deposits (13 samples), Hana-Haku-1 (10 samples) and Kamenka-1 (5 samples) varies in silica content of all samples from 94-45%. There are also some samples that contain very little SiO_2 (37.8%, 11.2% and 7.8%).

TiO_2 does not exceed the values of 0.08% (two samples from Hana-Haku-1), the rest fluctuate in the range of 0.048-0.063. The content of Fe does not exceed 0.44% for all samples.

The content of potassium oxide barely exceeds 0.21% in several samples (one sample per outcrop), while K_2O is on average contained in all samples in the range from 0.048 to 0.172%.

Comparison of samples on the content of chemical elements was carried out using the method of principal components. For each of the deposits, the average percentage of elements was calculated from samples originating from it. At the first stage, in order to identify those groups of elements that have the maximum capacity for distinguishing various deposits, the analysis included data on the entire set of elements (Figure 5.)

Totally, the first two main components reflect 77% of the total variability of the initial indicators. The first main component differentiates the deposits into two groups according to the content of MnO, Fe, CaO, K_20, Rb, Zr and Na_20 in the samples. In the first group (Baksan-1 and Chegem-1) the content of the listed elements is higher than in the second group (Kamenka-1, Shtauchukua-1-1, Shtauchukua-1-2, Hana-haku-1). The second component separates the deposits mainly in terms of Cu content in samples – the proportion of this metal is higher in samples from the Baksan-1, Shtauchukua-1-1, Shtauchukua-1-2 and Hana-haku-1 outcrops and less in the Chegem-1 and Kamenka-1 outcrops.

A certain set of trace elements and the average content of rock-forming components can be used as the main geochemical characteristics of the groups of flints. These characteristics, together with the analysis of the mineralogical composition can be used in the analysis of sources of raw materials for flint artifacts from Paleolithic sites.

3.2. Middle Paleolithic raw material procurement at Saradj-Chuko grotto

In Layer 6B at Saradj-Chuko Grotto, a large (1591 artefacts; Table 2) assemblage from the 2017 excavation includes 12 cores (0.8%), flakes (18.4%), numerous shatter (676 pieces, 42.5%) and

Raw materials	Cores	Shatters	Chips	Flakes			Tools	Total
				Technical flakes	Blades/ laminar flakes	Flakes		
Obsidian	12	669	597	2	14/85	140	38	1557
Light gray flint (Shtauchukua-1/ Hana-haku-1)	-	5	8	-	0/2	6	3	24
Pink flint (Kamenka-1)	-	1	4	-	-	1	-	6
Black flint n/a (? km)	-	1	-	-	-	1	1	3
Silicified limestone (? km)	-	-	-	-	-	1	-	1
Total:	12	676	609	2	14/87	149	42	1591

Table 2. Saradj-Chuko Grotto. Raw materials types in the lithic assemblage of ly. 6B. 2017 excavations.

chips (609 pieces, 38.2%), and 42 retouched tools (2.6%). Almost 98% of artefacts (1591 pieces) in the assemblage are made from obsidian, including all cores, technical and primary flakes (Table 2). Fourteen obsidian artefacts from layer 6B in Saradj-Chuko Grotto were analysed using the ThermoScientific *Quant'*X EDXRF spectrometer in the Geoarchaeological XRF Laboratory, Albuquerque (USA; http://www.swxrflab.net/). Results indicated that all sampled artefacts were procuced from obsidian originating from the Zayukovo source, located 5-7 km to the west from Saradj-Chuko Grotto (Figure 6 and Table 4). As mentioned above, one obsidian source, which we discovered recently (Zayukovo-3), is located close to the Hana-Haku flint source.

Only 33 artefacts are made from flint and one from silicified limestone. The flint artefacts include 12 chips, 10 flake fragments, 7 small fragments, and 4 tools (Table 2).

The results of geochemical analysis of samples from layer 6B are presented in Table 3. The set of analyzed traits includes signs that have the greatest differentiating ability for separation of outcrops, except for some samples from Saradj-Chuko, for which the content was not defined. The total of the five trace elements was taken into account in the new analysis: MnO, Fe, CaO, K_20 and Cu. Totally, the first two main components reflect about 85% of the total variability. The samples from Saradj-Chuko grotto, which occupy the field of extreme positive values in the space of the second main component, according to the results of cluster analysis, are most similar to the group of sources, including Kamenka-1, Shtauchukua-1-1, Shtauchukua-1-2, and Hana-haku-1. The highest similarity with Kamenka-1 is due to the low copper content in samples from Saradj-Chuko. Also, the samples 36, 38 and 39 differ from the main group of samples from the cave with the high percentage of K_20, which is more typical for samples from the Chegem-1 and Baksan-1 sources.

Preliminary results of petrographic (Figure 7) and geochemical analyses indicate a local origin of flint, probably from the Cretaceous flint sources located about 5-7 km to the north-west (Hana-Haku-1 and Shtauchukua-1) and south-east (Kamenka) from the site (Tables 2-3 and Figures 7-8). Because flints from Hana-Haku-1 outcrop and Shtauchukua-1 sources belong to one geological layer and are very similar in colour and inclusions, at the current step of analysis we are unable to separate artifacts made from these varieties of flint in archaeological collections (see Table 2). Flints from the Jurassic sources (Baksan-1 and Chegem-1) were not defined in the studied lithic collection from Saradj-Chuko Grotto. Also, we defined black flint in the assemblage, but source of this flint is unknown yet.

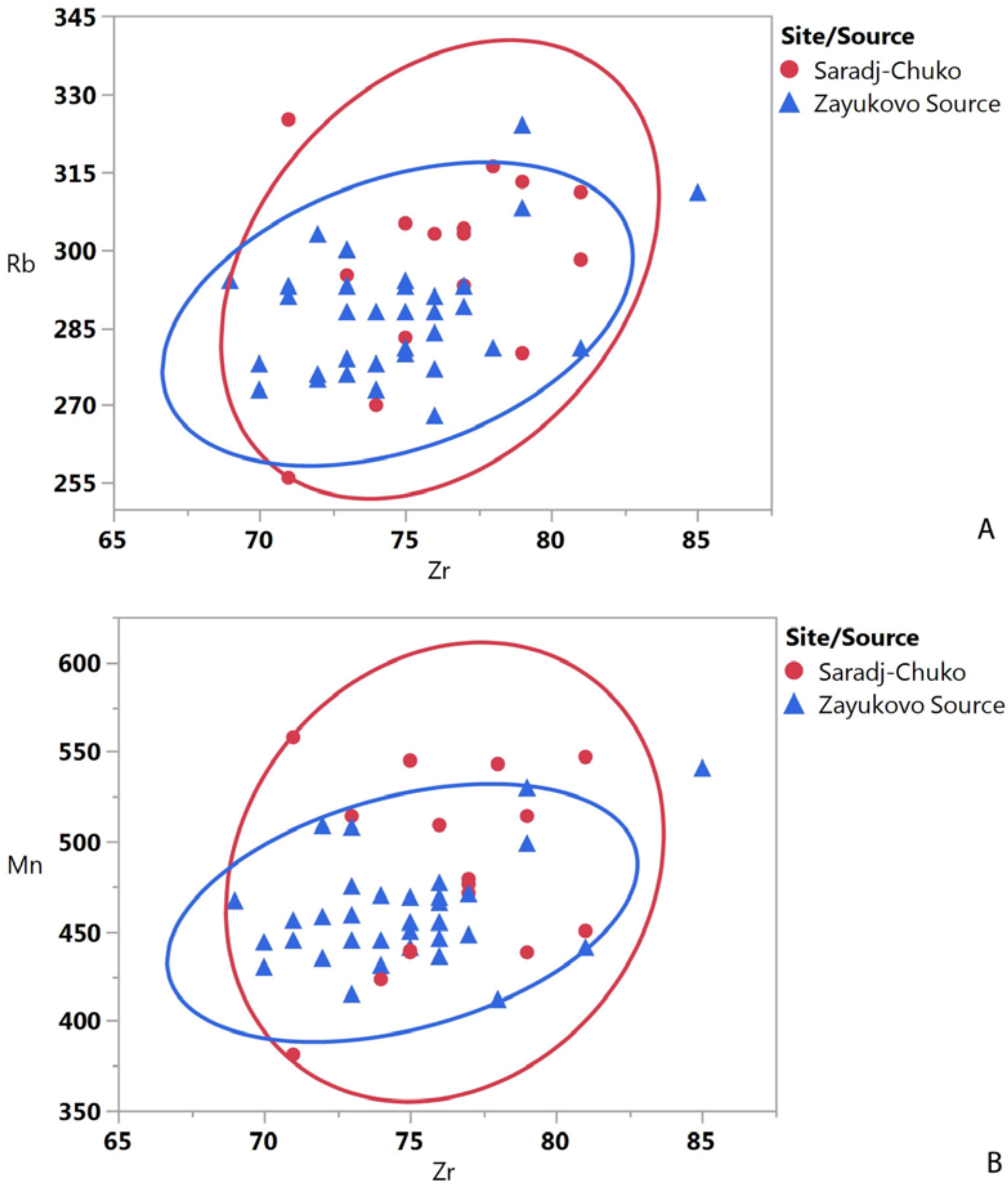


Figure 6. Zr/Rb (A) and Zr/Mn (B) bivariate plots of the Saradj-Chuko artifacts and Zayukovo source standards (see Shackley *et al.* 2018). Confidence ellipses at 95%.

№	Sample	TiO2	MnO	Fe	Cu	Zn	Sr	CaO	Al2O3	SiO2	P2O5	K2O	Rb	Ba	Zr	Na2O	Nb
		%	%	%	ppm	ppm	ppm	%	%	%	%	%	ppm	ppm	ppm	%	ppm
35	Ly. 6B, h.2, 210, tool frag	0,05	0,007	0,3	16	n/o	64	0,3	0,65	62,3	n/o	0,106	n/o	116	4,02	n/o	1,19
36	Ly. 6B, h.2, Q-13, chip	1,07	n/o	0,2	< 5	< 5	8	0,4	1,16	58,3	0,03	0,31	13	72	37	1,07	7
37	Ly. 6B, h.2, Q-13, chip	0,06	0,007	0,3	21	n/o	52	0,2	0,72	68,5	n/o	0,162	n/o	160	3,54	n/o	3, 24
38	Ly. 6B, h.2, Q-13, flake frag.	0,06	0,004	0,3	10	7,4	23	0,2	1,06	96,5	n/o	0,311	5,7	35	15,8	<0,2	5,02
39	Ly. 6B, h.2, Q-14, chip	0,04	0,01	0,3	<5	<5	15	0,4	0,97	72,5	0,04	0,36	13	113	38,7	0	9

Table 3. Geochemical characterization of several flint samples from ly. 6B in Saradj-Chuko Grotto (2017 collection). All measurements are in %.

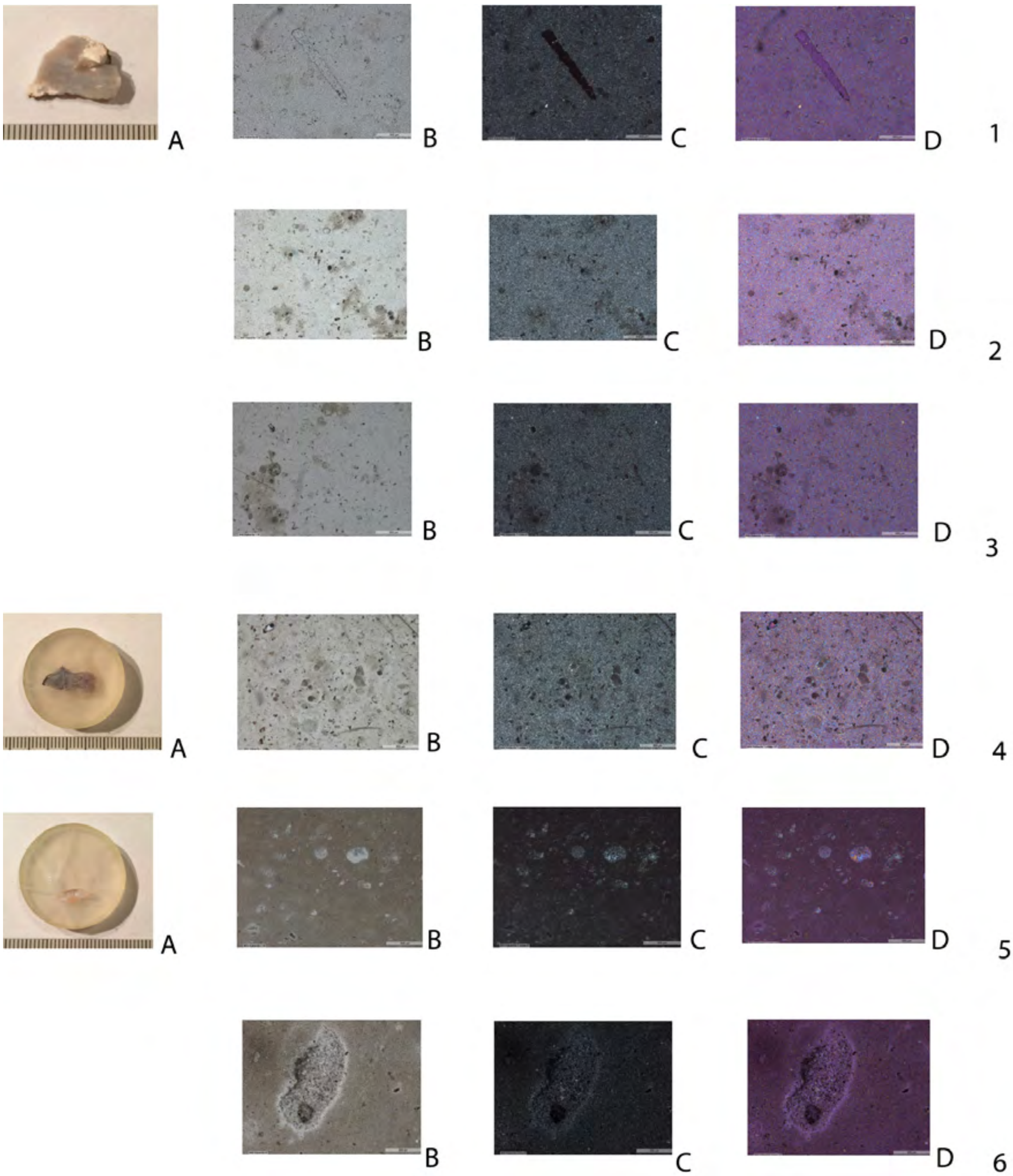
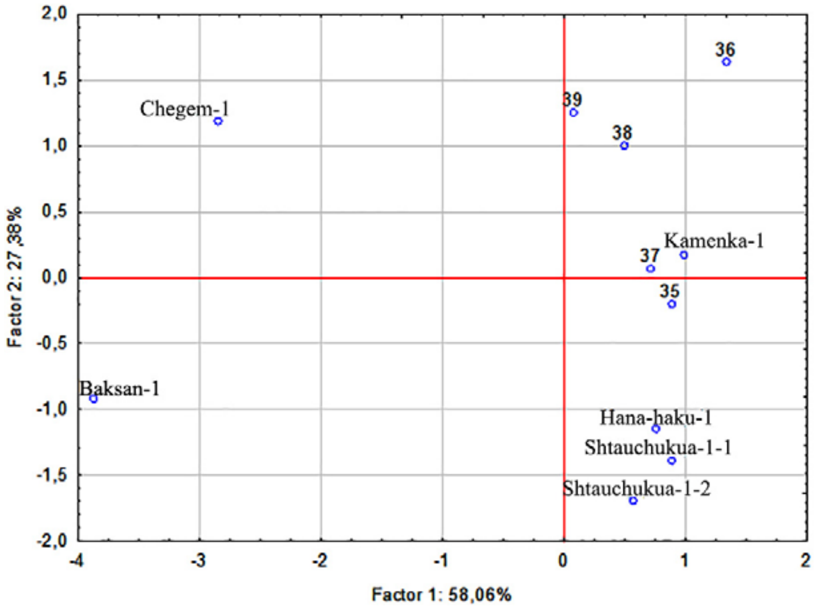


Figure 7. Petrographic study of flint artifacts from ly. 6B in Saradj-Chuko grotto: 1 – sample 45, Saradj-Chuko 2017, ly, 6B, hor. 1, 38, flake. Attributed to Hana-Haku-1 source; 2 – sample 47, Saradj-Chuko 2017, ly 6B, hor. 2, 74, tool fragment. Attributed to Hana-Haku-1 source; 3 – sample 46, Saradj-Chuko 2017, ly. 6B, hor.2, 260, flake. Attributed to Hana-Haku-1 source. 4 – sample 44, Saradj-Chuko 2017, ly. 6B, 59, shatter. Attributed to Shtauchukua-1-1 source. 5 – sample 50, Saradj-Chuko grotto 2017, ly. 6B, hor. 2, 190, shatter. Attributed to Kamenka-1 source. 6 – sample 49. Saradj-Chuko 2017, ly. 6B, h.2, 13, flake. Attributed to Kamenka-1 source. A – a sample, B – a macrograph without analyzer, C – In polarized light, D – In polarized light with a quartz plate. Scale 500 mkm.

In general, the results of petroarchaeological study of obsidian and much more rare flint artefacts indicate that the local Neanderthals exploited raw material sources located within a radius of 7 km west, north-west (Baksan river valley) and south-east (Kamenka river valley) of the site. About a quarter (23.2%) of obsidian flakes have cortex areas on dorsal surfaces. Artefact refitting results

Figure 8. The position of the flint samples in the space of the first two main components. The numbers denote samples from Saradj-Chuko Grotto (see Table 4).



Sample	Site	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Ba	Th	Source
43	Saradj-Chuko-2017, 6B, hor. 1, P-11, shatter	772	423	8908	270	56	33	74	18	196	14	
42	Saradj-Chuko-2017, 6B, hor. 2, P-14, tool frag.	847	450	9420	298	56	29	81	17	227	31	
48	Saradj-Chuko-2017, 6B, hor. 2, P-14, shatter	920	547	10377	311	59	26	81	12	145	33	
45	Saradj-Chuko-2017,6B, hor. 1, P-11, shatter	887	514	9867	295	58	25	73	15	260	22	
46	Saradj-Chuko-2017, 6B, hor. 2, Q-12, flake	821	381	8344	256	49	27	71	16	221	35	
50	Saradj-Chuko-2017, 6B, hor. 2, P-12, flake	828	438	9097	280	52	33	79	14	221	32	
44	Saradj-Chuko-2017, 6B, hor. 2, Q-12, flake fragm.	908	514	10122	313	57	28	79	15	220	31	
47	Saradj-Chuko-2017, 6B, hor. 2, P-12, flake fragm.	817	545	9780	305	58	26	75	8	187	31	
49	Saradj-Chuko-2017, 6B, hor. 2, Q-12, flake fragm.	814	476	9356	303	59	26	77	11	149	22	Zayukovo (Baksan)
1	SRD-2016-N1	760	439	8880	283	54	26	75	14	224	32	
2	SRD-2016-N2	784	438	8951	283	53	27	75	14	205	21	
3	SRD-2016-N3	869	543	10395	316	62	27	78	18	184	25	
7 *	Saradj-Chuko-2018, ly. 6B, S-11	n/a	479	n/a	293	54	29	77	17	235	22	
8 *	Saradj-Chuko-2018, ly. 6B, R-11	n/a	509	n/a	303	54	31	76	16	219	30	
RGM1-S4			282		150	109	26	214	8	815	11	

Table 4. Elemental concentrations and source assignments for the samples from ly. 6B from Saradj-Chuko grotto, and USGS RGM-1 rhyolite standard. All measurements in parts per million (ppm). Data from: Doronicheva *et al.* 2017, 2019; Shackley *et al.* 2018 and new samples from 2018 excavations (marked as *).

confirm on-site knapping of obsidian and that the area of obsidian knapping is correlated with the main concentration of artefacts.

The following core types were defined: 6 unifacial one-platform cores, 3 unifacial two-platform cores, 2 bifacial three-platform cores, and an unidentifiable core-like fragment. The cores are small (4-9 cm) and reduced, with mainly parallel and more rare convergent removals struck from weakly convex surfaces. Core platforms are prepared by small removals, one removal (plain platforms),

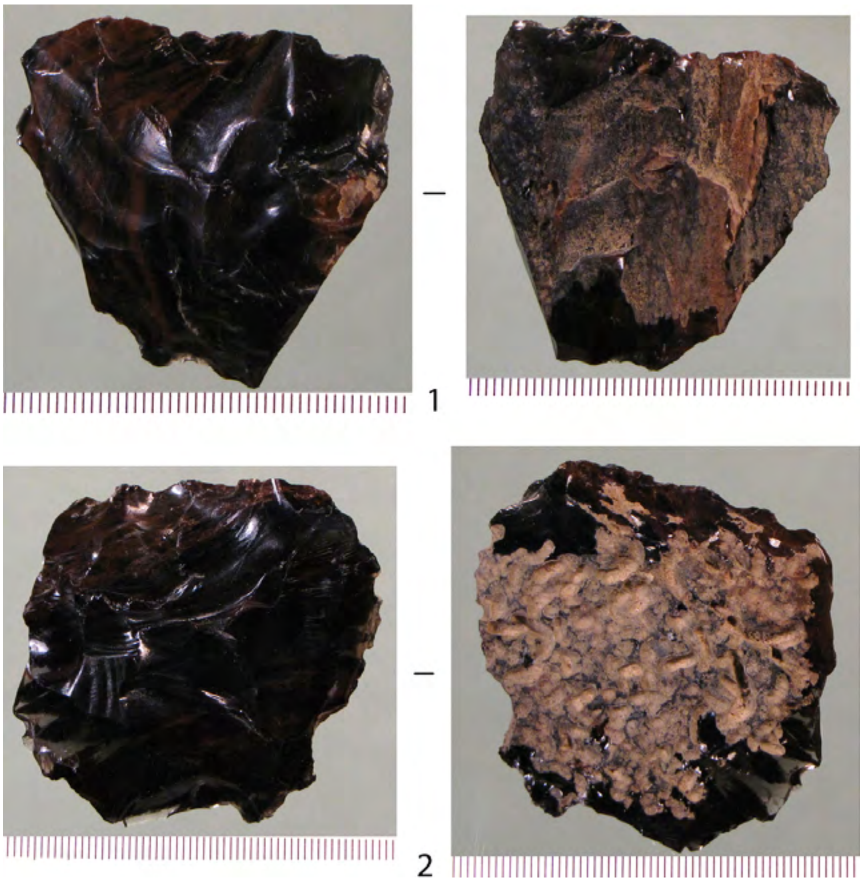


Figure 9. Saradj-Chuko grotto. Layer 6B. 2017 excavations. 1-2 – obsidian cores.

or retouched (on 3 cores), with platform angle about 70-80°. The predominance of single-platform cores also indicates that core reduction mainly ended at this stage, after which most cores were discarded. The rare two- and three-platform cores reflect a more prolonged reduction of some cores, using mainly opposite (from two opposite directions) and orthogonal (from two perpendicular directions) flaking methods (Figure 9). The rarity of two-platform opposite and orthogonal cores is well correlated a low number of flakes with parallel-orthogonal, transversal, and opposite removals on dorsal surfaces of flakes.

Most flakes (86%) are fragmented. There are only two core preparation technical flakes made from obsidian.

All these data indicate that obsidian was transported to the cave as cobbles ('volcanic bombs') that were knapped on the site. On the contrary, the composition of flint artefacts indicates that flint was brought to the cave as ready to use flakes and retouched tools that were only rejuvenated in the cave.

An indicative feature of the lithic industry from layer 6B is the large number of laminar flakes (35.2%). True blades (5.5%) and typical Levallois triangular flakes or points (3.1%) are rare. The index of faceted platforms (IFs=46%) is high. These technical characteristics allow us to define this industry as the laminar Mousterian.

The retouched tools in layer 6B are not numerous yet, but include tool types, such as prevailing simple scrapers, rare diagonal and angled scrapers, convergent tools, and Mousterian points that are typical for other Levallois laminar Mousterian industries in the South-Eastern Caucasus. Only 4 tools are made from flint (Figure 10). Several tools have thinning ventral retouch, which is also a characteristic feature of the Levallois laminar Mousterian industries in the South-Eastern Caucasus (Golovanova & Doronichev 2003, 2005).

Figure 10. Saradj-Chuko grotto. Layer 6B. 2017 excavations.
1 – View on the Saradj-Chuko grotto from the opposite bank of the river,
2-9 – obsidian and flint tools.

4. Discussion and Conclusions

In 2016-2017, we began fieldwork in the North-Central Caucasus, in the Elbrus region, for surveying and study of the regional flint sources, which could be used during the Palaeolithic. Since 2016, we have started to collect an etalon source collection (lithotheque) of flints from the north-central Caucasus, and performed in total over 60 petrographic and 40 geochemical analyses of flint samples from regional raw material outcrops and archaeological sites. As mentioned above, we included the Zayukovo (Baksan) obsidian source and collected samples of obsidian recently published (Shackley *et al.* 2018; Doronicheva *et al.* 2019).

For the Saradj-Chuko grotto, preliminary results of the analysis of lithic and faunal assemblages indicate that Neanderthals living in this region were engaged in intensive knapping of obsidian, and production and use of tools made mostly from obsidian for butchering and consumption of hunting prey that was represented mainly by ungulate animals (Figure 11). Our results indicated that 98% of artefacts in layer 6B were made from obsidian originating from the Zayukovo source, located 5-7 km to the west from Saradj-Chuko Grotto. Also, preliminary results of petrographic and geochemical analyses of flint artefacts indicate a local origin of flint, probably from sources located about 5-7 km to the north-west (Hana-Haku-1 and Shtauchukua-1) and south-east (Kamenka-1) from the site. This suggests that local Neanderthals used raw materials from the local outcrops: obsidian (5-6-7 km), flint (5-7 km). Probably, Neanderthals could collect obsidian and light-grey Cretaceous flint (Hana-Haku-1 and Shtauchukua-1) from the same micro-region within small tributaries of the Baksan River – Hana-Haku and Shtauchukua valleys, located close to each other.

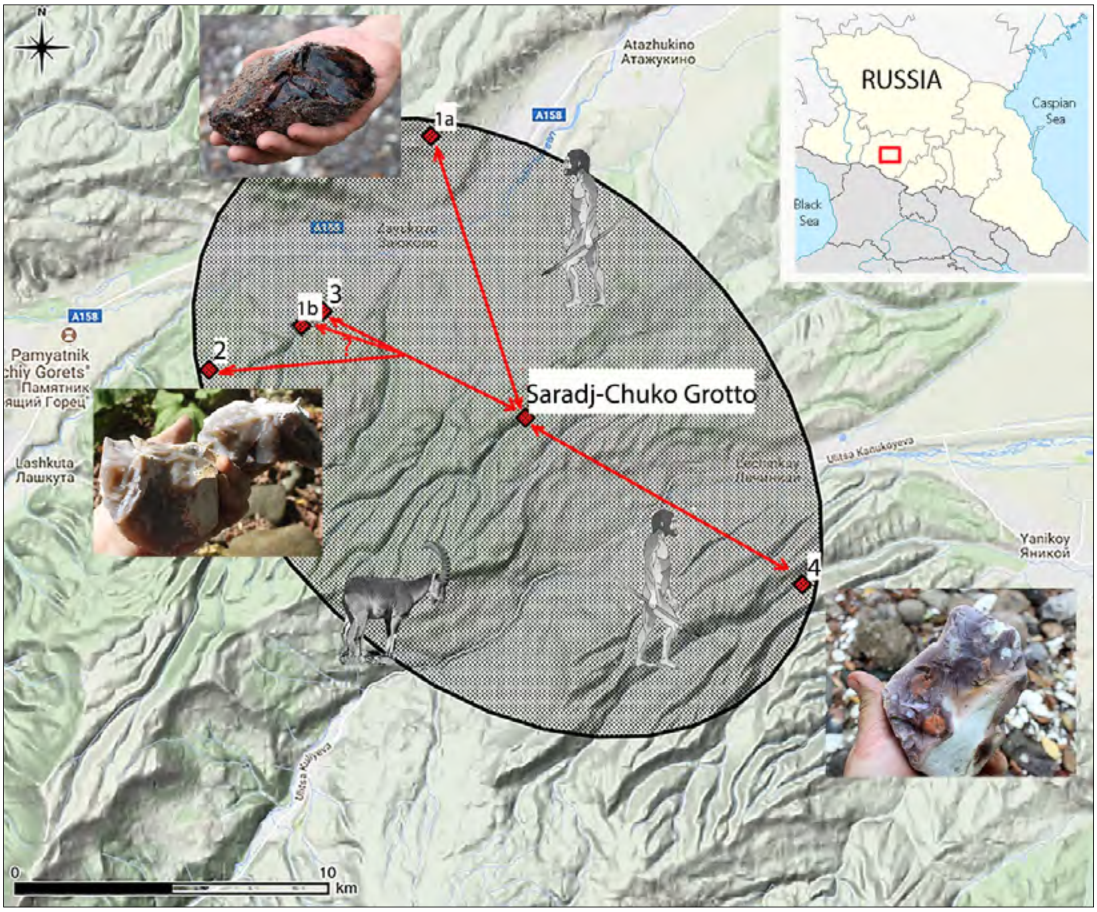


Figure 11. Saradj-Chuko grotto. Proposed territorial model of resource exploitation. Legend: 1a – Zayukovo-1 and Zayukovo -2 obsidian sources, 1b – Zayukovo-3 obsidian source, 2 – Shtauchukua-1 grey flint source, 3 – Hana-Haku-1 grey flint source, 4 – Kamenka-1 red alluvial flint source.

Regarding the Kamenka-1 source we have only data for the alluvial scattering of flint within the region and do not know yet where the outcrops are located, so the definition of distances to these sources is very preliminary. Also, the published data on the Weasel cave shows that local inhabitants used micro quartzite and flint, and rarely – andesite. Known sources of raw materials presumably located at a distance of 20-30 km, which means that the inhabitants of the site used deposits of the second zone and local raw materials. This indicates the development of predominantly short-term mobility at the sites of the North-Central Caucasus. Data on remote mobility and transportation of exotic raw materials is not yet available. Raw material studies are only beginning for this region. Future research, mapping and sampling of flint sources, research and excavations at Palaeolithic sites will resolve questions about cultural peculiarities and contacts, raw material transport and exploitation in the Middle Palaeolithic of the region.

Acknowledgements

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First data on the characterisation of siliceous raw materials and the catchment areas from Cova de les Malladetes (Valencia, Spain)

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Abstract

This paper presents the first lithic raw material analysis results from Cova de les Malladetes level IX, dated to the Gravettian period. New survey works were developed in the surrounding area, where some Middle and Upper Palaeolithic sites—such as Cova del Parpalló, Cova de les Meravelles, Cova Negra, Cova de la Petxina, Cova del Bolomor, Barranc Blanc and Cova Foradada—are located. These works allow us to characterise the different lithologies documented in the archaeological assemblages. With this information, the raw material outcrops used by hunter-gatherer groups can be identified and a map on chert exploitation during the Palaeolithic period in the central Mediterranean region of the Iberian Peninsula can be created.

Keywords: raw materials; catchment areas; Cova de les Malladetes; early Upper Palaeolithic

Résumé

Cet article présente les premiers résultats obtenus à partir des matières premières du niveau IX de Malladetes, attribuées au Gravettien. De même, de nouveaux travaux de prospection sont en cours dans les zones immédiates du site, en raison également de la forte représentation des sites du Paléolithique moyen et supérieur à la proximité (Cova del Parpalló, Cova de les Meravelles, Cova Negra, Petxina, Bolomor, Barranc Blanc o Cova Foradada, entre d'autres). En ce sens, il est nécessaire de réaliser ce type de travail afin de caractériser les différentes lithologies déterminées dans tous ces ensembles et ainsi pouvoir dresser une première carte des sites d'approvisionnement à la fois du Paléolithique moyen et supérieur dans la région centrale de la Méditerranée ibérique.

Mots-clés : matieres premieres ; aires d'approvisionnement ; Cova de les Malladetes ; Paleolithique superieur recent

1. Introduction

Raw materials analysis and their catchment areas allow us to know the relationships between hunter-gatherer groups and the environment they inhabited; we can infer important information about these groups' mobility patterns and their use of different territories (Demars 1982; Geneste 1988; Féblot-Augustins 1999; Turq 2000; Terradas 2001; Mangado 2005; Tarriño 2006). In the

Mediterranean Iberian Peninsula, the information for the Upper Palaeolithic period is unequal. While there are a good number of works in the northern area, they focus on the characterisation of different outcrops as well as archaeological and geological chert types from a petrographic (Mangado 1998 and 2005; Roy *et al.* 2013; Sánchez de la Torre 2015) and geochemistry perspective (Sánchez de la Torre *et al.* 2017a, b), the central and southern regions have less works, and the majority focuses on chert macroscopic characterisation from the archaeological excavations carried out (García-Carrillo *et al.* 1990; Menargues 2005; Tiffagom 2006; Simón & Cortes 2007; Faus 2008-2009). Due to the lack of works of this nature in the central Iberian Mediterranean area, we believe it is necessary to carry out a macro– and microscopic study on the raw materials documented in Cova de les Malladetes—a site that has been subjected to new excavations and as studies of outcrops. This study will also compare Malladetes with other archaeological sites in the area, particularly Cova del Parpalló, to establish a starting point from which to expand by taking samples of other Palaeolithic assemblages and a greater work of systematic survey to identify lithic procurement sources of this whole area. All of this will allow us to develop a geological map of the distribution of the various siliceous variants used in the different periods of Valencian Prehistory.

2. The site

Malladetes is located in the municipality of Barx (Valencia), encompassed within the Mondúver range. Geologically, the cave is composed of materials belonging to the Upper Cretaceous period: an important dolomitic mass with cryptocrystalline limestone banks emerging from the upper part, followed by a dolomitic calcareous complex and sandy dolomite that present siliceous conglomerate lens formed by small quartz granules (Fumanal 1988). The cave is located in the upper-middle part of the slope at 551 m above sea level; the entrance has a northwest orientation and opens into the Turonian-Senonian cretaceous limestone. The great limestone strata form the visor and walls in projection, and with respect to the slope, form a slope break with the lower unit.

The site was excavated in different phases, first by L. Pericot and F. Jordà in 1946 and 1949, and later by F. Jordà and J. Fortea in the 1970s. As far as the initial Upper Palaeolithic is concerned, the Aurignacian is documented from the upper part of level XIV to level XII. Meanwhile, the Gravettian is documented between levels XI and VII. From this level, the identification of a final Gravettian or an ancient Solutrean is pending from data results obtained in recent years and, simultaneously, a review of the associated industry.

Recent works conducted by V. Villaverde and A. Sanchis during 2016 and 2017 have focused on more precisely defining the different strata from a sedimentary point of view, as well as obtaining complete sequences of microfauna and charcoal remains. The aim was to update the chronostratigraphic and paleoenvironmental information sequence, and establish a complete series of absolute dates in collaboration with E. Wild and P. Steier.

3. Methods

Raw materials macroscopic analysis (Masson, 1979) was carried out with a binocular microscope under 20x or 40x magnification and used the Munsell table. Colour, texture, impurities and cortex features were recorded. Raw samples were analysed by means of energy dispersive X-ray fluorescence spectrometry (EDXRF) and X-ray powder diffraction (XRD). Chert samples were analysed in a non-destructive mode by means of a portable EDXRF spectrometer to characterize the elemental composition of the samples. The spectrometer has a low-power x-ray tube with a silver anode operating in transmission mode and a thermoelectrically cooled Si-PIN detector with an energy resolution of 165 eV. An aluminium collimator was used to ensure a 5 mm beam diameter in the sample's surface. The X-ray beam impinged perpendicular to the sample, and the tube and detector were placed with an excitation-detection geometry of 45º and a 2 cm sample-detector distance. Qualitative identification of the mineral phases were carried out on powdered chert samples of homogeneous size through XRD by means of a diffractometer model D8-Avance A25 Bruker brand equipped with a CCD multichannel detector (PSD LynxEye). The system operated with the following parameters: Ni filted Cu Kα radiation excited at 40 kV and 30 mA, 2θ angular interval between 5º and 80º, step size of 0.02º and 0.2 s per step. Mineral phase identification was carried out using the PANalytical X'Pert HighScore software. All measurements were performed at the Archaeometry Unit of the Materials Science Institute, University of Valencia (ICMUV) by C. Roldán, S. Murcia and D. Vie.

4. Results

4.1. Field survey results

Field surveys have been aimed at the characterisation of the well-known outcrops and the search for new places, both in primary and secondary position. In this sense, more than 20 km^2 have been surveyed, and a total of four different geological formations and over 10 outcrops have been documented (Figure 1). The Serpis coastline formation is in a southeast direction, and the terraces are located about 15 km away from the mouth of the Serpis River. Here, chert appears reworked in fluvial origin coastal deposits, between which they emphasise the types previously defined, such as Serreta, Mariola and Marxuquera (Molina 2016). The Marxuquera formation is in the same

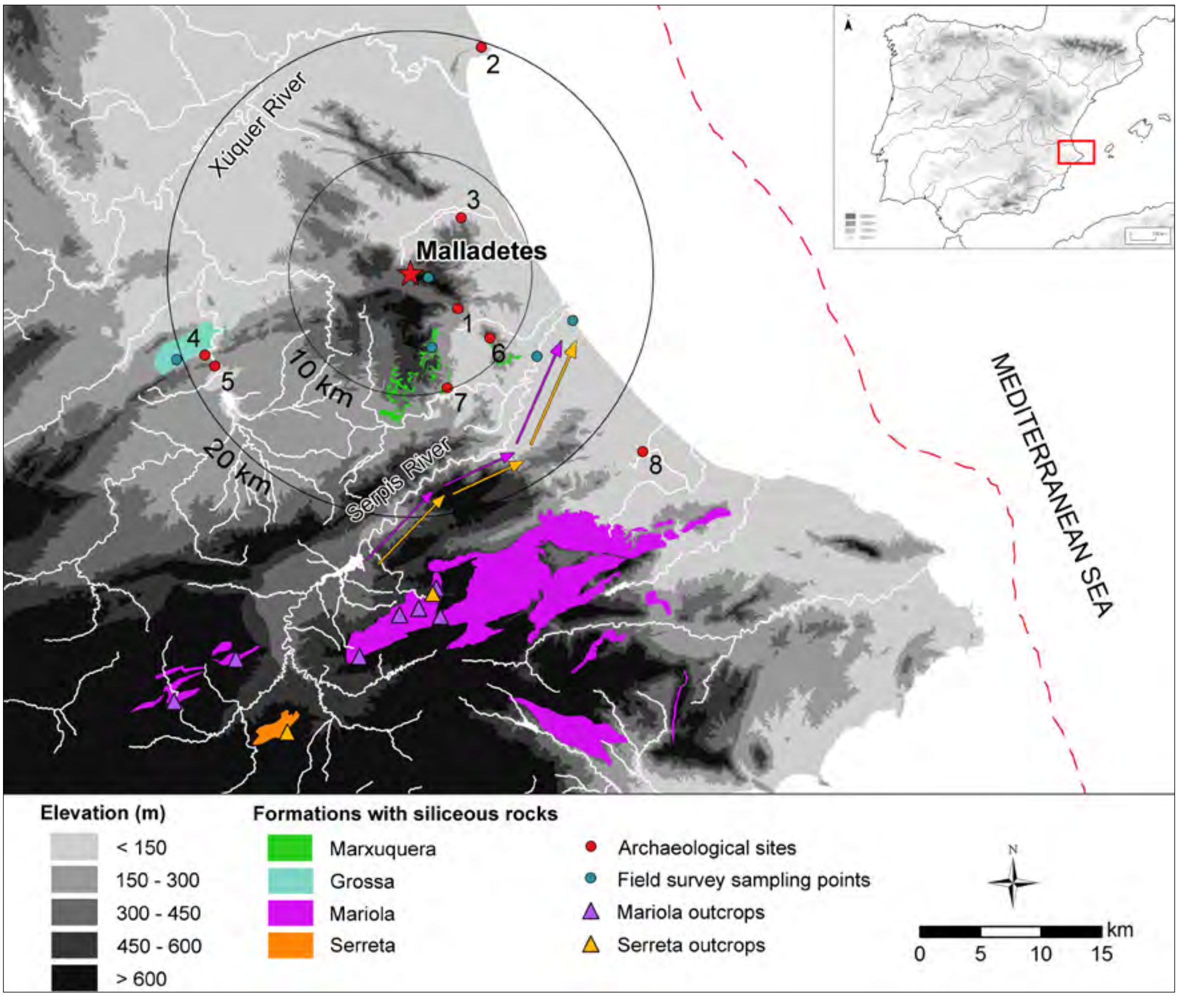

Figure 1. Map with geological formations, main rivers, the approximate Gravettian coastline (in red dashed line), catchment areas and main sites mentioned in the text: 1- Cova del Parpalló, 2- Cova del Volcán del Faro, 3- Cova del Bolomor, 4- Cova Negra, 5- Cova de la Petxina, 6- Cova de les Meravelles, 7- Barranc Blanc, 8- Cova Foradada.

direction as the previous one; at a distance of about 10 km, we came across the Falconera and Marxuquera ranges. In both foothills, a sequence of well-layered Coniacian age limestones are found on the Turonian dolomites, containing abundant silicified irregular concretions and chert nodules, which are included under the Marxuquera type nomenclature (IGME 1981, 2016). Finally, the Grossa formation is about 20 km away from the site in a southwest direction, facing the Grossa range (Xàtiva)—a formation belonging to the Cenomanian-Turonian (Upper Cretaceous), in which chert appears in nodular formats together with slightly uniform veined structures framed under the Grossa type.

4.2. Macroscopic and microscopic characterisation

The materials analysed in this work correspond to the level IX assigned to the Gravettian and belonging to sector ZII and ZIII of the excavation campaigns carried out in 1970 and 2016-2017. Total remains amounts to 179 elements, of which >90% are in chert while the rest (limestone and quartzite) reach in testimonial proportions. Within chert—the dominant raw material—we have been able to macroscopically differentiate several types already known in the existing bibliography. Regarding to the elemental and mineralogical analyses, EDXRF spectrometry identifies the characteristic fluorescence lines of Si, S, K, Ca, Ti, V, Mn, Fe, Zn and Sr in all the analysed samples. On the other hand, the XRD patterns reveal the presence of Quartz (SiO_2) as the main mineral phase of the studied samples and minor contents of Calcite ($CaCO_3$).

Although these microscopic and geochemical analyses have not been conclusive, most of the information comes from the macroscopic characterization. A new series of XRD and EDXRF analyzes are in process, together with new data from INAA. As we can see, in Table 1, preliminary analysis report the identified phases ordered in relation to the intensity of the diffractogram peaks. Quartz (SiO_2) is the main mineralogical component of the samples. Some samples exhibit the simultaneous presence of Quartz and Calcite ($CaCO_3$). The archaeological sample T3S1 exhibits a diffraction pattern without the presence of Quartz, being Calcite the only mineral phase identified in this sample.

Hierarchical Cluster Analysis (HCA) was performed taking into account as variables the net areas of the EDXRF lines normalized to the total counts of the spectra (Figure 2). Sample T3S1 is an outlier that present high intensity XRF peaks of Ca, very low XRF peaks of Si and the only identified crystalline phase by XRD is calcite. This sample is differenced in the dendogram of the EDXRF data where we can observe pieces of evidence for the attribution of single cases to two major clusters: cluster-1 (subs cluster a, b and c) and cluster-2. The samples ABC_1 and ABC_2_n are included in cluster-1a and are differenced because they present high intensity peaks of Ca and Sr. Cluster-1a and cluster 1-b include 11 of the 16 studied outcrops.

It does not seem that coherent groupings are observed between the geological samples and the macroscopic characterization of the archaeological samples. This fact leads us to consider that the present results are not conclusive because XRF and XRD have not allowed identifying trace elements associated to geochemical variables that can correlate the archaeological samples with the local or foreign outcrops. Currently, new analyses by instrumental neutron activation analysis (INAA) are planned to identify chemical fingerprints of flint samples.

In relation to the Serreta type chert, accounts for more than half of the elements (53%) (Table 2). This Eocene-age chert (Ypresian) is characterised by a variety of colourations, from dark black and green tones to lighter grey and orange, which are the majority. Macroscopically, the grain is fine and translucent with a smooth texture which gives it good quality for knapping. Internally, the biogenic component is very high, especially in the presence of polypper skeletons and gastropod shells. The cortex is white with brownish and orange tones, a multitude of sedimentary tracks and a small thickness (1-2 mm) (Figure 3). The nodules reach sizes that range 20-30 cm in length, Archaeological samples

Type	ID	Quartz	Calcite
1 Serreta	T1S1	X	
	T1S2	X	
	T1S3	X	
	T1S4	X	
	T1S5	X	
	T1S6	X	X
	T1S7	X	
2 Mariola	T2S1	X	
	T2S2	X	
	T2S3	X	
3	T3S1		X
4	T4S1	X	
	T4S2	X	X
	T4S3	X	
5	T5S5	X	X

Geological samples

Outcrop	ID	Quartz	Calcite
Barranco Caturla	ABC_1	X	X
	ABC_2_n	X	X
Marxuquera	AMARX_1	X	
Playa Gandía	APG_1	X	X
	APG_2	X	
Partida Martorell	APM	X	
Puig de la Llorença 1 (central)	APLL1_1	X	
	APLL1_2	X	
Puig de la Llorença 2 (norte)	APLL2_1	X	
	APLL2_2	X	
Puig de la Llorença 3 (norte)	APLL3_1	X	
	APLL3_2	X	
Puig de la Llorença 4 (sur)	APLL4_1	X	
	APLL4_2	X	
Cala Testos	ACT_1	X	X
Playa Granadella	APGRA_1	X	X

Table 1. XRD analysis of archaeological and geological samples.

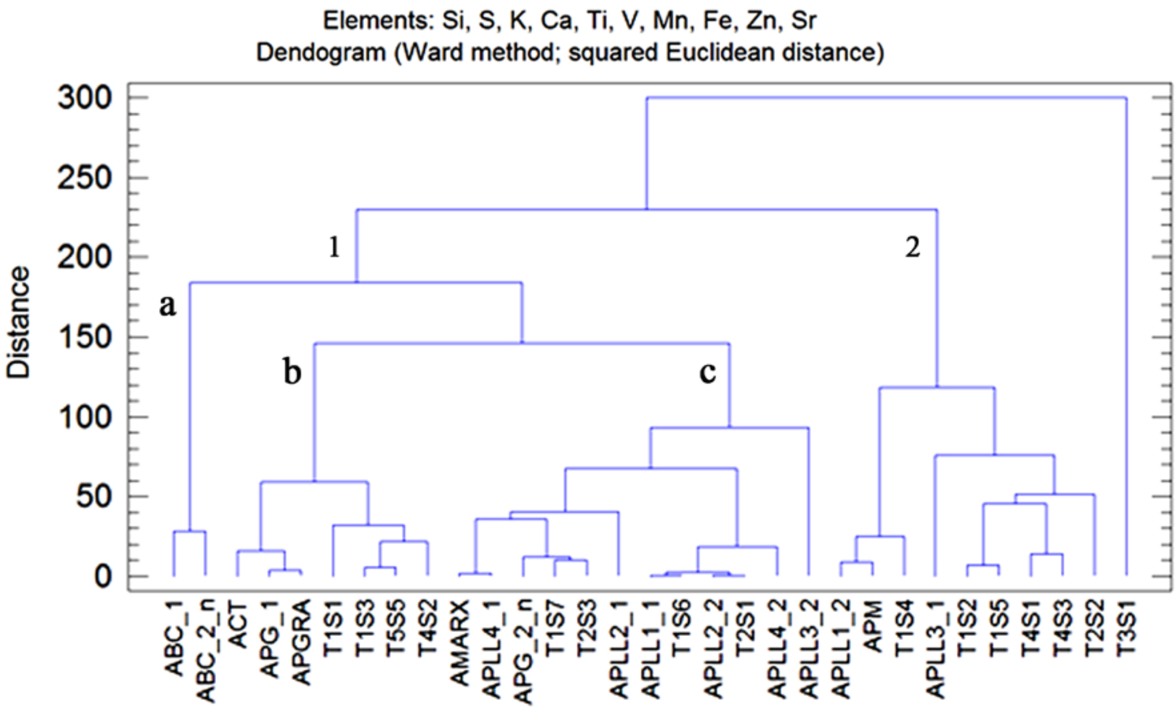

Figure 2. HCA of the EDXRF data.

and very irregular shapes with the presence of nodular and other tabular forms. If we value this chert with archaeological criteria at this level, it is observed that 79% of the tools (n=38), leaving chips aside, are of this type. This indicates that its values represent almost all the transformed products. Among them, backed pieces and composed tools predominate, followed by splinters and end-scrapers. In addition, all the cores documented in this level are made only in this raw material.

Another type corresponds to Mariola's chert, which represents much lower values than the previous one, oscillating around 6% of the record. It belongs to the Upper Cretaceous (Maastrichtian) and is characterised by a high chromatic variability, especially of grey, brown and black. Macroscopically, its texture is translucent and irregular due to the presence of numerous relict elements, mainly of biogenic origin, such as foraminifera, demosponges spicules and shells fragments in a wackestone

type	Serreta	Mariola	T1	Indet. F.	Indet. Thermal	Limestone	Quartzite	Total
Flakes	36 (9)	5	1	7 (1)	10	11		69
Laminar flakes	8 (2)	3 (1)		4 (2)	2	1		18
Blades	7 (5)	1 (1)		5 (1)				13
Bladelets	16 (6)	1		2	3 (1)			22
Splinters	5							5
Total Blanks	72	10	1	18	15	12	0	127
Cores	3 (1)							3
Semicrested blades			1		2	1		4
Core Semitablets	1							1
Core flank	5 (4)					1		6
Core transversal flank						1 (1)		1
Core lateral flank	1							1
CMP (Core maintenance products)	7	0	1	0	2	3	0	13
Debris	12	1	2	5	12	1	2	34
TOTAL	94	11	4	23	29	16	2	179
Retouched	79%	5%	0%	11%	3%	3%	0%	
Unretouched	45%	6%	3%	13%	20%	11%	1%	

Table 2. Raw materials used in level IX differentiated by unretouched and retouched blanks (retouched material is in brackets). The lower part indicates each material's percentages of retouched and unretouched material.

type matrix. The neocortex is practically non-existent, while the cortex is rough with orange and white colorations. The numerous impurities generate a medium aptitude for knapping. Archeologically, flakes and laminar flakes predominate (n=8) and blades and bladelets are marginal (n=2). The degree of transformation by retouching this lithology is much lower, barely exceeding 5% of its strength, which indicates that it is a poorly represented type both in the retouched and untouched.

While the type 1 indeterminate presents some common characteristics, it is a chert that we do not know as much at the level of formation as outcrops and it is different from Parpalló type 1. Their colourations range from brown to grey. The grain is fine, with a soft texture and opaque appearance. Internally, it has few inclusions, but there are some cavities in which silicification is observed. The cortical surface is calcareous with beige colorations and appears in semi-rounded formats. Both cortex and neocortex are indistinguishable from each other. Technologically, the quality for knapping is good. Archeologically, it appears represented in a flake and in a crest but without elements transformed by retouching. In relation to the other chert types, a first preliminary macroscopic classification allowed us to separate them from each other. The specific definition of each group and their relationship with the outcrops and other archaeological sites are in process.

The group of indeterminate cherts includes all those pieces whose characteristics have not been defined or grouped in any of the previous groups because of alterations, mainly thermal (cupules, patinas, colouration changes, crackles, etc.). From an archaeological perspective, flakes and blades dominate on which burins, splinters and scrapers are made.

From a comparative macro-spatial standpoint, the relation between Malladetes and Parpalló—one of the most important sites of the area, placed less than 5 km away from Malladetes—can be highlighted. A preliminary analysis of the different lithologies used during the Gravettian period in Parpalló shows a complete predominance of chert over minority rocks, such as limestone or

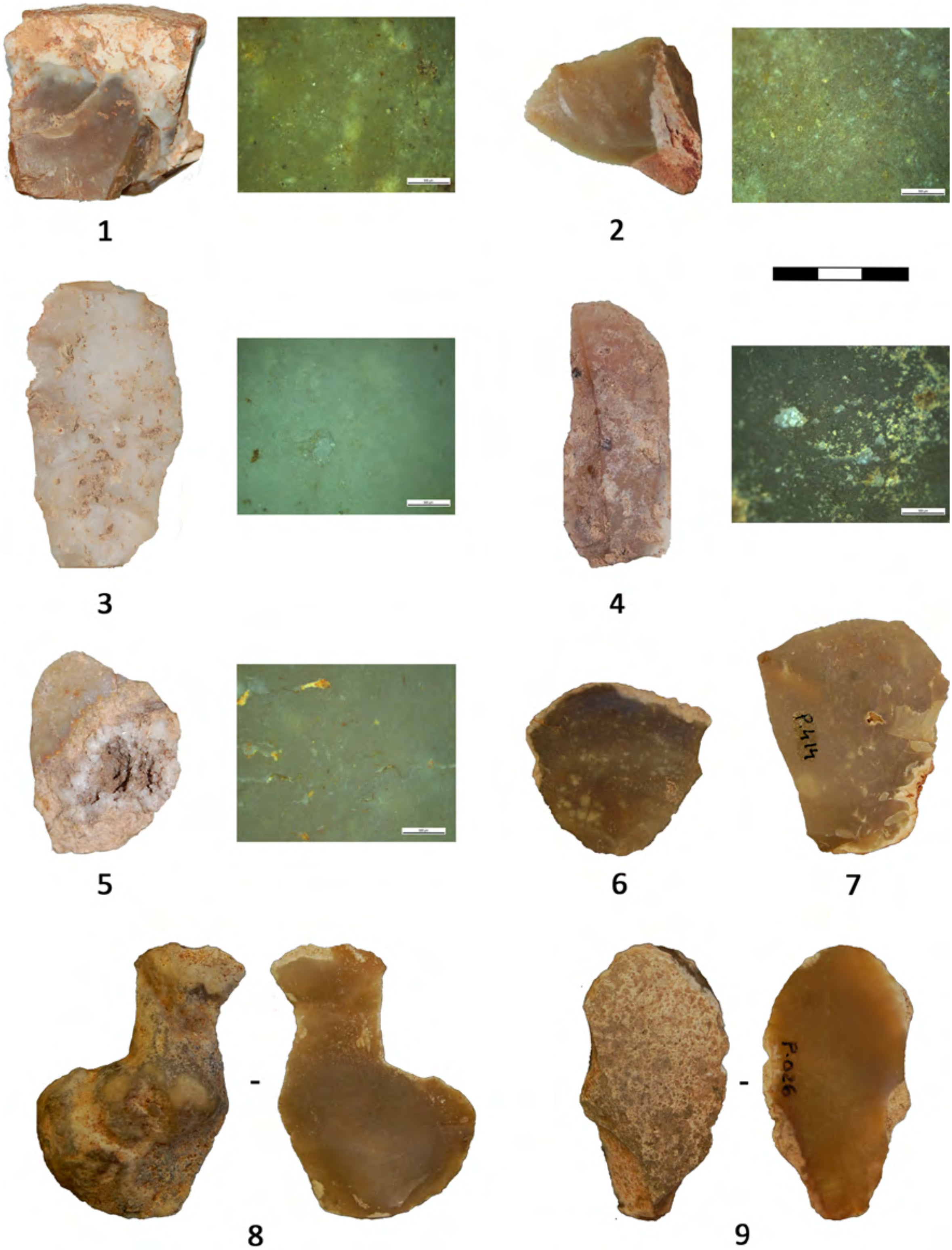

Figure 3. Chert types and macroscopic details: 1, 2- Serreta Type (Malladetes); 3, 4- Mariola Type (Malladetes); 5- Type 1 indeterminate (Malladetes); 6- Serreta Type (Parpalló); 7- Mariola Type (Parpalló); 8- Mariola Type (Parpalló) with polished cortex of marine morphology; 9- Serreta Type (Parpalló) with polished cortex of marine morphology.

jasper (Table 3). We have distinguished eight types of chert, placing predominance on Serreta and Mariola, as in Malladetes. Nevertheless, these two types represent 59% of the assemblage in Malladetes and 83% of the total in Parpalló. Despite its low quantitative importance, the lithological

	Serreta	Mariola	T1	T2	T3	T4	T5	T6	Indet. F.	Indet. Thermal	Limestone	Jasper	Total
Flakes	159 (19)	58 (4)	10		5	1		1 (1)	10 (2)	21 (2)	1		17
Laminar flakes	41 (7)	21 (1)							4 (1)	4		1 (1)	4
Blades	81 (26)	28 (7)	2 (1)		1 (1)	1 (1)			5 (1)	1 (1)			0
Bladelets	26 (2)	7	1	1 (1)	4 (2)				2	2			12
Total Blanks	307	114	13	1	10	2	0	1	21	28	1	1	499
Cores	19 (2)	17 (3)							2 (1)	3			3
CMP (Core maintenance products)	68 (18)	10 (1)	4 (1)				1 (1)		2	2			4
Debris	7	1	2						2	14			26
TOTAL	401	142	19	1	10	2	1	1	27	47	1	1	653
Retouched	69%	15%	2%	1%	3%	1%	1%	1%	5%	3%		1%	
Unretouched	60%	23,1%	3,1%		1,3%	0,2%			4,0%	8,1%	0,2%		

Table 3. Raw materials used in Gravettian levels of Parpalló differentiated by unretouched and retouched blanks (retouched material is in brackets). The lower part indicates each material's percentages of retouched and unretouched material.

diversity is higher in Parpalló, with a minimum of eight types. We must keep in mind that a part of the assemblage is undetermined and, probably, these tools would be integrated into the so-called personal mobile toolkits in contrast to the minimum of three defined types in Malladetes.

A more detailed analysis of the two main chert types (Mariola and Serreta), in relation to cortical surfaces, evidences rounded morphologies and polished surfaces of marine origin in more than 90% of the cases. In this sense, it seems that occupants from Parpalló, as those from Malladetes, caught Serreta and Mariola types in secondary deposits of coastal beaches placed 5-30 km away from the site in the Gravettian period, following the studies on the evolution of coastline (Benjamin *et al.* 2017). The Serpis river, which transported different types of cherts from the primary outcrops placed to the south, formed these deposits. In Parpalló, regarding the retouch, it affects almost the 70% of Serreta pieces, forming end-scrappers and splintered pieces, which summed to the configuration of tools in every kind of blanks (even core maintenance products or cores) in both Serreta and Mariola types, evidencing an exhaustive exploitation of both types. In the same way, the low presence of cores, the high proportion between retouched and non-retouched material, the *chaînes operatoires* fragmentation and the absence of refits in this preliminary study point to Parpalló and Malladetes a pattern of occupations fairly ephemerals.

5. Conclusions

The archaeological and geological samples analysed in this pilot study revealed distinctions among the chert samples. Preliminary macro- and microscopic analyses (EDXRF and XRD) separated different types of raw materials. The continuation of geological surveys and obtaining a greater number of samples, especially from other methods that attain a higher resolution of the elements, will create a better comparative framework for the deposits of the Upper Palaeolithic from the central region of the Mediterranean Iberia. Unlike other methods which permits examination of only the surfaces of objects, with INAA (in progress), the penetration of neutrons through a sample results in the activation of all parts of the object.

This first approach to Cova de les Malladetes' raw materials and their nearby outcrops has allowed us to establish differences between catchment areas. While the closest primary outcrops (5-15 km away) with the worst chert quality are not used, most of the archaeological remains are linked to good raw materials obtained in secondary deposits (15-30 km). These are transported from their place of origin located in more southern areas by rivers and ravines to deposit in the terraces and marine beaches near the coast. This shows us a movements of human groups through the fluvial courses in the east direction, and from there, towards to the south. Unlike the Middle Palaeolithic sites, where the presence of Grossa chert type is documented (Negra, Petxina or Bolomor), its inexistence during the Upper Palaeolithic (Parpalló, Meravelles or Barranc Blanc) is probably linked to technological constraints (laminar knapping, raw material optimisation or leptolisation).

At a diachronic scale, scarce variations in quantification is detected between the upper (VII and VIII) and the lower levels (X) ascribed to Gravettian. Only level VII shows some noteworthy characteristics, where Serreta type has the lower values of the sequence (32% of the assemblage), while Mariola type reaches its higher representation (20%). Comparing both types, this is the major balance between them. It could be also highlighted that type 1 and limestone, have the high values of the sequence, with the exception of level XIII for type 1. Thus, this advanced phase of the Gravettian period shows some diversity and relative balance within used types (32%, 20% and 17%).

In relation to level VIII, there is only chert, with a dominance of Serreta type that reaches values higher than those of level IX (70%). Mariola type (6%) and type 1 (2%) both have low quantifications, similar to their values in level IX. However, in level X—the richest unit of the whole sequence—the proportions evidence the balance of Mariola type, Type 1 and limestones; conversely, the main raw material (Serreta) reaches higher values than in previous cases, overcoming 74% of the total. This process of diachronic change is detected and increased if we compare it with Aurignacian levels. In this sense, from level XI to XIV, the pattern is stronger. Meanwhile, in the Gravettian levels, the values swing between 32% and 74%, whereas in the Aurignacian levels, the values are over 75% and even reach 96% in the case of Serreta type. In the case of Mariola chert, types 1 and 2 increase or decrease in relation to main type. This evidences a continued rise of Serreta type as we move back in time with a relative predilection, and in determined cases, an absolute dominance of this material and its use for the elaboration of tools in older moments. Also, as seen previously, a great part of these effectives were transformed by the retouch, taking advantage of a good quality lithology for lithic *débitage* and easy catching in secondary deposits (Serpis, coastal beaches, etc.) in some cases close to the site.

Regarding the comparison between Malladetes and Parpalló, some cultural conclusions arise. Based on technological and raw material data, Malladetes is a site with very short occupations with low density remains and recurrent frequency during a period with an unknown duration. Conversely, in Parpalló, the combination of economic, techno-typological and artistic data (Fullola 1979; Fortea *et al.* 1983; Villaverde 1994; Aura 1995; Villaverde *et al.* 1998; Aura *et al.* 2002) using this preliminary analysis of raw material shows a site that arises as a neuralgic centre that articulates a much wider territory to which Malladetes, and possibly Meravelles, Volcán del Faro or Barranc Blanc, belong. The high concentration of sites in this area evidences seasonal occupations linked to different biotopes exploitation by the same group articulated around Parpalló.

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Raw material procurement at Abrigo do Poço Rock shelter (Central Portugal)

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Abstract

Abrigo do Poço is a rock shelter located in the karstic canyon of Ribeira das Chitas in the River Lis basin (Central Portugal). The site has an Epipaleolithic occupation overlying a Solutrean occupation. Despite the multiple available resources in the vicinity, the main activity during the Upper Paleolithic occupation seems to have been the exploitation of a small chert outcrop located right above it. This outcrop extends in patches throughout the vicinity due to the combination of tectonic activity and fluvial erosion that results in multiple canyons. Interestingly, the outcrop above the site is one in which the chert is less expressive, probably due to exhaustion during the Solutrean, during which the site was used to heat-treat chert for the production of blades and, especially, bifacial points. The chert from this site has different colors, patterns and textures due to internal variability and to external agents (tectonic, patina). Here we present the macroscopic and geochemical characteristics of this outcrop throughout the valley and discuss the issue of potentially misleading interpretations when only one of these approaches is used.

Keywords: Epipalaeolithic; Solutrean; chert; River Lis basin; western Iberia

Résumé

Abrigo do Poço est un abri rocheux situé dans le canyon karstique de Ribeira das Chitas, dans le bassin de la rivière Lis (centre du Portugal). Le site a une occupation épipaléolithique qui recouvre une occupation solutréenne. Malgré les multiples ressources disponibles dans les environs, l'activité principale pendant l'occupation du Paléolithique supérieur semble avoir été l'exploitation d'un petit affleurement de chaille (chert) situé juste au-dessus. Cet affleurement s'étend en parcelles dans tout le voisinage en raison de la combinaison de l'activité tectonique et de l'érosion fluviale qui se traduit par de multiples canyons. Fait intéressant, l'affleurement au-dessus du site est celui dans lequel la chaille est moins massive, probablement en raison de l'épuisement pendant le Solutréen, période au cours de laquelle le site a été utilisé pour traiter à la chaleur la chaille pour la production de lames et, en particulier, des pointes bifaciales. La chaille de ce site a différentes couleurs, motifs et textures, en raison de la variabilité interne et des agents externes (tectonique, patine). Nous présentons ici les caractéristiques macroscopiques et géochimiques de cet affleurement dans toute la vallée et discutons de la question des interprétations potentiellement trompeuses, lorsqu'une seule de ces approches est utilisée.

Mots-clés : Epipaleolithique ; Solutreen ; chaille ; bassin de la riviere Lis ; Iberie occidentale

1. The EcoPLis Project

The behavioural ecology and ecodynamics of the Pleistocene and Early Holocene populations that lived in westernmost Iberia is a crucial paleoanthropological issue. This is because there is increased information about coastal foraging not only by modern humans, but also by pre-modern humans. In addition, this particular coast is rich in marine and brackish resources, including when climatic shifts resulted in increased upwelling (Abrantes 1988, 1990, 1991, 2000; Abrantes and Moita 1999; Abrantes *et al.* 1998; Fiuza 1982, 1983; Loureiro *et al.* 2005). Further still, far too often archaeological and paleoanthropological research projects tend to focus on a single landscape rather than the connection between them, resulting in a biased interpretation of the framework in which the human behaviour occurred.

To help contribute more relevant data, in 2015 we started the EcoPLis project (Human Occupations in the Pleistocene Ecotones of River Lis). The River Lis Basin (Leiria, Portugal) is an ecotone between different landscapes rich in multiple resources. This project focuses not only on the coast, but also on the inland and territories in between, giving special attention to the karstic canyons where multiple caves, rock shelters and open-air sites preserve long sequences with rich assemblages and organic material with great preservation. The recurrent presence of salty/brackish water shellfish in sites more than 25 km inland, as well as sites located on the shore were strong indicators that human populations have since the Middle Pleistocene been recurrently circulating between the coast and the inland through karstic canyons. Despite this, there has never been a systematic investigation focusing on the human behavioral ecology and patterns of coastal foraging in this region.

Through EcoPLis, we aim to solve the problem of coarse and dispersed information from westernmost Iberia in order to produce a more detailed understanding of human behavioural ecology and ecodynamics during the Pleistocene and Early Holocene. Among other issues, it aims to bring relevant data about coastal foraging patterns, from a diachronic perspective, and using a high-resolution approach. Surveys, tests and excavations in rock shelters, caves and open-air sites done since 2015 already cover a chronology from the Acheulean to the Chalcolithic. One of the sites tested and then subsequently excavated is Poço Rock Shelter.

2. Geological and geomorphological background

The River Lis basin has 850 km^2 of surface drainage and 945 km^2 taking into account its underwater drainage (Almeida *et al.* 1989; Dinis 1996; Gonçalves and Dinis 2007; INAG 1999), and runs between 585 and 0 m.a.s.l.. It is located in the Western Portuguese Mesocenozoic Edge (Almeida *et al.* 1989; Gonçalves and Dinis 2007). The basin sits on Mesozoic deposits, with the oldest ones associated with lagoon formations during the Hetangian-Recian. In the past, the continental environment produced the present plaster and salt deposits. With the Lusitanian there is a strong marine regression and the creation of marls, clays and sandstone deposits, frequently with associated fossils. In the beginning of the Jurassic the formation of the Leiria-Monte Real diapir began, and with volcanic activity, doleritic domes and lodges were formed (Teixeira *et al.* 1968). The Leiria-Parceiros and Monte Real diapirs, along with the Torrinhas/Reguengo do Fetal and Senhora do Monte main faults drove the N-S orientation of the Lis and Lena rivers, as well as the E-W orientation of most of the smaller streams, with the most important springs along the western face of the eastern mountains (Almeida *et al.* 1989).

Until the end of the Middle Jurassic there was a long-term transgressive phase that, especially during the Batonian and Callovian, resulted in a strong accumulation of calcareous sediments. However, between the Middle and Upper Jurassic there is a hiatus in the geological record (Azerêdo *et al.* 2003; Gonçalves and Dinis 2007) that is followed by a large marine transgression with the sea covering the entire region (Teixeira *et al.* 1968). In the last phase of the Cretaceous and beginning of the Cenozoic another marine regression with specific environmental conditions result in the silification of Turonian limestone. During the Cenomanian another marine transgression flooded the entire basin and between the Cenomanian and the Eocene there was strong erosion (Gonçalves and Dinis 2007; Teixeira *et al.* 1968). Through the Miocene the region was a continental landscape with lagoons but, by the Pliocene, several marine transgressions covered large areas, leaving a rich fossil record (Teixeira *et al.* 1968).

In higher areas during the Pleistocene, the drainage system created a network of canyons, caves and other karstic phenomena in the Jurassic and Cretacic deposits. This shaped a hilly landscape with steep cliffs but in lower areas it created fluvial and marine siliclastic deposits (quartz and quartzite gravels supported packed by sand to clay) over the Miocene and Pliocene formations (Gonçalves and Dinis 2007; Teixeira *et al.* 1968). It is possible that during the Last Glacial Maximum the sea level was 120 to 140 m below the present sea level, exposing hundreds of km^2 of the continental platform (Dias *et al.* 2000; Dias 2004) and creating a very different landscape, with much steeper talwegs, and making the present coast a deep inland territory. With the post-glacial progressive global warming, but particularly during the Holocene, the sea level rose and a thick dune was formed along with other eolian deposits, lagoons and estuaries (Dias 2004; Dinis 1996; Gonçalves and Dinis 2007; Teixeira *et al.* 1968).

3. Poço Rock Shelter (AdP)

Poço Rock Shelter (Figure 1) sits in the Chitas Valley, between 100 and 115 m.a.s.l., and ~26 km from the present sea coast. Around it are several primary chert outcrops. The 14 Stratigraphic Units thus far identified encompass Epipaleolithic and Solutrean archaeological horizons (Figure 2 and Table 1):

Epipaleolithic: Abundant sandy and brackish/salty waters species (*Scrobicularia plana, Cerastoderna edule* and *Ensis sp.*), micromammals, Leporidae, fragmented unidentifiable macromammal diaphyses and charcoal. The rich lithic assemblage has quartzite (fire cracks, flakes and chopper-like cores), quartz (prismatic and bipolar cores, chipped stones, small flakes and bladelets) but is mostly chert (small prismatic cores, burins, flakes and bladelets). AMS dates on Arbutus unedo (8208 ± 38 BP) and Cerastoderna edule (8276 ± 40 BP) point for an occupation at the Early-Middle Holocene transition and an AMS date on *Scrobicularia plana* (9205 ± 40 BP) may be inflated by the ecology of this species.

Stratigraphic unit.	Material	Result
1	*Scrobicularia plana*	9205 ± 40
1	*Arbutus unedo*	8208 ± 38
4	*Cerastoderna edule*	8276 ± 40
6-10	Bone (ind)*	19170 ± 120
6-10	*Salix/Populus*	209 ± 27
14	*Cervus elaphus***	18510 ± 100

Table 1. Poço Rock Shelter. AMS absolute dates.

Solutrean: Mostly composed of lithics with a small faunal assemblage dominated by *Cervus elaphus*. The lithic assemblage has quartzite (fire cracks, hammer stones, anvils, flakes and chopper-

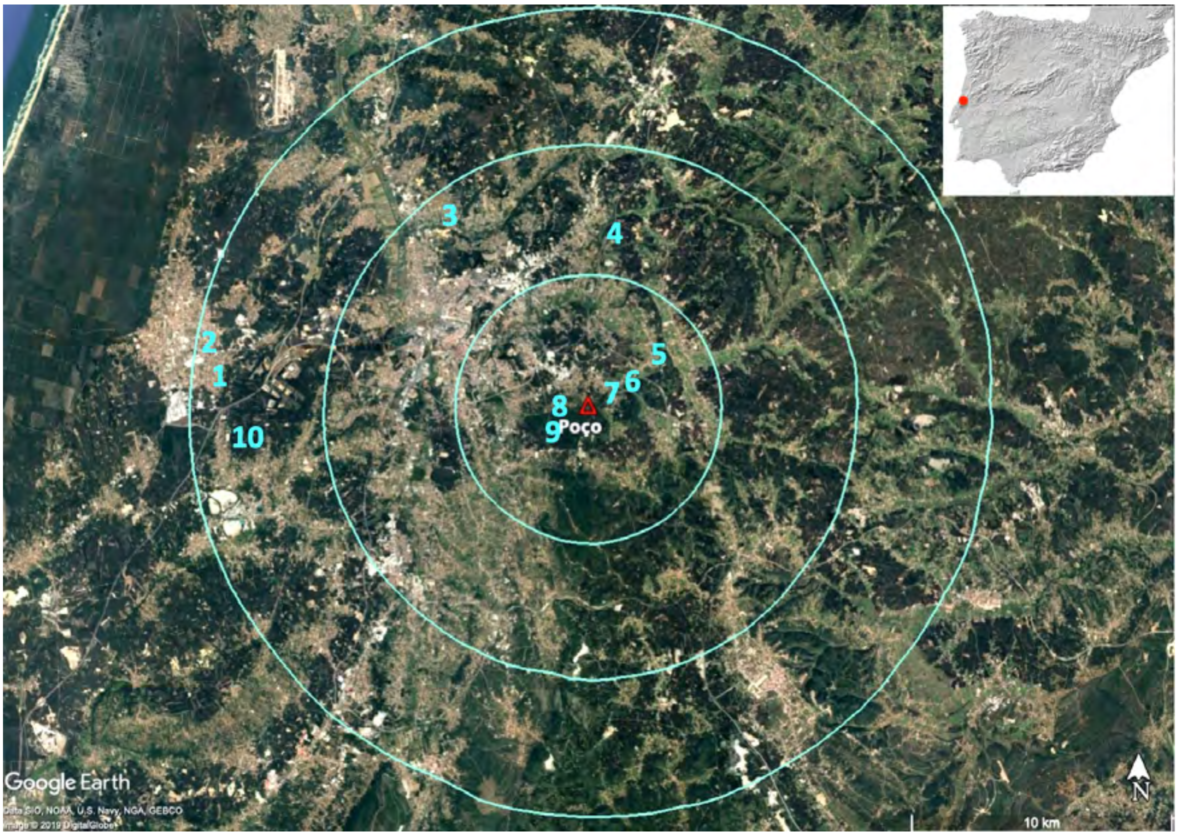

Figure 1. Poço Rock Shelter. A: Location in the Iberian Peninsula from Google Earth. and location of Poço Rock Shelter (red triangle) with 5, 10 and 15 km ranges. Chert sources: 1- Picassinos, 2- Tojeira, 3- Areeiro do Aeródromo Este (AAE); 4- Boavista, 5- Opeia, 6- Martinela, 7- Epígrafe, 8- Bancada das Chitas (BChitas), 9- Curvachia, 10- Arroteia.

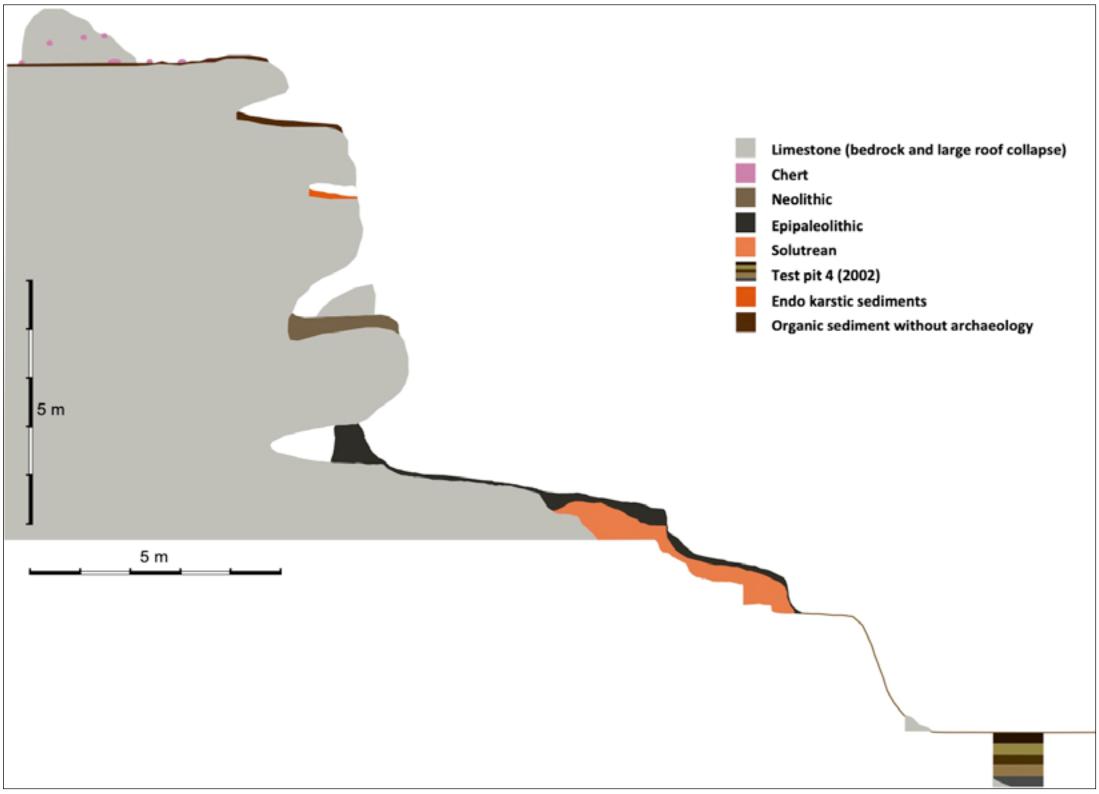

Figure 2. Poço Rock Shelter. Schematic profile with the location of the chert outcrop, the excavated trench, and the test pit excavated in 2002 that lead to the identification of the site.

like cores), quartz (prismatic and bipolar cores, chipped stones, small flakes and bladelets) but mostly chert (prismatic cores, large burins, flakes, blades and bladelets, large amounts of crests, flanks, and bifacial trimming flakes along with bifacial preforms and bifacial fragmented tips with central tang). Lithics are often burned, suggesting in situ heat-treatment. AMS dates on indeterminate bone of medium/large fauna (19,170 ± 120 BP) and *Cervus elaphus* 18,510 ± 100 BP point for an occupation at the between the GS2 and the GS3.

4. Materials and Methods

Many of the raw material sources identified and georeferenced in the River Lis basin have been previously documented but not characterized (Carvalho 2011; Carvalho and Carvalho 2007; Município de Leiria 2015). With EcoPLis we began to produce a much more detailed geographic record of these primary, sub-primary and secondary sources and their characterization. With regard to chert, primary sources were defined as a continuous limestone formation with chert nodules and/or lenses. Sub-primary sources were defined as concentrations of nodules or chunks found outside of the bedrock but adjacent to it, usually immediately in front of, or downslope of, the outcrop. Finally, secondary sources were defined as a concentration of nodules or chunks that are outside of and clearly away from the original bedrock. In this case, these nodules or chunks are usually rolled and packed in marine or fluvial terraces, or can be found along the coast, brought in by wave action. This suggests they were brought from inland by the fluvial network, or that there are other chert sources underwater that may have been available to Pleistocene hunter-gatherers when the sea was several kilometres away. Thus, these and other outcrops may not be visible (e.g. covered by a thick deposit such as a marine or fluvial terrace, dune fields, the Ocean, or construction) or no longer exist (e.g. the softer limestone with chert is highly exposed and was heavily eroded to exhaustion, modern work obliteration, etc.). The concentration can occur at the surface (often as debris flow), inside or at the surface of a terrace or below in a colluvium but often as loose gravel and usually visible due to local erosion (e.g. a road cut, torrential stream or slope dynamics) (Figure 3).

The recording of the perimeter of each visible primary, sub-primary and secondary chert source has been marked using a tablet or smartphone with GPS in order to make a georeferenced polygon with a ca. 5 m error. In the case of quartz and quartzite used for knapping, as well as other local volcanic raw materials that may have been used for knapping and adornments (Nora *et al.* 2017; Pereira *et al.* 2018), these can be found in the rich gravel deposits associated with marine and fluvial terraces. These terraces have extensive areas and most of them are already mapped on geological maps (Teixeira *et al.* 1968). For the purpose of study of the chert, we collected multiple hand samples from each source in order to cover its internal variability (size, shape, colours, internal flaws, etc.).

To identify the geochemical signature of the different chert sources in the River Lis basin, we randomly selected hand samples from each source and analysed their geochemical composition. The geochemical analysis was done from Magnesium (^{12}Mg) to Uranium (^{92}U) by p-XRF for 240 seconds (equally divided in 120 seconds for heavy and light elements) using a portable energy dispersive spectrometer Bruker™ S1 Titan®. The equipment was mounted in «Desktop Configuration» with the lid closed during analysis on a solid professional desktop. During the readings, the personnel were kept at a safe distance to avoid radiation exposure and any contact that could result in the movement of the samples. The p-XRF was equipped with a rhodium X-ray tube and FAST® SDD detector, 5 mm collimator, S1RemoteCtrl filter, and S1Sync software. The calibration used was set on the default calibration (Application Geochem General Method Dual Mining). The archaeological specimens (Figure 4) were selected in order to get the most macroscopic variability as possible, and each artefact was analysed on a clean, flat and homogeneous surface. When possible, due to the dimensions and volume of the sample, more

Figure 3. Different chert sources in the basin of the River Lis and used in this study. a) Bancada das Chitas; b) Martinela; c) Opeia; d) Remaining nodules from the Poço plateau outcrop.

than one analysis was done on each specimen. The geological specimens were analysed on a clean, flat and homogeneous fresh cut.

Statistical analysis aimed to verify internal variability of the chert samples from Poço and their similarity to other regional sources. In order to do that we performed cluster analysis (Classical hierarchical clustering) with PAST® 3.24 software using the unweighted pair group method with arithmetic mean (UPGMA) algorithm and Euclidean Similarity Index and Stratigraphy Constrained with a cophenetic correlation of 0.2332.

5. Results

Results from the geochemical analysis can be seen in Figure 5 and Table 2.

Chert specimens present macroscopic and geochemical variability. From a geochemical point of view, the chert from the River Lis basin is relatively homogeneous with regard to the presence and absence of light and heavy elements. Bancada das Chitas (BChitas), Epigafe, Curvachia correspond to the same outcrop on the valley separated by only some hundred meters. These sources show some geochemical variability, including on the same nodule (ex: 589-590, 599-600 and 605-606). Areeiro do Aeródromo Este (AAE) is a 20 m thick sand-supported terrace with a gravel-supported base dominated by quartzite and quartz but in which large pebbles of good quality and homogeneous light-red chert are easily found. Usually these nodules are distinct and the original source is still to be found. Other nodules from this terrace cluster with those from Curvachia, Opeia and Tojeira suggesting natural feeding of the River Lis terraces by local but complex fluvial erosion and transportation of nodules. Tojeira and Picassinos

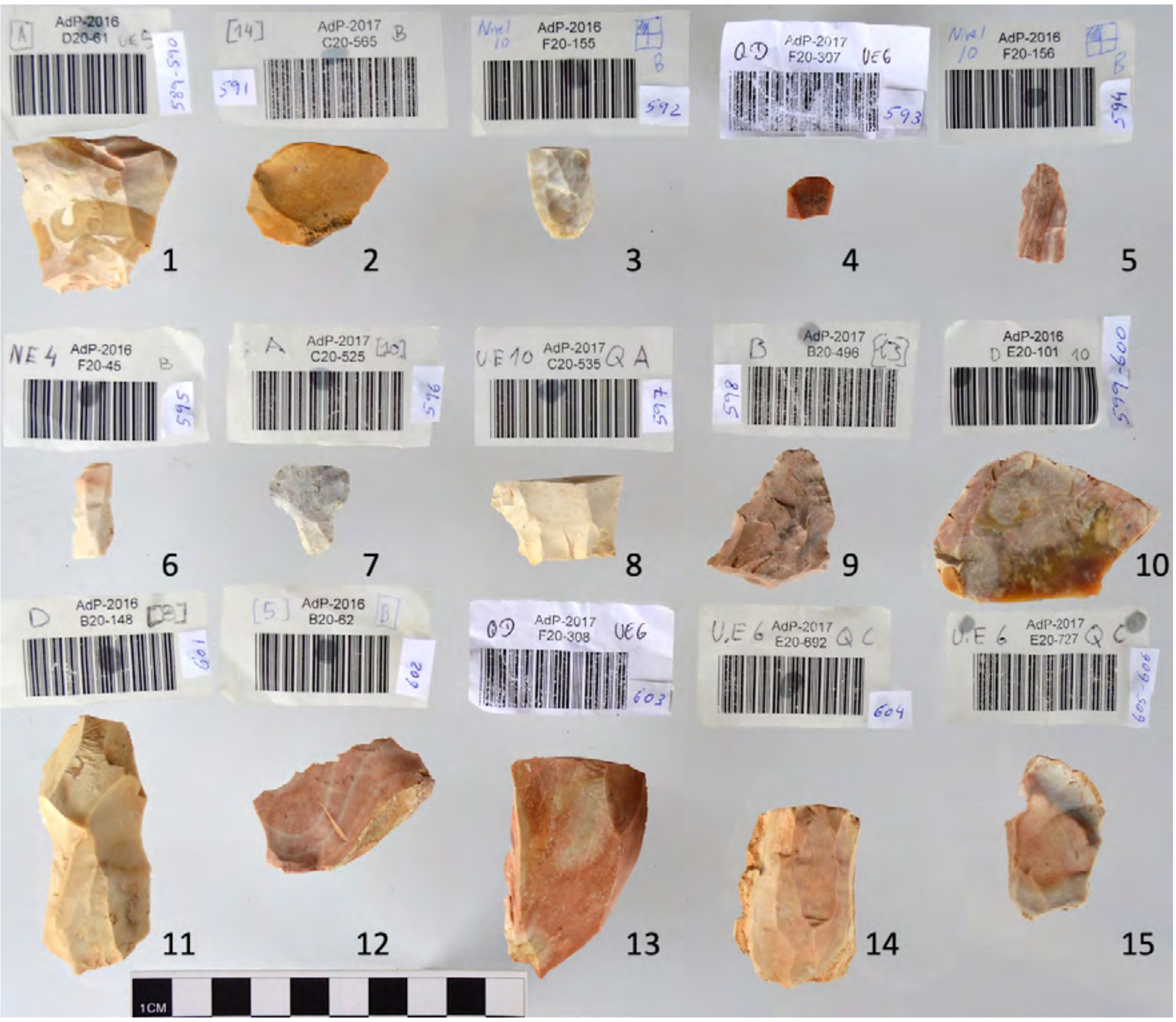

Figure 4. Poço Rock Shelter. Archaeological specimens used in this study.

correspond to a terrace with nodules in secondary position. The fact that they cluster with the samples taken from the primary and sub-primary sources of Opeia and Epígrafe reinforces this idea.

From a geochemical point of view, most samples have high values of Silicon but some samples gathered in secondary position are clearly dissilicified. Elements such as Cobalt, Nickel, Strontium, Zirconium, Molybdenum, Silver, Tin, Barium, Cerium, Tungsten and Zink are rare and Cobalt, Nickel, Zink, Silver, Tin, Barium, Cerium, Tungsten were not detected in Poço samples. Chromium was also not detected in Poço samples but is common in the ot her samples. Aluminum, Iron, Calcium and Potassium are relevant in the Poço samples.

Overall Poço (AdP) samples are very similar to each other and cluster outside of the remaining samples, suggesting an outcrop with very distinct characteristics. These characteristics are significantly different from the other nearby sources such as Bancada das Chitas, Martinela and Epígrafe, and this may have been the reason for the selection of this site for the production of the Solutrean points instead of the others, despite its being very small. Nevertheless, an overall perspective of this outcrop is difficult due to its almost complete exhaustion. Detailed and complementary analysis will be necessary in the near future, namely to recognize chert that may have been brought from other sources and discarded at Poço.

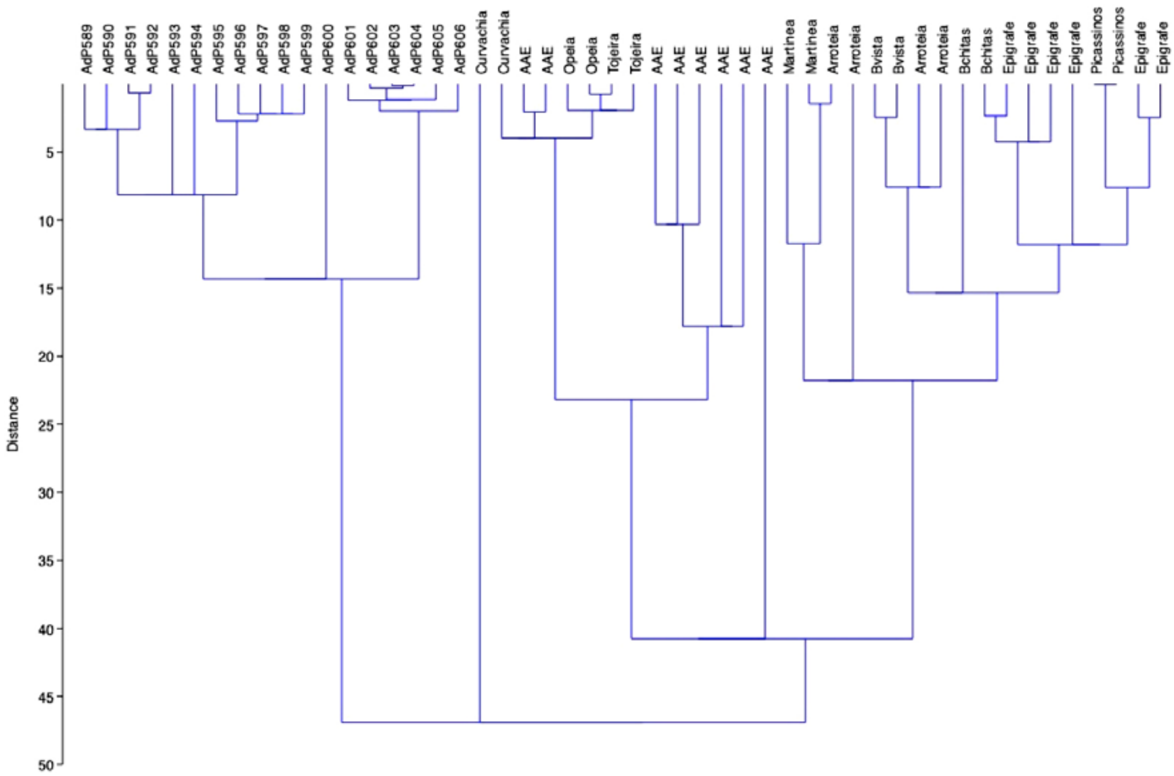

Figure 5. Classical hierarchical cluster analysis using the unweighted pair group method with arithmetic mean (UPGMA) algorithm and Euclidean similarity index and stratigraphy constraint.

6. Discussion

Previous work has shown that, following the pattern from Portugal, quartz, quartzite and chert were the most common raw materials used also in the Lis River basin during the Pleistocene and Early Holocene (Almeida *et al.* 2002; Aubry *et al.* 2005; Brás *et al.* 2006; Cunha-Ribeiro 1999; Haws *et al.* 2010; Pereira 2010; Zambujo and Carvalho 2005). These rocks occur in different conditions in the landscape. Nodules of quartz and quartzite of good quality can be easily found only in secondary position as water-worn pebbles in the gravel deposits of the marine and fluvial terraces. A different scenario occurs with chert that can be acquired in primary, sub-primary and secondary deposits. Primary deposits correspond to layers in Cenomanian limestone that can be very discrete and localized lenses or can cover larger areas but usually with ca. 100 m^2. Often the chunks gathered in these places have multiple flaws caused by tectonics that make them crumble very easily. Overall, the farther away the nodule is from the outcrop, the better its quality, because nature took care of destroying the smaller and fragile elements and of removing loose parts of larger boulders, leaving regular and homogeneous nodules of pebble- to boulder- size in the terraces. Still, these were better to use during the Acheulean, not only for the production of handaxes and cleavers but also because it is where it seems that people were living. In fact, occupations of such age are still unknown in the canyons, suggesting that the formation of the canyons may have been later, but before the Upper Palaeolithic.

The geomorphology of Chitas canyon makes it an easy and safe path between the inland mountains and the coast, while its fertile and humid conditions allow a diverse and abundant fauna and flora. As such, it may have had almost perfect ecological conditions to serve as a refuge during the harsher portions of the Pleistocene. The sheltered position of Poço Rock Shelter, facing two transversal smaller valleys, the presence of a spring, and the abundance of chert make it a perfect hunting stand. The combination of these assets in a single place may have been

File #	MgO	MgO Err	Al2O3	Al2O3 Err	SiO2	SiO2 Err	P2O5	P2O5 Err	S	S Err	Cl	Cl Err	K2O	K2O Err	CaO	CaO Err	TiO2	TiO2 Err	V	V Err	Cr
AdP589	< LOD	0.6332	0.6908	0.1630	100.0000	0.5908	0.0291	0.0092	0.0368	0.0064	< LOD	0.0120	0.0820	0.0049	0.0099	0.0039	0.0062	0.0031	< LOD	< LOD	< LOD
AdP590	0.7724	0.6680	3.6204	0.2028	98.6415	0.5698	0.0409	0.0105	0.0454	0.0066	0.0143	0.0118	0.1668	0.0059	0.0515	0.0043	0.0216	0.0031	< LOD	< LOD	< LOD
AdP591	< LOD	0.6410	0.5189	0.1629	100.0000	0.5969	0.0350	0.0096	0.0373	0.0065	< LOD	0.0117	0.0482	0.0045	0.0347	0.0042	0.0033	0.0031	< LOD	< LOD	< LOD
AdP592	< LOD	0.6331	< LOD	0.1531	100.0000	0.5847	0.0273	0.0092	0.0250	0.0064	< LOD	0.0122	0.0505	0.0046	< LOD	0.0038	0.0043	0.0032	< LOD	< LOD	< LOD
AdP593	< LOD	0.3602	0.7417	0.1506	91.6757	0.5281	0.0424	0.0083	< LOD	0.0061	0.1385	0.0164	0.0560	0.0041	< LOD	0.0034	0.0059	0.0027	< LOD	0.0002	< LOD
AdP594	< LOD	0.6549	0.4399	0.1654	100.0000	0.6217	0.0291	0.0095	0.0574	0.0068	0.0323	0.0122	0.1043	0.0053	0.0508	0.0044	0.0107	0.0031	< LOD	< LOD	< LOD
AdP595	< LOD	0.3712	0.6227	0.1544	96.3779	0.5547	0.0508	0.0096	0.0392	0.0066	0.0446	0.0139	0.0491	0.0043	0.1840	0.0057	0.0076	0.0028	< LOD	0.0001	< LOD
AdP596	< LOD	0.3810	0.5091	0.1593	100.0000	0.5992	0.0512	0.0093	0.0402	0.0064	0.0215	0.0133	0.0483	0.0044	0.1881	0.0057	0.0052	0.0029	< LOD	< LOD	< LOD
AdP597	0.6916	0.6363	0.9498	0.1641	97.7370	0.5638	0.0262	0.0094	0.0185	0.0064	< LOD	0.0124	0.0580	0.0047	0.0254	0.0042	0.0063	0.0031	0.0001	0.0001	< LOD
AdP598	< LOD	0.6419	0.6135	0.1616	100.0000	0.5760	0.0339	0.0102	0.0094	0.0063	< LOD	0.0120	0.0671	0.0049	0.0250	0.0042	0.0112	0.0031	< LOD	< LOD	< LOD
AdP599	< LOD	0.6564	1.6253	0.1758	98.0419	0.5660	0.0286	0.0099	0.0122	0.0065	< LOD	0.0126	0.1067	0.0054	< LOD	0.0040	0.0097	0.0032	0.0002	< LOD	< LOD
AdP600	0.7089	0.6018	1.4365	0.1603	84.1478	0.4909	0.0438	0.0110	< LOD	0.0065	< LOD	0.0126	0.0862	0.0050	0.3152	0.0069	0.0150	0.0031	0.0022	0.0004	< LOD
AdP601	< LOD	0.4180	2.1261	0.1850	100.0000	0.5876	0.0481	0.0107	0.0439	0.0067	< LOD	0.0115	0.0911	0.0051	0.0768	0.0046	0.0187	0.0032	< LOD	< LOD	< LOD
AdP602	< LOD	0.3850	0.6493	0.1603	100.0000	0.5873	0.0474	0.0087	< LOD	0.0062	0.0490	0.0157	0.0522	0.0043	0.0088	0.0039	0.0093	0.0028	< LOD	< LOD	< LOD
AdP603	< LOD	0.6647	0.6225	0.1660	100.0000	0.6040	0.0255	0.0094	0.0307	0.0065	< LOD	0.0121	0.0670	0.0049	0.0246	0.0041	0.0090	0.0032	< LOD	< LOD	< LOD
AdP604	< LOD	0.6813	0.7573	0.1704	100.0000	0.6084	0.0292	0.0099	0.0217	0.0064	< LOD	0.0121	0.0762	0.0051	0.0285	0.0042	0.0055	0.0032	< LOD	< LOD	< LOD
AdP605	< LOD	0.4526	1.7932	0.1904	100.0000	0.6426	0.0428	0.0102	0.0344	0.0066	0.0134	0.0131	0.1196	0.0056	0.0658	0.0046	0.0126	0.0032	< LOD	< LOD	< LOD
AdP606	0.6452	0.6017	1.4597	0.1694	98.2624	0.5668	0.0562	0.0095	0.0282	0.0062	< LOD	0.0135	0.0717	0.0046	0.1092	0.0049	0.0108	0.0029	< LOD	< LOD	< LOD
Curvachia	1.1812	0.3973	0.1501	0.1161	43.5038	0.3314	0.1381	0.0165	< LOD	0.0102	< LOD	0.0077	0.0348	0.0046	0.0916	0.0052	0.0333	0.0026	< LOD	0.0015	0.0072
Curvachia	< LOD	< LOD	0.2296	0.1688	100	0.6434	0.0717	0.0127	0.0074	0.0051	< LOD	0.0162	0.0317	0.0044	0.0188	0.004	0.004	0.0017	< LOD	< LOD	0.0069
AAE	< LOD	< LOD	0.2241	0.1534	97.0368	0.5656	0.0545	0.0121	< LOD	0.0056	0.0186	0.0159	0.0275	0.0042	0.0116	0.0038	0.0046	0.0017	0.0003	0.0001	0.0066
AAE	< LOD	< LOD	0.5593	0.157	95.0225	0.5534	0.0533	0.012	0.0148	0.0059	0.0357	0.0157	0.0576	0.0046	0.0268	0.004	0.0046	0.0016	0.0002	0.0001	0.0061
Opeia	< LOD	< LOD	< LOD	0.1518	100	0.5892	0.066	0.0109	0.0343	0.0053	0.0231	0.0152	0.0361	0.004	0.013	0.0034	0.0026	0.0016	< LOD	< LOD	0.008
Opeia	< LOD	< LOD	< LOD	0.1482	97.5249	0.5687	0.0666	0.0113	0.0128	0.0054	< LOD	0.0154	0.0255	0.0041	0.0089	0.0036	< LOD	0.0016	0.0001	< LOD	0.0073
Tojeira	< LOD	< LOD	0.278	0.1539	98.2064	0.5736	0.0643	0.0121	< LOD	0.0054	0.0202	0.0152	0.0374	0.0044	0.0534	0.0044	0.0038	0.0017	0.0001	< LOD	0.0065
Tojeira	< LOD	< LOD	< LOD	0.1564	99.7592	0.5863	0.0782	0.0132	< LOD	0.0054	< LOD	0.0153	0.0257	0.0042	0.037	0.0042	0.009	0.0018	< LOD	< LOD	0.008
AAE	1.0205	0.4041	0.7712	0.1414	72.8204	0.4467	0.0505	0.012	< LOD	0.007	0.04	0.0128	0.0969	0.0051	0.1356	0.0052	0.0124	0.0019	0.0063	0.0006	0.0033
AAE	1.2835	0.353	< LOD	0.1135	62.5505	0.4027	0.0529	0.0107	< LOD	0.007	< LOD	0.0105	0.0183	0.0037	0.0442	0.0039	0.0074	0.0018	0.0089	0.0008	0.0021
AAE	1.1205	0.4257	0.5948	0.1377	75.745	0.4586	0.0525	0.0114	< LOD	0.0063	< LOD	0.0122	0.0405	0.0041	0.0651	0.0042	0.0091	0.0018	0.0033	0.0006	0.002
AAE	< LOD	< LOD	0.7017	0.1534	90.9782	0.531	0.063	0.0117	< LOD	0.0057	< LOD	0.0152	0.0432	0.0044	0.0495	0.0042	0.0081	0.0017	0.0017	0.0002	0.007
AAE	1.0794	0.477	3.412	0.1879	73.4145	0.4526	0.1727	0.0162	< LOD	0.0071	< LOD	0.0134	0.1088	0.0052	0.0442	0.0042	0.0142	0.002	0.0031	0.0006	0.0103
AAE	1.1326	0.3684	0.2585	0.1126	47.8521	0.3437	0.1183	0.0136	< LOD	0.0086	< LOD	0.0092	0.0094	0.0037	0.0138	0.0036	0.0097	0.0021	0.0109	0.0012	0.0017
Martinea	< LOD	< LOD	0.4248	0.1733	100	0.6536	0.0719	0.0122	0.0169	0.0052	< LOD	0.0168	0.0615	0.0048	0.0402	0.0042	0.0067	0.0017	< LOD	< LOD	0.0085
Martinea	1.0829	0.4495	< LOD	0.1375	89.0487	0.5207	0.0547	0.0112	< LOD	0.0057	< LOD	0.0149	0.0242	0.004	0.0114	0.0036	0.0069	0.0017	0.0023	0.0003	0.006
Arroteia	1.2235	0.4666	0.4129	0.1459	87.659	0.5141	0.0539	0.0115	< LOD	0.006	< LOD	0.0149	0.0528	0.0045	0.0204	0.0039	0.0121	0.0018	0.0022	0.0003	0.0041
Arroteia	1.1002	0.4127	1.4292	0.1509	70.4911	0.4367	0.0523	0.0118	< LOD	0.0072	< LOD	0.0124	0.0809	0.0048	0.0254	0.0038	0.0168	0.0019	0.0063	0.0007	< LOD
Bvista	< LOD	< LOD	4.0835	0.2138	98.5383	0.576	0.0756	0.0136	0.0062	0.0056	< LOD	0.0167	0.1324	0.0057	0.0338	0.0041	0.0073	0.0016	0.0001	< LOD	0.0071
Bvista	< LOD	< LOD	6.0461	0.2378	100	0.5922	0.0798	0.0134	0.0259	0.0057	< LOD	0.016	0.1924	0.0062	0.0834	0.0046	0.012	0.0016	< LOD	< LOD	0.0078
Arroteia	< LOD	< LOD	1.6398	0.1724	92.4239	0.539	0.0531	0.0125	< LOD	0.0059	< LOD	0.0157	0.0701	0.0048	0.0228	0.004	0.0114	0.0017	0.0014	0.0002	0.0067
Arroteia	< LOD	< LOD	1.68	0.187	100	0.6306	0.0724	0.0121	0.029	0.0052	< LOD	0.016	0.0361	0.0042	0.0469	0.004	0.0063	0.0016	< LOD	< LOD	0.0043
Bchitas	1.1108	0.6269	5.0183	0.2212	82.704	0.4949	0.5452	0.0255	0.1996	0.0105	0.025	0.0163	0.2388	0.0071	0.4675	0.0082	0.0232	0.002	0.0008	0.0004	0.0112
Bchitas	< LOD	< LOD	< LOD	0.1505	100	0.5863	0.0677	0.0118	0.0133	0.0054	< LOD	0.0156	0.017	0.004	0.0184	0.0038	0.0018	0.0016	< LOD	< LOD	0.0061
Epigrafe	< LOD	< LOD	2.3177	0.1995	100	0.6377	0.0838	0.0134	0.0277	0.0054	< LOD	0.0172	0.072	0.0049	0.0876	0.0047	0.0052	0.0016	< LOD	< LOD	0.0086
Epigrafe	< LOD	< LOD	3.0157	0.1969	95.9422	0.5599	0.0736	0.0134	< LOD	0.006	< LOD	0.0162	0.0795	0.0051	0.1367	0.0054	0.0092	0.0017	0.0003	0.0001	0.0066
Epigrafe	< LOD	< LOD	4.2652	0.2212	100	0.6124	0.0888	0.0143	0.0336	0.0059	< LOD	0.017	0.1004	0.0053	0.1064	0.0049	0.0114	0.0016	< LOD	< LOD	0.0091
Epigrafe	0.9034	0.4943	2.1223	0.1748	84.8381	0.5007	0.0701	0.0129	< LOD	0.0064	< LOD	0.0148	0.0575	0.0047	0.1249	0.0051	0.011	0.0018	0.0024	0.0004	0.0046
Picassinos	< LOD	< LOD	0.2636	0.1653	100	0.629	0.0727	0.012	0.0269	0.0052	< LOD	0.0163	0.0248	0.0042	0.0355	0.0041	0.002	0.0016	< LOD	< LOD	0.0077
Picassinos	< LOD	< LOD	0.2315	0.164	100	0.62	0.0684	0.0126	0.0132	0.0053	< LOD	0.0168	0.0226	0.0043	0.0501	0.0044	0.0025	0.0017	< LOD	< LOD	0.0085
Epigrafe	< LOD	< LOD	3.9727	0.2085	92.282	0.5402	0.0869	0.0149	< LOD	0.0063	< LOD	0.0162	0.1299	0.0059	0.3777	0.0074	0.0188	0.0018	0.0011	0.0002	0.0077
Epigrafe	< LOD	< LOD	1.9069	0.178	93.5759	0.5457	0.051	0.0131	< LOD	0.0058	< LOD	0.0154	0.064	0.0048	0.098	0.0049	0.009	0.0017	0.0006	0.0001	0.0066

Table 2. Supplementary Information : results from the geochemical analysis.

File #	Cr Err	MnO	MnO Err	Fe2O3	Fe2O3 Err	Co	Co Err	Ni	Ni Err	Cu	Cu Err	Zn	Zn Err	As	As Err	Se	Se Err	Rb	Rb Err	Sr	Sr Err
AdP589	0.0014	< LOD	0.0043	0.1181	0.0044	< LOD	0.0013	< LOD	0.0005	0.0011	0.0004	< LOD	0.0001	< LOD	< LOD	< LOD	0.0002	< LOD	0.0000	< LOD	0.0004
AdP590	0.0014	< LOD	0.0041	0.1425	0.0048	< LOD	0.0013	< LOD	0.0006	0.0009	0.0004	< LOD	0.0001	< LOD	< LOD	< LOD	0.0002	< LOD	0.0000	< LOD	0.0003
AdP591	0.0014	< LOD	0.0043	0.4917	0.0084	< LOD	0.0018	< LOD	0.0005	0.0011	0.0004	< LOD	0.0001	< LOD	< LOD	< LOD	0.0002	< LOD	0.0000	< LOD	0.0003
AdP592	0.0015	< LOD	0.0041	0.0752	0.0036	< LOD	0.0012	< LOD	0.0005	0.0011	0.0004	< LOD	0.0001	< LOD	< LOD	< LOD	0.0002	< LOD	0.0000	< LOD	0.0004
AdP593	0.0013	< LOD	0.0040	0.1125	0.0043	< LOD	0.0013	< LOD	0.0006	0.0013	0.0004	< LOD	0.0001	< LOD	0.0004	< LOD	0.0002	< LOD	0.0001	< LOD	0.0003
AdP594	0.0014	< LOD	0.0040	0.1471	0.0048	< LOD	0.0013	< LOD	0.0005	0.0011	0.0004	< LOD	0.0000	< LOD	< LOD	< LOD	0.0002	< LOD	0.0000	< LOD	0.0003
AdP595	0.0013	0.0057	0.0042	0.0816	0.0038	< LOD	0.0012	< LOD	0.0006	0.0010	0.0004	< LOD	0.0001	< LOD	< LOD	< LOD	0.0002	< LOD	0.0000	< LOD	0.0003
AdP596	0.0013	< LOD	0.0045	0.0911	0.0040	< LOD	0.0012	< LOD	0.0006	0.0008	0.0004	< LOD	0.0001	< LOD	< LOD	< LOD	0.0002	< LOD	0.0000	< LOD	0.0003
AdP597	0.0015	< LOD	0.0040	0.1101	0.0043	< LOD	0.0012	< LOD	0.0005	0.0008	0.0004	< LOD	0.0001	< LOD	< LOD	< LOD	0.0002	< LOD	0.0000	< LOD	0.0004
AdP598	0.0014	< LOD	0.0044	0.1403	0.0048	< LOD	0.0013	< LOD	0.0006	0.0008	0.0004	< LOD	0.0001	< LOD	< LOD	< LOD	0.0002	< LOD	0.0000	< LOD	0.0004
AdP599	0.0015	< LOD	0.0042	0.1355	0.0047	< LOD	0.0013	< LOD	0.0006	0.0011	0.0004	< LOD	0.0001	< LOD	< LOD	< LOD	0.0002	< LOD	0.0000	< LOD	0.0003
AdP600	0.0015	< LOD	0.0039	0.1089	0.0043	< LOD	0.0012	< LOD	0.0007	0.0008	0.0004	< LOD	0.0002	< LOD	0.0013	< LOD	0.0002	< LOD	0.0002	< LOD	0.0004
AdP601	0.0014	< LOD	0.0044	0.1193	0.0045	< LOD	0.0013	< LOD	0.0006	0.0009	0.0004	< LOD	0.0001	< LOD	< LOD	< LOD	0.0002	< LOD	0.0000	< LOD	0.0003
AdP602	0.0012	< LOD	0.0048	0.1581	0.0051	< LOD	0.0015	< LOD	0.0006	0.0010	0.0004	< LOD	0.0001	< LOD	< LOD	< LOD	0.0002	< LOD	0.0000	0.0004	0.0003
AdP603	0.0014	< LOD	0.0045	0.1452	0.0048	< LOD	0.0014	< LOD	0.0005	0.0010	0.0004	< LOD	0.0001	< LOD	< LOD	< LOD	0.0002	< LOD	0.0000	< LOD	0.0003
AdP604	0.0014	< LOD	0.0045	0.1264	0.0046	< LOD	0.0013	< LOD	0.0005	0.0012	0.0004	< LOD	0.0001	< LOD	< LOD	< LOD	0.0002	< LOD	0.0000	0.0004	0.0003
AdP605	0.0014	< LOD	0.0047	0.1056	0.0043	< LOD	0.0013	< LOD	0.0005	0.0011	0.0004	< LOD	0.0000	< LOD	< LOD	< LOD	0.0003	< LOD	0.0000	0.0004	0.0002
AdP606	0.0013	< LOD	0.0045	0.1214	0.0045	< LOD	0.0013	< LOD	0.0006	0.0	0.0004	< LOD	0.0001	< LOD	< LOD	< LOD	0.0002	< LOD	0.0000	< LOD	0.0004
Curvachia	0.0013	2.0853	0.0178	< LOD	0.0047	0.0027	0.0009	< LOD	0.0008	0.0011	0.0004	< LOD	0.0003	< LOD	0.0002	< LOD	0.0003	< LOD	0.0003	< LOD	0.0003
Curvachia	0.0008	0.0057	0.0025	0.0777	0.003	< LOD	< LOD	< LOD	0.0006	0.0012	0.0004	< LOD	0.0003	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	< LOD	0.0003
AAE	0.0008	0.0025	0.0023	0.0762	0.0029	< LOD	< LOD	< LOD	0.0007	0.0008	0.0004	0.0005	0.0003	< LOD	0.0003	< LOD	0.0002	< LOD	0.0003	0.0005	0.0003
AAE	0.0008	< LOD	0.0023	0.0786	0.003	< LOD	< LOD	< LOD	0.0007	0.0011	0.0004	0.0004	0.0003	< LOD	0.0003	< LOD	0.0003	< LOD	0.0003	0.0004	0.0003
Opeia	0.0008	0.0027	0.0025	0.0651	0.0028	< LOD	< LOD	< LOD	0.0007	0.0009	0.0004	< LOD	0.0003	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	< LOD	0.0004
Opeia	0.0008	0.0025	0.0023	0.057	0.0026	< LOD	< LOD	< LOD	0.0007	0.0011	0.0004	< LOD	0.0003	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	< LOD	0.0003
Tojeira	0.0009	0.0042	0.0024	0.0793	0.003	< LOD	< LOD	< LOD	0.0007	0.0008	0.0004	< LOD	0.0003	< LOD	0.0003	< LOD	0.0002	< LOD	0.0003	< LOD	0.0003
Tojeira	0.0008	0.0031	0.0025	0.4113	0.0064	< LOD	< LOD	< LOD	0.0007	0.0011	0.0004	0.0006	0.0003	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	< LOD	0.0003
AAE	0.0009	0.0024	0.0021	0.0659	0.0027	< LOD	0.0002	< LOD	0.0008	0.0009	0.0004	0.0004	0.0004	< LOD	0.0003	< LOD	0.0003	< LOD	0.0003	< LOD	0.0004
AAE	0.0009	0.0033	0.002	0.0792	0.0029	< LOD	0.0004	0.0012	0.0009	0.0014	0.0004	0.0005	0.0004	< LOD	0.0003	< LOD	0.0003	< LOD	0.0003	< LOD	0.0004
AAE	0.0009	0.0039	0.0021	0.0724	0.0028	< LOD	0.0001	< LOD	0.0008	0.0011	0.0004	< LOD	0.0003	< LOD	0.0003	< LOD	0.0003	< LOD	0.0003	< LOD	0.0004
AAE	0.0008	0.0034	0.0023	0.0877	0.0031	< LOD	< LOD	< LOD	0.0007	0.001	0.0004	0.0003	0.0003	< LOD	0.0003	< LOD	0.0003	< LOD	0.0002	< LOD	0.0003
AAE	0.001	0.0039	0.0024	0.5373	0.0071	< LOD	0.0002	< LOD	0.0007	0.0012	0.0004	0.0005	0.0003	< LOD	0.0003	< LOD	0.0003	< LOD	0.0003	< LOD	0.0003
AAE	0.0011	0.0027	0.002	0.3809	0.0059	< LOD	0.0009	0.0013	0.001	0.0012	0.0005	0.0004	0.0004	< LOD	0.0002	< LOD	0.0003	< LOD	0.0003	< LOD	0.0004
Martinea	0.0008	< LOD	0.0026	0.0842	0.0031	< LOD	< LOD	< LOD	0.0006	0.0007	0.0003	0.0003	0.0003	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	0.0004	0.0003
Martinea	0.0009	< LOD	0.0022	0.0655	0.0027	< LOD	< LOD	< LOD	0.0007	0.0011	0.0004	0.0005	0.0003	< LOD	0.0003	< LOD	0.0003	< LOD	0.0003	< LOD	0.0004
Arroteia	0.0009	0.0034	0.0022	0.0807	0.003	< LOD	< LOD	< LOD	0.0007	0.001	0.0004	< LOD	0.0003	< LOD	0.0003	< LOD	0.0003	< LOD	0.0003	< LOD	0.0003
Arroteia	0.0009	0.0031	0.0021	0.0718	0.0028	< LOD	0.0002	< LOD	0.0008	0.0011	0.0004	0.0004	0.0003	< LOD	0.0003	< LOD	0.0003	< LOD	0.0003	< LOD	0.0004
Bvista	0.0008	0.0041	0.0024	0.1065	0.0034	< LOD	< LOD	< LOD	0.0007	0.0012	0.0004	0.0004	0.0003	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	< LOD	0.0003
Bvista	0.0008	0.0036	0.0025	0.122	0.0036	< LOD	< LOD	< LOD	0.0006	0.0009	0.0003	0	0.0003	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	< LOD	0.0003
Arroteia	0.0008	< LOD	0.0023	0.0772	0.0029	< LOD	< LOD	< LOD	0.0007	0.001	0.0004	0	0.0003	< LOD	0.0003	< LOD	0.0003	< LOD	0.0002	< LOD	0.0003
Arroteia	0.0008	0.0033	0.0026	0.0677	0.0029	< LOD	< LOD	< LOD	0.0007	0.0012	0.0004	0.0004	0.0003	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	< LOD	0.0003
Bchitas	0.001	0.0167	0.0028	0.2513	0.0051	< LOD	< LOD	< LOD	0.0006	0.0012	0.0003	0.0005	0.0003	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	< LOD	0.0004
Bchitas	0.0008	0.0028	0.0024	0.0661	0.0028	< LOD	< LOD	< LOD	0.0007	0.001	0.0004	0	0.0003	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	< LOD	0.0003
Epigrafe	0.0008	0.0037	0.0025	0.1138	0.0035	< LOD	< LOD	< LOD	0.0006	0.001	0.0003	0.0003	0.0003	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	< LOD	0.0003
Epigrafe	0.0009	0.0043	0.0024	0.0955	0.0032	< LOD	< LOD	< LOD	0.0006	0.001	0.0003	0.0004	0.0003	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	< LOD	0.0003
Epigrafe	0.0008	0.0049	0.0026	0.0965	0.0033	< LOD	< LOD	< LOD	0.0006	0.0009	0.0003	0.0003	0.0003	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	< LOD	0.0004
Epigrafe	0.0009	0.0042	0.0022	0.0855	0.003	< LOD	< LOD	< LOD	0.0007	0.0009	0.0004	0.0003	0.0003	< LOD	0.0003	< LOD	0.0003	< LOD	0.0003	< LOD	0.0003
Picassinos	0.0008	0.0025	0.0025	0.0965	0.0033	< LOD	< LOD	< LOD	0.0006	0.001	0.0004	0.0003	0.0003	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	< LOD	0.0003
Picassinos	0.0008	0.0032	0.0025	0.0744	0.0029	< LOD	< LOD	< LOD	0.0006	0.001	0.0004	0.0004	0.0003	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	< LOD	0.0004
Epigrafe	0.0009	0.0036	0.0024	0.1402	0.0038	< LOD	< LOD	< LOD	0.0007	0.001	0.0004	0.0005	0.0003	< LOD	0.0003	< LOD	0.0002	< LOD	0.0003	< LOD	0.0004
Epigrafe	0.0009	0.003	0.0023	0.1117	0.0034	< LOD	< LOD	< LOD	0.0007	0.0011	0.0004	0	0.0003	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	< LOD	0.0004

Table 2. Continued.

File #	Y	Y Err	Zr	Zr Err	Nb	Nb Err	Mo	Mo Err	Rh	Rh Err	Pd	Pd Err	Ag	Ag Err	Cd	Cd Err	Sn	Sn Err	Sb	Sb Err	Ba	Ba Err	La
AdP589	< LOD	0.0003	< LOD	0.0003	< LOD	< LOD	< LOD	0.0001	< LOD	< LOD	< LOD	< LOD	< LOD	0.0000	< LOD	0.0000	< LOD	0.0015	< LOD	0.0000	< LOD	0.0102	< LOD
AdP590	< LOD	0.0003	< LOD	0.0002	< LOD	< LOD	< LOD	0.0002	< LOD	< LOD	< LOD	< LOD	< LOD	0.0000	< LOD	0.0000	< LOD	0.0018	< LOD	0.0000	< LOD	0.0107	< LOD
AdP591	< LOD	0.0003	< LOD	0.0002	< LOD	< LOD	< LOD	0.0001	< LOD	< LOD	< LOD	< LOD	< LOD	0.0000	< LOD	0.0000	< LOD	0.0013	< LOD	0.0000	< LOD	0.0096	< LOD
AdP592	< LOD	0.0003	< LOD	0.0003	< LOD	< LOD	< LOD	0.0002	< LOD	< LOD	< LOD	< LOD	< LOD	0.0000	< LOD	0.0000	< LOD	0.0017	< LOD	0.0000	< LOD	0.0082	< LOD
AdP593	< LOD	0.0002	< LOD	0.0004	< LOD	< LOD	< LOD	0.0004	< LOD	< LOD	< LOD	< LOD	< LOD	0.0000	< LOD	0.0003	< LOD	0.0030	< LOD	0.0000	< LOD	0.0113	< LOD
AdP594	< LOD	0.0003	< LOD	0.0002	< LOD	< LOD	0.0001	0.0001	< LOD	< LOD	< LOD	< LOD	< LOD	0.0000	< LOD	0.0000	< LOD	0.0008	< LOD	0.0000	< LOD	0.0080	< LOD
AdP595	< LOD	0.0002	< LOD	0.0003	< LOD	< LOD	< LOD	0.0003	< LOD	< LOD	< LOD	< LOD	< LOD	0.0000	< LOD	0.0001	< LOD	0.0024	< LOD	0.0000	< LOD	0.0113	< LOD
AdP596	< LOD	0.0003	< LOD	0.0003	< LOD	< LOD	0.0001	0.0001	< LOD	< LOD	< LOD	< LOD	< LOD	0.0000	< LOD	0.0000	< LOD	0.0013	< LOD	0.0000	< LOD	0.0104	< LOD
AdP597	< LOD	0.0003	< LOD	0.0003	< LOD	< LOD	< LOD	0.0002	< LOD	< LOD	< LOD	< LOD	< LOD	0.0000	< LOD	0.0000	< LOD	0.0021	< LOD	0.0000	< LOD	0.0104	< LOD
AdP598	< LOD	0.0003	< LOD	0.0003	< LOD	< LOD	< LOD	0.0002	< LOD	< LOD	< LOD	< LOD	< LOD	0.0000	< LOD	0.0000	< LOD	0.0016	< LOD	0.0000	< LOD	0.0107	< LOD
AdP599	< LOD	0.0003	< LOD	0.0003	< LOD	< LOD	0.0003	0.0002	< LOD	< LOD	< LOD	< LOD	< LOD	0.0000	< LOD	0.0000	< LOD	0.0021	< LOD	0.0000	< LOD	0.0111	< LOD
AdP600	< LOD	0.0002	< LOD	0.0005	< LOD	< LOD	< LOD	0.0006	< LOD	< LOD	< LOD	< LOD	< LOD	0.0000	< LOD	0.0008	< LOD	0.0044	< LOD	0.0010	< LOD	0.0115	< LOD
AdP601	< LOD	0.0003	< LOD	0.0002	< LOD	< LOD	0.0002	0.0001	< LOD	< LOD	< LOD	< LOD	< LOD	0.0000	< LOD	0.0000	< LOD	0.0015	< LOD	0.0000	< LOD	0.0090	< LOD
AdP602	< LOD	0.0003	0.0003	0.0003	< LOD	< LOD	0.0002	0.0002	< LOD	< LOD	< LOD	< LOD	< LOD	0.0000	< LOD	0.0000	< LOD	0.0017	< LOD	0.0000	< LOD	0.0118	< LOD
AdP603	< LOD	0.0003	< LOD	0.0002	< LOD	< LOD	0.0001	0.0001	< LOD	< LOD	< LOD	< LOD	< LOD	0.0000	< LOD	0.0000	< LOD	0.0012	< LOD	0.0000	< LOD	0.0104	< LOD
AdP604	< LOD	0.0003	< LOD	0.0002	< LOD	< LOD	0.0001	0.0001	< LOD	< LOD	< LOD	< LOD	< LOD	0.0000	< LOD	0.0000	< LOD	0.0011	< LOD	0.0000	< LOD	0.0084	< LOD
AdP605	< LOD	0.0003	< LOD	0.0001	< LOD	< LOD	0.0000	0.0000	< LOD	< LOD	< LOD	< LOD	< LOD	0.0000	< LOD	0.0000	< LOD	0.0005	< LOD	0.0000	< LOD	0.0081	< LOD
AdP606	< LOD	0.0003	< LOD	0.0003	< LOD	< LOD	< LOD	0.0002	< LOD	< LOD	< LOD	< LOD	< LOD	0.0000	< LOD	0.0000	< LOD	0.0022	< LOD	0.0000	< LOD	0.0099	< LOD
Curvachia	< LOD	0.0003	< LOD	0.0002	< LOD	0.0003	0.0007	0.0004	< LOD	0.0009	< LOD	< LOD	< LOD	0.0008	< LOD	0.001	< LOD	0.0104	< LOD	0.0015	< LOD	0.01	< LOD
Curvachia	< LOD	0.0003	< LOD	0.0002	< LOD	0.0001	0.0004	0.0003	< LOD	0.001	< LOD	0.0018	< LOD	0.0007	< LOD	0.0009	< LOD	< LOD	< LOD	0.0013	< LOD	0.0116	< LOD
AAE	< LOD	0.0003	< LOD	0.0002	< LOD	0.0001	< LOD	0.0003	< LOD	0.001	< LOD	< LOD	< LOD	0.0007	< LOD	0.0009	< LOD	0.0002	< LOD	0.0019	0.0255	0.0102	< LOD
AAE	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	< LOD	0.0004	< LOD	0.0009	< LOD	0.0017	< LOD	0.0007	< LOD	0.0009	< LOD	0.0006	< LOD	0.002	0.0166	0.0105	< LOD
Opeia	< LOD	0.0003	< LOD	0.0002	< LOD	0.0001	< LOD	0.0003	< LOD	0.0017	< LOD	< LOD	< LOD	0.0007	< LOD	0.0009	< LOD	< LOD	< LOD	0.002	< LOD	0.0129	< LOD
Opeia	< LOD	0.0003	< LOD	0.0002	< LOD	0.0001	< LOD	0.0003	< LOD	0.001	< LOD	0.0017	< LOD	0.0007	< LOD	0.0009	< LOD	0.0001	< LOD	0.0019	< LOD	0.0121	< LOD
Tojeira	< LOD	0.0003	< LOD	0.0002	< LOD	0.0001	< LOD	0.0003	< LOD	0.001	< LOD	< LOD	< LOD	0.0007	< LOD	0.0009	< LOD	< LOD	< LOD	0.0019	< LOD	0.01	< LOD
Tojeira	< LOD	0.0003	0.0002	0.0002	< LOD	0.0001	0.0005	0.0003	< LOD	0.001	< LOD	0.0018	< LOD	0.0007	< LOD	0.0009	< LOD	< LOD	< LOD	0.0018	< LOD	0.0096	< LOD
AAE	< LOD	0.0004	< LOD	0.0003	< LOD	0.0003	< LOD	0.0004	< LOD	0.0008	< LOD	< LOD	< LOD	0.0009	< LOD	0.0011	< LOD	0.0045	< LOD	0.0016	< LOD	0.0128	< LOD
AAE	< LOD	0.0004	< LOD	0.0003	< LOD	0.0003	< LOD	0.0005	< LOD	0.0008	< LOD	< LOD	< LOD	0.001	< LOD	0.0012	< LOD	0.006	< LOD	0.0025	< LOD	0.0134	< LOD
AAE	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	< LOD	0.0004	< LOD	0.0009	< LOD	< LOD	< LOD	0.0009	< LOD	0.001	< LOD	0.004	< LOD	0.0022	< LOD	0.0127	< LOD
AAE	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	0.0005	0.0004	< LOD	0.0009	< LOD	< LOD	< LOD	0.0007	< LOD	0.001	< LOD	0.0013	< LOD	0.002	< LOD	0.0124	< LOD
AAE	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	0.0005	0.0004	< LOD	0.0009	< LOD	< LOD	< LOD	0.0007	< LOD	0.001	< LOD	0.0044	< LOD	0.002	< LOD	0.0116	< LOD
AAE	< LOD	0.0004	< LOD	0.0003	< LOD	0.0004	< LOD	0.0005	< LOD	0.0008	< LOD	< LOD	< LOD	0.001	< LOD	0.0012	0.0103	0.0083	< LOD	0.0026	< LOD	0.013	< LOD
Martinea	< LOD	0.0003	< LOD	0.0002	< LOD	0.0001	< LOD	0.0003	< LOD	0.0011	< LOD	0.0019	< LOD	0.0007	< LOD	0.0008	< LOD	< LOD	< LOD	0.0017	< LOD	0.0115	< LOD
Martinea	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	< LOD	0.0004	< LOD	0.0009	< LOD	< LOD	< LOD	0.0007	< LOD	0.001	< LOD	0.0018	< LOD	0.002	< LOD	0.0123	< LOD
Arroteia	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	0.0007	0.0004	< LOD	0.0009	< LOD	< LOD	< LOD	0.0007	< LOD	0.001	< LOD	0.002	< LOD	0.0014	< LOD	0.01	< LOD
Arroteia	< LOD	0.0004	< LOD	0.0002	< LOD	0.0003	< LOD	0.0004	< LOD	0.0008	< LOD	< LOD	< LOD	0.0009	< LOD	0.0011	< LOD	0.0049	< LOD	0.0023	< LOD	0.0127	< LOD
Bvista	< LOD	0.0003	< LOD	0.0002	< LOD	0.0001	< LOD	0.0003	< LOD	0.001	< LOD	0.0018	< LOD	0.0007	< LOD	0.0009	< LOD	< LOD	< LOD	0.0013	< LOD	0.0122	< LOD
Bvista	< LOD	0.0003	< LOD	0.0002	< LOD	0.0001	< LOD	0.0003	< LOD	0.001	< LOD	0.0018	< LOD	0.0007	< LOD	0.0009	< LOD	< LOD	< LOD	0.0013	< LOD	0.0122	< LOD
Arroteia	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	< LOD	0.0004	< LOD	0.0009	< LOD	< LOD	< LOD	0.0007	< LOD	0.0009	< LOD	0.001	< LOD	0.0019	< LOD	0.012	< LOD
Arroteia	< LOD	0.0003	< LOD	0.0002	< LOD	0.0001	0.0005	0.0003	< LOD	0.0018	< LOD	< LOD	0.0014	0.0007	< LOD	0.0009	< LOD	< LOD	< LOD	0.002	< LOD	0.0134	< LOD
Bchitas	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	< LOD	0.0003	< LOD	0.001	< LOD	0.0018	< LOD	0.0007	< LOD	0.0009	< LOD	0.0026	< LOD	0.0013	< LOD	0.011	< LOD
Bchitas	< LOD	0.0003	< LOD	0.0002	< LOD	0.0001	0.0005	0.0003	< LOD	0.001	< LOD	< LOD	< LOD	0.0007	< LOD	0.0009	< LOD	< LOD	< LOD	0.0019	< LOD	0.0124	< LOD
Epigrafe	< LOD	0.0003	< LOD	0.0002	< LOD	0.0001	< LOD	0.0003	< LOD	< LOD	< LOD	0.0018	< LOD	0.0007	< LOD	0.0009	< LOD	< LOD	< LOD	0.0018	< LOD	0.0119	< LOD
Epigrafe	< LOD	0.0003	< LOD	0.0002	< LOD	0.0001	< LOD	0.0003	< LOD	0.001	< LOD	< LOD	< LOD	0.0007	< LOD	0.0009	< LOD	0.0001	< LOD	0.0018	< LOD	0.0117	< LOD
Epigrafe	< LOD	0.0003	< LOD	0.0002	< LOD	0.0001	< LOD	0.0003	< LOD	0.001	< LOD	0.0018	< LOD	0.0007	< LOD	0.0009	< LOD	< LOD	< LOD	0.0018	< LOD	0.012	< LOD
Epigrafe	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	< LOD	0.0004	< LOD	0.0009	< LOD	< LOD	< LOD	0.0007	< LOD	0.001	< LOD	0.0024	< LOD	0.0014	< LOD	0.0098	< LOD
Picassinos	< LOD	0.0003	< LOD	0.0002	< LOD	0.0001	< LOD	0.0003	< LOD	0.001	< LOD	0.0018	< LOD	0.0007	< LOD	0.0009	< LOD	< LOD	< LOD	0.0018	< LOD	0.01	< LOD
Picassinos	< LOD	0.0003	< LOD	0.0002	< LOD	0.0001	< LOD	0.0003	< LOD	0.001	< LOD	< LOD	< LOD	0.0007	< LOD	0.0009	< LOD	< LOD	< LOD	0.0018	< LOD	0.0119	< LOD
Epigrafe	< LOD	0.0003	< LOD	0.0002	< LOD	0.0001	< LOD	0.0003	< LOD	0.001	< LOD	< LOD	< LOD	0.0007	< LOD	0.0009	< LOD	0.0008	< LOD	0.0019	< LOD	0.0116	< LOD
Epigrafe	< LOD	0.0003	< LOD	0.0002	< LOD	0.0002	< LOD	0.0004	< LOD	0.0009	< LOD	< LOD	< LOD	0.0007	< LOD	0.0009	< LOD	0.0007	< LOD	0.002	< LOD	0.0122	< LOD

Table 2. Continued.

File #	La Err	Ce	Ce Err	Hf	Hf Err	Ta	Ta Err	W	W Err	Pt	Pt Err	Au	Au Err	Hg	Hg Err	Tl	Tl Err	Pb	Pb Err	Bi	Bi Err	Th	Th Err	U	U Err
AdP589	0.0141	< LOD	0.0054	< LOD	0.0017	< LOD	0.0047	< LOD	0.0036	< LOD	0.0012	< LOD	0.0005	< LOD	0.0026	< LOD	0.0004	< LOD	0.0010	< LOD	0.0004	< LOD	0.0015	< LOD	0.0006
AdP590	0.0110	< LOD	0.0054	< LOD	0.0015	< LOD	0.0045	< LOD	0.0035	< LOD	0.0012	< LOD	0.0005	< LOD	0.0025	< LOD	0.0005	< LOD	0.0009	< LOD	0.0005	< LOD	0.0015	< LOD	0.0005
AdP591	0.0134	< LOD	0.0052	< LOD	0.0016	< LOD	0.0046	< LOD	0.0035	< LOD	0.0012	< LOD	0.0005	< LOD	0.0025	< LOD	0.0004	< LOD	0.0009	< LOD	0.0004	< LOD	0.0015	< LOD	0.0004
AdP592	0.0095	< LOD	0.0056	< LOD	0.0017	< LOD	0.0081	< LOD	0.0036	< LOD	0.0012	< LOD	0.0005	< LOD	0.0026	< LOD	0.0005	< LOD	0.0009	< LOD	0.0005	< LOD	0.0015	< LOD	0.0006
AdP593	0.0102	< LOD	0.0040	< LOD	0.0016	< LOD	0.0040	< LOD	0.0033	< LOD	0.0011	< LOD	0.0005	< LOD	0.0023	< LOD	0.0003	< LOD	0.0008	< LOD	0.0012	< LOD	0.0015	< LOD	0.0011
AdP594	0.0111	< LOD	0.0050	< LOD	0.0016	< LOD	0.0045	< LOD	0.0035	< LOD	0.0012	< LOD	0.0005	< LOD	0.0024	< LOD	0.0004	< LOD	0.0009	< LOD	0.0001	< LOD	0.0015	< LOD	0.0002
AdP595	0.0149	< LOD	0.0040	< LOD	0.0016	< LOD	0.0044	< LOD	0.0035	< LOD	0.0011	0.0006	0.0005	< LOD	0.0024	< LOD	0.0004	< LOD	0.0009	< LOD	0.0008	< LOD	0.0015	< LOD	0.0009
AdP596	0.0144	< LOD	0.0047	< LOD	0.0016	< LOD	0.0046	< LOD	0.0035	< LOD	0.0012	< LOD	0.0005	< LOD	0.0025	< LOD	0.0004	< LOD	0.0009	< LOD	0.0003	< LOD	0.0015	< LOD	0.0005
AdP597	0.0099	< LOD	0.0057	< LOD	0.0016	< LOD	0.0046	< LOD	0.0035	< LOD	0.0012	< LOD	0.0005	< LOD	0.0026	< LOD	0.0004	< LOD	0.0009	< LOD	0.0007	< LOD	0.0015	< LOD	0.0008
AdP598	0.0148	< LOD	0.0054	< LOD	0.0017	< LOD	0.0047	< LOD	0.0037	< LOD	0.0012	< LOD	0.0005	< LOD	0.0026	< LOD	0.0004	< LOD	0.0009	< LOD	0.0005	< LOD	0.0015	< LOD	0.0006
AdP599	0.0108	< LOD	0.0058	< LOD	0.0019	< LOD	0.0048	< LOD	0.0037	< LOD	0.0012	< LOD	0.0005	< LOD	0.0026	< LOD	0.0004	< LOD	0.0010	< LOD	0.0007	< LOD	0.0015	< LOD	0.0007
AdP600	0.0126	< LOD	0.0062	< LOD	0.0017	< LOD	0.0072	< LOD	0.0036	< LOD	0.0011	0.0005	0.0005	< LOD	0.0026	< LOD	0.0003	< LOD	0.0010	< LOD	0.0018	< LOD	0.0016	< LOD	0.0018
AdP601	0.0158	< LOD	0.0052	< LOD	0.0016	< LOD	0.0047	< LOD	0.0035	< LOD	0.0012	< LOD	0.0005	< LOD	0.0025	< LOD	0.0004	< LOD	0.0009	< LOD	0.0004	< LOD	0.0015	< LOD	0.0005
AdP602	0.0114	< LOD	0.0038	< LOD	0.0017	< LOD	0.0046	< LOD	0.0035	< LOD	0.0012	0.0006	0.0005	< LOD	0.0025	< LOD	0.0004	< LOD	0.0009	< LOD	0.0005	< LOD	0.0015	< LOD	0.0006
AdP603	0.0102	< LOD	0.0053	< LOD	0.0016	< LOD	0.0049	< LOD	0.0037	< LOD	0.0013	< LOD	0.0006	< LOD	0.0026	< LOD	0.0004	< LOD	0.0009	< LOD	0.0003	< LOD	0.0015	< LOD	0.0004
AdP604	0.0102	< LOD	0.0053	< LOD	0.0016	< LOD	0.0079	< LOD	0.0036	< LOD	0.0012	< LOD	0.0005	< LOD	0.0025	< LOD	0.0004	< LOD	0.0009	< LOD	0.0002	< LOD	0.0015	< LOD	0.0003
AdP605	0.0146	< LOD	0.0050	< LOD	0.0017	< LOD	0.0048	< LOD	0.0036	< LOD	0.0012	0.0007	0.0006	< LOD	0.0027	< LOD	0.0005	< LOD	0.0010	< LOD	0.0000	< LOD	0.0015	< LOD	0.0000
AdP606	0.0117	< LOD	0.0047	< LOD	0.0015	< LOD	0.0076	0.0040	0.0034	< LOD	0.0012	< LOD	0.0005	< LOD	0.0024	< LOD	0.0004	< LOD	0.0008	< LOD	0.0006	< LOD	0.0015	< LOD	0.0007
Curvachia	0.0188	0.1002	0.0091	< LOD	0.0015	< LOD	0.0003	< LOD	0.0004	< LOD	0.0007	< LOD	0.0005	< LOD	0.0003	< LOD	0.0003	< LOD	0.0008	< LOD	0.0009	< LOD	0.0012	< LOD	0.0025
Curvachia	0.0113	< LOD	< LOD	< LOD	0.0018	< LOD	0.0002	< LOD	0.0004	< LOD	0.0006	0.0007	0.0005	< LOD	0.0005	< LOD	0.0005	< LOD	0.0007	< LOD	0.0008	< LOD	0.0011	< LOD	0.0022
AAE	0.0176	< LOD	< LOD	< LOD	0.0015	< LOD	0.0002	< LOD	0.0004	< LOD	0.0006	< LOD	0.0005	< LOD	0.0004	< LOD	0.0005	< LOD	0.0007	< LOD	0.0008	< LOD	0.0011	< LOD	0.0024
AAE	0.0187	< LOD	< LOD	< LOD	0.0016	< LOD	0.0002	< LOD	0.0004	< LOD	0.0006	< LOD	0.0005	< LOD	0.0004	< LOD	0.0005	< LOD	0.0007	< LOD	0.0008	< LOD	0.0011	< LOD	0.0024
Opeia	0.0186	< LOD	< LOD	< LOD	0.0015	< LOD	0.0002	< LOD	0.0004	< LOD	0.0006	0.0005	0.0005	< LOD	0.0005	< LOD	0.0005	< LOD	0.0007	< LOD	0.0008	< LOD	0.0011	< LOD	0.0023
Opeia	0.0125	< LOD	< LOD	< LOD	0.0015	< LOD	0.0004	< LOD	0.0004	< LOD	0.0005	< LOD	0.0005	< LOD	0.0004	< LOD	0.0005	< LOD	0.0008	< LOD	0.0008	< LOD	0.0011	< LOD	0.0023
Tojeira	0.0124	< LOD	< LOD	< LOD	0.0016	< LOD	0.0002	< LOD	0.0004	< LOD	0.0006	< LOD	0.0005	< LOD	0.0005	< LOD	0.0005	< LOD	0.0007	< LOD	0.0008	< LOD	0.0011	< LOD	0.0024
Tojeira	0.0117	< LOD	< LOD	< LOD	0.0017	< LOD	0.0002	< LOD	0.0004	< LOD	0.0006	< LOD	0.0005	< LOD	0.0005	< LOD	0.0005	< LOD	0.0007	< LOD	0.0008	< LOD	0.0011	< LOD	0.0023
AAE	0.0147	< LOD	< LOD	< LOD	0.0014	< LOD	0.0003	0.0006	0.0005	< LOD	0.0006	< LOD	0.0006	< LOD	0.0003	< LOD	0.0004	< LOD	0.001	< LOD	0.001	< LOD	0.0013	< LOD	0.0029
AAE	0.0233	< LOD	< LOD	< LOD	0.0013	< LOD	0.0003	< LOD	0.0005	< LOD	0.0006	< LOD	0.0006	< LOD	0.0002	< LOD	0.0002	< LOD	0.0011	< LOD	0.001	< LOD	0.0014	< LOD	0.0031
AAE	0.0144	< LOD	< LOD	< LOD	0.0014	< LOD	0.0005	< LOD	0.0004	< LOD	0.0006	< LOD	0.0006	< LOD	0.0003	< LOD	0.0004	< LOD	0.0009	< LOD	0.0009	< LOD	0.0013	< LOD	0.0027
AAE	0.0187	< LOD	< LOD	< LOD	0.0015	< LOD	0.0002	0.0005	0.0004	< LOD	0.0006	< LOD	0.0005	< LOD	0.0004	< LOD	0.0004	< LOD	0.0008	< LOD	0.0008	< LOD	0.0012	< LOD	0.0025
AAE	0.0186	< LOD	< LOD	< LOD	0.0015	< LOD	0.0004	< LOD	0.0004	< LOD	0.0006	< LOD	0.0005	< LOD	0.0004	< LOD	0.0004	< LOD	0.0008	< LOD	0.0008	< LOD	0.0012	< LOD	0.0024
AAE	0.0244	< LOD	< LOD	< LOD	0.0013	< LOD	0.0003	< LOD	0.0005	< LOD	0.0006	< LOD	0.0007	< LOD	0.0002	< LOD	0.0002	< LOD	0.0011	< LOD	0.0011	< LOD	0.0015	< LOD	0.0033
Martinea	0.0112	< LOD	< LOD	< LOD	0.0019	< LOD	0.0004	< LOD	0.0004	< LOD	0.0006	< LOD	0.0005	< LOD	0.0006	< LOD	0.0006	< LOD	0.0007	< LOD	0.0008	< LOD	0.001	< LOD	0.0022
Martinea	0.013	< LOD	< LOD	< LOD	0.0014	< LOD	0.0003	< LOD	0.0004	< LOD	0.0006	< LOD	0.0005	< LOD	0.0004	< LOD	0.0004	< LOD	0.0008	< LOD	0.0009	< LOD	0.0012	< LOD	0.0026
Arroteia	0.0187	< LOD	< LOD	< LOD	0.0015	< LOD	0.0003	< LOD	0.0004	< LOD	0.0006	0.0007	0.0005	< LOD	0.0004	< LOD	0.0004	< LOD	0.0008	< LOD	0.0009	< LOD	0.0012	< LOD	0.0023
Arroteia	0.0151	< LOD	< LOD	< LOD	0.0014	< LOD	0.0003	0.0006	0.0005	< LOD	0.0006	< LOD	0.0006	< LOD	0.0003	< LOD	0.0003	< LOD	0.001	< LOD	0.0009	< LOD	0.0013	< LOD	0.0027
Bvista	0.0178	< LOD	< LOD	< LOD	0.0017	< LOD	0.0004	< LOD	0.0004	< LOD	0.0006	< LOD	0.0005	< LOD	0.0005	< LOD	0.0005	< LOD	0.0007	< LOD	0.0008	< LOD	0.0011	< LOD	0.0023
Bvista	0.0123	< LOD	< LOD	< LOD	0.0016	< LOD	0.0002	< LOD	0.0004	< LOD	0.0006	< LOD	0.0005	< LOD	0.0005	< LOD	0.0005	< LOD	0.0007	< LOD	0.0008	< LOD	0.0011	< LOD	0.0023
Arroteia	0.0125	< LOD	< LOD	< LOD	0.0015	< LOD	0.0002	< LOD	0.0004	< LOD	0.0006	< LOD	0.0005	< LOD	0.0004	< LOD	0.0004	< LOD	0.0008	< LOD	0.0008	< LOD	0.0011	< LOD	0.0024
Arroteia	0.0131	< LOD	< LOD	< LOD	0.0016	< LOD	0.0002	< LOD	0.0004	< LOD	0.0005	0.0007	0.0005	< LOD	0.0005	< LOD	0.0005	< LOD	0.0007	< LOD	0.0008	< LOD	0.0011	< LOD	0.0023
Bchitas	0.012	< LOD	< LOD	< LOD	0.0016	< LOD	0.0002	< LOD	0.0004	< LOD	0.0006	< LOD	0.0005	< LOD	0.0005	< LOD	0.0005	< LOD	0.0008	< LOD	0.0008	< LOD	0.0011	< LOD	0.0023
Bchitas	0.0178	< LOD	< LOD	< LOD	0.0016	< LOD	0.0002	< LOD	0.0004	< LOD	0.0006	< LOD	0.0005	< LOD	0.0005	< LOD	0.0005	< LOD	0.0007	< LOD	0.0008	< LOD	0.0011	< LOD	0.0023
Epigrafe	0.0166	< LOD	< LOD	< LOD	0.0017	< LOD	0.0002	< LOD	0.0004	< LOD	0.0006	0.0005	0.0005	< LOD	0.0005	< LOD	0.0006	< LOD	0.0006	< LOD	0.0008	< LOD	0.001	< LOD	0.0022
Epigrafe	0.0121	< LOD	< LOD	< LOD	0.0016	< LOD	0.0004	< LOD	0.0004	< LOD	0.0006	0.0005	0.0005	< LOD	0.0005	< LOD	0.0005	< LOD	0.0007	< LOD	0.0008	< LOD	0.0011	< LOD	0.0023
Epigrafe	0.012	< LOD	< LOD	< LOD	0.0016	< LOD	0.0004	< LOD	0.0004	< LOD	0.0006	0.0008	0.0005	< LOD	0.0005	< LOD	0.0005	< LOD	0.0007	< LOD	0.0007	< LOD	0.0011	< LOD	0.0023
Epigrafe	0.0132	< LOD	< LOD	< LOD	0.0015	< LOD	0.0003	< LOD	0.0004	< LOD	0.0006	< LOD	0.0005	< LOD	0.0004	< LOD	0.0005	< LOD	0.0008	< LOD	0.0009	< LOD	0.0012	< LOD	0.0024
Picassinos	0.0121	< LOD	< LOD	< LOD	0.0016	< LOD	0.0004	< LOD	0.0004	< LOD	0.0006	< LOD	0.0005	< LOD	0.0005	< LOD	0.0005	< LOD	0.0007	< LOD	0.0008	< LOD	0.0011	< LOD	0.0021
Picassinos	0.0169	< LOD	< LOD	< LOD	0.0017	< LOD	0.0002	< LOD	0.0004	< LOD	0.0006	< LOD	0.0005	< LOD	0.0005	< LOD	0.0005	< LOD	0.0007	< LOD	0.0008	< LOD	0.0011	< LOD	0.0023
Epigrafe	0.0121	< LOD	< LOD	< LOD	0.0017	< LOD	0.0002	< LOD	0.0004	< LOD	0.0006	< LOD	0.0005	< LOD	0.0005	< LOD	0.0005	< LOD	0.0008	< LOD	0.0008	< LOD	0.0011	< LOD	0.0022
Epigrafe	0.0127	< LOD	< LOD	< LOD	0.0015	< LOD	0.0002	< LOD	0.0004	< LOD	0.0006	0.0005	0.0005	< LOD	0.0004	< LOD	0.0005	< LOD	0.0008	< LOD	0.0008	< LOD	0.0011	< LOD	0.0024

Table 2. Continued.

even more attractive during the Last Glacial Maximum. Afterwards, during the Epipaleolithic occupation, the abundant marine evidence suggest that the occupation was by inland groups after they had harvested at the coast. It is, in fact, possible that the site represents the limit of safe consumption of coastal resources. Otherwise, it would be expected that coastal groups would consume those resources closer to the source, where quartzite, quartz and chert nodules could also be found easily.

Since the Portuguese Upper Palaeolithic is mostly based on bladelets and flakes (Zilhão, 1997) the characteristics of outcrops highly affected by tectonics would allow such production through the exploitation of any primary, sub-primary or secondary source. However, for periods such as the Solutrean, during which high quality nodules were necessary for the production of bifacial arrow tips sometimes using heat treatment, not all of these sources were suitable and probably only those with extraordinary quality would have been selected. This may be a parsimonious explanation for the explicit selection of this site to the detriment of others (including those just to the side and just in front of it but where tectonic flaws occur in almost all nodules), the almost exhaustion of the outcrop and the in situ heat-treatment processing of the chert. It is then possible that Poço chert may be found across this transect and deeper in the inland mountains at East.

The irregular terrain of the River Lis basin, marked by plateaux and steep rich canyons surely marked the circulation of past hunter-gatherers. This may include the possible construction of short circular and long bi-directional range paths according the morphology of the valleys. The presence of regional sources with different qualities and chemical signatures may allow the reconstruction and corroborating of such circulation.

7. Conclusion

With this geochemical analysis it was possible to characterize the Poço Rock Shelter lithic raw material procurement. Our results show that the driving factor of use of this site must have been a small outcrop with nodules of outstanding quality. Such a combination of size and quality led to its almost complete exhaustion, and the absence of similar occupations in sources right to the side and immediately in front of the source, but marked by abundant cleavages due to tectonics. Chert from other sources is also present at the site, suggesting the exploitation of other local sources as, contrary to most Portuguese regions, in the River Lis basin chert is a ubiquitous raw material. However, these occur in small amounts. Considering the quality of the Poço outcrop, it is highly plausible that this chert may be found in other sites of the region and also in adjacent regions. Its distinct geochemical signal (that makes it distinct even from other sources from the same valley) will support that approach. Nevertheless, and notwithstanding their similarities and differences, the Lis samples show internal coherence, which allow using them as reliable markers for the variability of the western-most Iberian chert sources.

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Multi-method study of a Pyrenean lithological tracer and its presence in the Magdalenian of Cova del Parco and Forcas I rock shelter (NE Iberia)

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Abstract

The multi-method study of a Pyrenean lithological tracer, the Montgaillard-Montsaunès chert type, is presented in this paper. These cherts outcrop in the northern Pyrenees, in three outcrops belonging to two Upper Cretaceous formations: the marly flysch cherts from the Campanian-Maastrichtian (Buala and Montsaunès outcrops) and the grey flysch cherts from the Turonian-Santonian (Montgaillard outcrop).

After macroscopic and petrographic characterization, geochemical analyses by ED-XRF, LA-ICP-MS and PIXE were conducted to establish chemical differences between outcrops and formations. Then, archaeological cherts potentially associated to this tracer were included in the study. These cherts were recovered from the Magdalenian levels of Cova del Parco and Forcas I rock shelter, in the southern Pyrenees. Results demonstrate the presence of this lithological tracer in the archaeological series studied, highlighting wide mobility of these materials through Pyrenean hunter-gatherers at the end of the Upper Palaeolithic.

Keywords: Geochemistry; lithic provenance studies; Chert, Magdalenian; NE Iberia

Résumé

L'approche multi-méthode sur un traceur lithologique pyrénéen, les silex du type Montgaillard-Montsaunès, est présenté dans cet article. Ces silex affleurent dans le versant nord des Pyrénées centrales, en trois gîtes appartenant à deux formations du Crétacé supérieur : les flysch marneux du Campanien-Maastrichtien (gîtes de Buala et Montsaunès) et les flysch gris du Turonien-Santonien (gîte de Montgaillard).

Après une caractérisation macroscopique et pétrographique, des analyses géochimiques par ED-XRF, LA-ICP-MS et PIXE ont été menés afin d'établir des différences entre gîtes et formations. Ensuite, des silex archéologiques potentiellement associés avec ce traceur ont été soumis au même protocole analytique. Ce sont des artefacts provenant des niveaux magdaléniens de la Cova del Parco et l'Abri de Forcas I, en versant sud pyrénéen. Les résultats ont permis de constater la présence de ces traceurs dans les séries archéologiques étudiés, mettant en évidence une mobilité importante de ceux matériaux à travers des chasseurs-cueilleurs pyrénéens à la fin du Paléolithique supérieur.

Mots-clés : Géochimie ; étude de provenance lithique ; silex ; Magdalénien ; NE Péninsule Ibérique

1. Introduction

Chert provenance studies provide valuable data about past human groups, specifically regarding their mobility and procurement strategies. The chert outcrops exploited as sources of tool-making raw materials are generally well documented for the Paleolithic communities of Europe. Their geological products have been characterized mainly at the macroscopic and petrographic scale, based on textural and micropaleontological descriptions. In some cases, if a chert source is well delimited geographically and possesses specific textural or micropaleontological traits, recognizing its archaeological use is possible just using macroscopic or microscopic methods. Nevertheless, in other cases, cherts exhibit identical macroscopic and petrographic features, also when they belong to different geological formations. In these cases, geochemical methods are required to distinguish between different sources.

In this paper a multi-method study concerning a lithological tracer outcropping in the Pyrenees is concerned. The Pyrenean mountain range is located in south-western Europe and separates the Iberian Peninsula to its south from the rest of continental Europe to the north. It extends for almost 500 km from the Bay of Biscay to the Mediterranean Sea. Archaeological work in this region, carried on especially since the last century (Mangado *et al.* 2010, Utrilla *et al.* 2010) has confirmed that this natural barrier was occupied, at least at the eastern margins, since the Lower Palaeolithic (Falguères *et al.* 2015, de Lumley *et al.* 2004). Moreover, some studies have demonstrated that certain connections existed, at least during the Upper Palaeolithic, between both Pyrenean slopes, specifically considering lithic productions (Langlais 2011, Langlais *et al.* 2016, Sánchez de la Torre 2015).

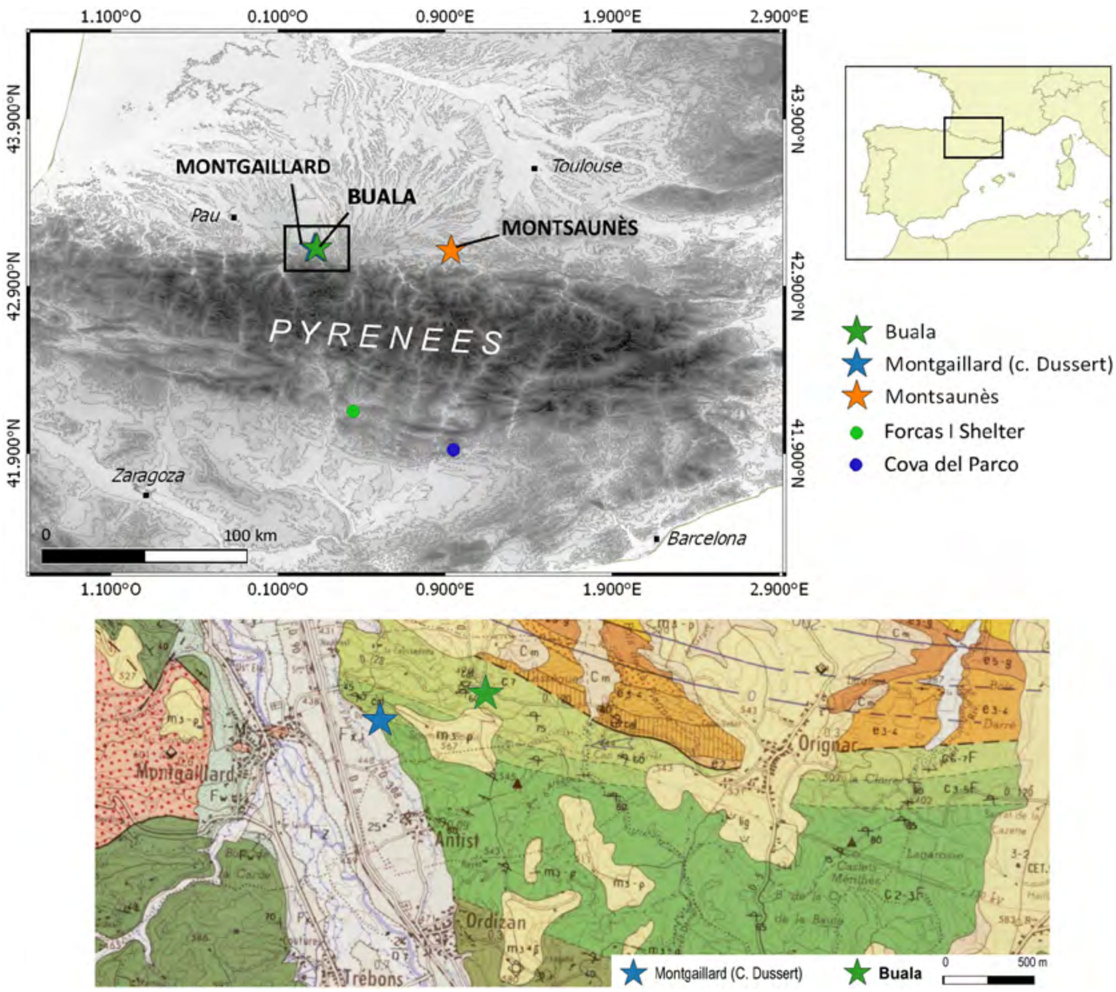

Figure 1. Location of the chert outcrops and the archaeological sites studied in this paper.

Considered its value as a promising lithic tracer potentially used by Palaeolithic groups of both Pyrenean slopes, a marine chert type outcropping in the northern slope of the Central Pyrenees was selected for this study: the Montgaillard-Montsaunès cherts. It is a marine chert type that already at the macroscopic scale presents parallels with cherts found at several Palaeolithic sites from both Pyrenean slopes (Sánchez de la Torre 2015). Three outcrops of this chert type have been recognized in the northern slopes of the Central Pyrenees. They belong to two Upper Cretaceous formations: the marl flysch cherts from the Campanian-Maastrichtian (Buala and Montsaunès outcrops) and the grey flysch cherts from the Turonian-Santonian (Montgaillard outcrop).

The first formation is comprised of the Montgaillard flysch cherts. This silicification originates from the flysch limestone from the Turonian to the Santonian outcropping in primary position near the Montgaillard village (Hautes-Pyrénées, France), and in secondary position near Hibarette, Bénac, Saint Martin and Visker (Hautes-Pyrénées, France), where lithic remains of ancient knapping were found (Barragué *et al.* 2001; Foucher *et al.* 2016). Cherts possess identical features in primary and secondary outcrops. Cortex are regulars, with variable thicknesses and colors from grey to brown with a high internal variability. The micropaleontological content is composed of sponge spicules and some small benthic foraminifera. In thin section, a criptoquartz mosaic is the main silica texture. Length-fast chalcedony is identified in few average. Siliceous sponge spicules are also observed. Carbonate components include micrite and some bioclastic skeletal remains partially transforming into silica. Metal oxides are abundant and detrital quartz crystals are also observed (Sánchez de la Torre 2015).

The Montsaunès-Buala cherts are embedded within the Nankin limestone of the Middle Maastrichtian and outcrop at the ancient quarry of Montsaunès (Haute-Garonne, France) (Séronie-Vivien *et al.* 2006) and the ancient quarry of Buala, near the village of Montgaillard (Hautes-Pyrénées, France) (Sánchez de la Torre *et al.* 2017b). The micropalaeontological content of this limestone is characterized by a rich assemblage of classical benthic Maastrichtian foraminifera (Bilotte and Andreu 2006). Cherts possess beige to brown colors with a micropaleontological content represented by sponge spicules and small foraminifera. In a few samples, some Maastrichtian benthic foraminifera were observed. In thin section, a criptoquartz mosaic is the main silica texture andlength-fast chalcedony appears in a few average. Siliceous sponge spicules are also visible. Carbonate components are represented by micrite and bioclastic remains in the process of being converted into silica.

Cherts showing similar macroscopic and petrographic features as the geological ones have been recognized in the archaeological record of the Magdalenian levels at Cova del Parco (Alòs de Balaguer, Spain) and Forcas I rock shelter (Graus, Spain), with radiocarbon dates ranging from 16,800 to 13,700 cal BP (Utrilla and Mazo 2007; Mangado *et al.* 2010).

Cova del Parco (Alòs de Balaguer, Spain) is an archeological site located in the southern Pyrenees, in the Segre river valley at 420 m asl, in a sheltered area. It features human occupation from the Paleolithic to the Bronze Age (Mangado *et al.* 2015; Fullola *et al.* 2012; Mangado *et al.* 2014). Fieldwork was started in the 1980s by a team from the University of Barcelona and is still in progress. The samples studied in this paper come from the Magdalenian levels. This period is well represented at the site, with several occupations going from the Middle to the Late Upper Magdalenian (Table 1).

Forcas I rock shelter (Graus, Spain) is located in the eastern province of Huesca, near the Ésera river, tributary of the Cinca river. Discovered by chance in 1990, the site was destroyed by 90% due to gravel exploitation in the area. Archaeological fieldwork was conducted by a team from the University of Zaragoza. Results demonstrated that the site was repeatedly occupied since the Magdalenian to the Early Mesolithic. Samples studied in this work come from the Magdalenian levels. This period is also well documented in the site, with some occupations from the Lower Magdalenian and the Upper Magdalenian (Utrilla and Mazo 2007; Utrilla and Mazo 2014).

Site	Data	Lab. Ref.	Met.	SN	Calendar 68% range Cal BP	Calendric Age Cal BC	Reference
Cova del Parco	12605±60 BP	OxA-10796	AMS	C	14662-15260	13011±299	Fullola *et al.* 2012
Cova del Parco	12460±60 BP	OxA-10797	AMS	C	14426-15055	12791±314	Mangado *et al.* 2006
Cova del Parco	12560±130 BP	OxA-10835	AMS	C	14535-15234	12935±349	Mangado *et al.* 2006
Cova del Parco	12995±50 BP	OxA-13597	AMS	C	15447-16245	13896±399	Mangado *et al.* 2006
Cova del Parco	13025±50 BP	OxA-13596	AMS	C	15503-16293	13948±395	Mangado *et al.* 2006
Cova del Parco	13095±55 BP	OxA-17730	AMS	C	15616-16387	14052±385	Mangado *et al.* 2010
Cova del Parco	13255±50 BP	OxA-29336	AMS	C	15778-16592	14235±407	Mangado *et al.* 2014
Cova del Parco	13475±50 BP	OxA-23650	AMS	C	16022-16839	14481±408	Mangado *et al.* 2014
Forcas I	12440±50 BP	GrA-32957	AMS	B	14378-15018	12748±320	Utrilla & Mazo 2007
Forcas I	12010±60 BP	GrA-33987	AMS	B	13783-14197	12040±207	Utrilla & Mazo 2007

Table 1. Radiocarbon dates concerning the Magdalenian levels of the two archaeological sites mentioned in the paper. The calendar age has been calculated by Online Calpal (quickal2007). CalCurve: CalPal_2007_HULU. 68% range cal BP. SN: Sample Nature. C: Charcoal. B: Bone.

2. Materials and methods

We selected 131 pieces of chert for analysis. Of these, 66 were geological products from Montsaunès (n=23), Montgaillard (n=23) and Buala (n=20), whereas 65 were artifacts from the sites of Cova del Parco (n=50) and Forcas I rock shelter (n=15). All of them have been characterized according to their texture and micropaleontological content, which revealed that they formed in a marine environment. These samples exhibit features identical to those observed in the geological cherts from the French Central Pyrenees.

To avoid the influence of surface alterations/geochemical weathering, geological samples were prepared in squares of 5 x 5 mm by removing the cortical surface and subsequent polishing. However, as it was our aim to compare the results here obtained with archaeological samples in a non-destructive mode, some of the geological samples were analyzed without any prior surface preparation. Results were similar to those obtained for the other geological samples.

To analyze major and minor elements, ED-XRF (Energy-Dispersive X-ray Fluorescence) was applied. Analyses were done at the Research Centre for Applied Physics in Archaeology, IRAMAT, Bordeaux, France. Nine elements were quantified (Na, Mg, Al, Si, P, K, Ca, Ti, Fe) using an X-ray fluorescence spectrometer SEIKO SEA 6000 VX (Orange *et al.* 2017). Fundamental parameters corrected by the granodiorite GSP2 from the U.S. Geological Survey (USGS) international standard (Wilson 1998) were used. A 3 x 3 mm collimator was used and analysis time was set to 400 seconds for each of the three measurement conditions (with air or He environment and Cr or Pb filter). To check instrument calibration and accuracy a JCh-1 chert standard from the Geological Survey of Japan (GSJ) was employed (Imai *et al.* 1996). To prove and validate the used formula and to check instrument accuracy a measurement with the JCh-1 chert standard was established, with an obtained standard deviation always lower than 0.08 wt%, validating the accuracy of the used formula (Sánchez de la Torre *et al.* 2017a).

To analyze trace elements, LA-ICP-MS (Laser Ablation Inductively Coupled Plasma Mass Spectrometry) was performed at the Ernest Babelon laboratory, IRAMAT, Orleans, France. Elements were quantified using a Thermo Fisher Scientific Element XR mass spectrometer associated with a Resonetics RESOlution M50e ablation device. The ablation device is an excimer laser (ArF, 193 nm), which was operated at 7-8 mJ and 20 Hz. A dual gas system with helium (0.65 l/min) released at the base of the chamber, and argon at the head of the chamber (1.1 l/min) carried the ablated material to the plasma torch. Ablation time was set to 40 seconds: 10 s pre-ablation to let the ablated material reach the spectrometer and 30 s collection time. Laser spot size was set to 100 μm and line mode acquisition was chosen to enhance sensitivity. Background measurements were run every 10 to 20 samples. Calibration was performed using standard reference glass NIST610 which was run periodically (every 10 to 20 samples) to correct for drift. NIST610 was used to calculate the response coefficient (k) of each element (Gratuze 1999, 2014) and the measured values of each element were normalized against 28Si, the internal standard, to produce a final percentage. Glass Standard NIST612 was analyzed independently of calibration to provide comparative data. After doing some tests with 56 elements, a total of 30 were measured (Li, Be, B, Mg, Al, Si, Ca, Ti, V, Cr, Fe, Ga, Ge, As, Rb, Sr, Y, Zr, Nb, Cs, Ba, La, Ce, Pr, Nd, Sm, W, Bi, Th, U).

After quantifying major, minor and trace elements by ED-XRF and LA-ICP-MS, PIXE (Particle Induced X-Ray Emission) was applied for developing trace element mapping. PIXE analyses tried to determine the place where trace elements appeared in cherts, identifying by mapping the surface if specific trace elements were related with the main Si matrix or with some inclusions. The PIXE measurements were performed at the scanning nuclear microprobe installed on the 0° beamline of the 5 MV Van de Graaff accelerator of MTA Atomki (Debrecen, Hungary) (Rajta *et al.* 1996). A proton beam of 3.2 MeV energy was focused down to ~4 x 4 μm with a current kept between 50-100 pA in order to avoid the charging up of the samples over these values. The scan size was 1 mm x 1 mm. On each sample 2-4 areas of 1 mm2 were measured. At first, elemental maps and summed up X-ray spectra on the full 1 mm x 1 mm area were recorded. If inhomogeneities were present, e.g. microfossils or mineral inclusions, the scan size and thus the scan area were reduced in order to better see these patterns, and additional measurements were made on the inclusion itself using the selected raster mode. For the light-element PIXE-PIXE measurements, two X-ray detectors placed at 135º geometry relative to the incident beam were applied to collect the emitted characteristic X-rays. An SDD detector with AP3.3 ultra-thin polymer window (SGX Sensortech) with 30 mm^2 active surface area was used to measure low and medium energy X-rays (0.2-12 keV, Z > 5). A Gresham type Be windowed Si(Li) X-ray detector with 30 mm^2 active surface area equipped with an additional kapton filter of 125 μm thickness was applied to detect the medium and high energy X-rays (3-30 keV, Z > 19). The accumulated charge was monitored with a beam chopper. Detailed description of the measurement setup can be found elsewhere (Kertész *et al.* 2009). Signals from all detectors (two PIXE and the particle detector of the chopper) were recorded event by event in list mode by the Oxford type OMDAQ2007 data acquisition system (Grime and Dawson 1995). PIXE spectra with better resolution and lower dead time were recorded parallel to this with an independent Canberra data acquisition system and with the SGX DX200 digital DPP. The obtained PIXE spectra were evaluated with the GUPIXWIN software (Campbell *et al.* 2010) to determine the elemental composition of the samples. Analyses of reference materials were carried out at the beginning and at the end of the measurement campaign in order to check the accuracy of the dose measurement and of the precision of the PIXE-PIXE system.

3. Results

Results obtained by energy-dispersive X-ray fluorescence show slight differences between the three analyzed geological cherts concerning major and minor elements (Table 2). Nine elements were chosen for analysis (Na, Mg, Al, Si, P, K, Ca, Ti, Fe) but only five were present above the detection limit of the spectrometer. SiO2 represents at least 98 wt% of the samples' composition. Minor components are Al_2O_3, CaO, Fe_2O_3 and K_2O. NaO, MgO, P_2O and TiO_2 results were not considered, as they were mostly below the detection limit. Thus, the major and minor general composition obtained after ED-XRF do not enable us to distinguish between the Montgaillard flysch cherts and the Montsaunès cherts. However, the Buala flysch cherts differ slightly from the other geological

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	K_2O	CaO	TiO_2	Fe_2O_3
Buala	<LD	0.002	0.558	98.955	<LD	0.022	0.350	0.004	0.111
Montgaillard	<LD	0.006	0.354	99.294	<LD	0.016	0.288	0.003	0.038
Montsaunès	<LD	<LD	0.347	99.473	<LD	0.020	0.128	0.005	0.027

Table 2. ED-XRF analytical median values (in wt%) of each analysed geological outcroup.

formations in their major and minor components. Thus, scatterplots combining the Al2O3, SiO2 and Fe_2O_3 percentages show a differential distribution for the Buala flysch cherts. Nevertheless, archaeological samples mostly fit with the overlapping area of Montsaunès and Montgaillard cherts, so no relevant results were obtained after ED-XRF analyses (Figure 2).

LA-ICP-MS analyses have shown several differences between the three formations and some interesting results regarding the association of some archaeological samples, in terms of some trace elements (Table 3). In this case, discrimination is possible between the three types of chert, giving a different dispersion area for each source. This discrimination is essentially based on the amounts of Ti, V, Sr and Th. Thus, the scatterplot concerning Ln [Th/Sr] vs Ln [Ti/Sr] shows three different dispersion areas for the three analyzed chert types (Figures 3 & 4). When introducing the archaeological samples of Cova del Parco (Figure 3, top), most of them are placed in the dispersion area of the Montgaillard geological cherts. Only one sample is clearly placed in the dispersion area of the Buala cherts, while none appears in the Montsaunès main geochemical dispersion. When introducing archaeological samples from Forcas I rock shelter (Figure 3, bottom), they are again mostly related with the main dispersion area of Montgaillard geological cherts. Nevertheless, some samples seem to be located at the boundary between the dispersion area of Montgaillard and Montsaunès cherts, given that one of them is clearly inside the Montsaunès dispersion area. However, any sample fits in the main dispersion area of the Buala cherts.

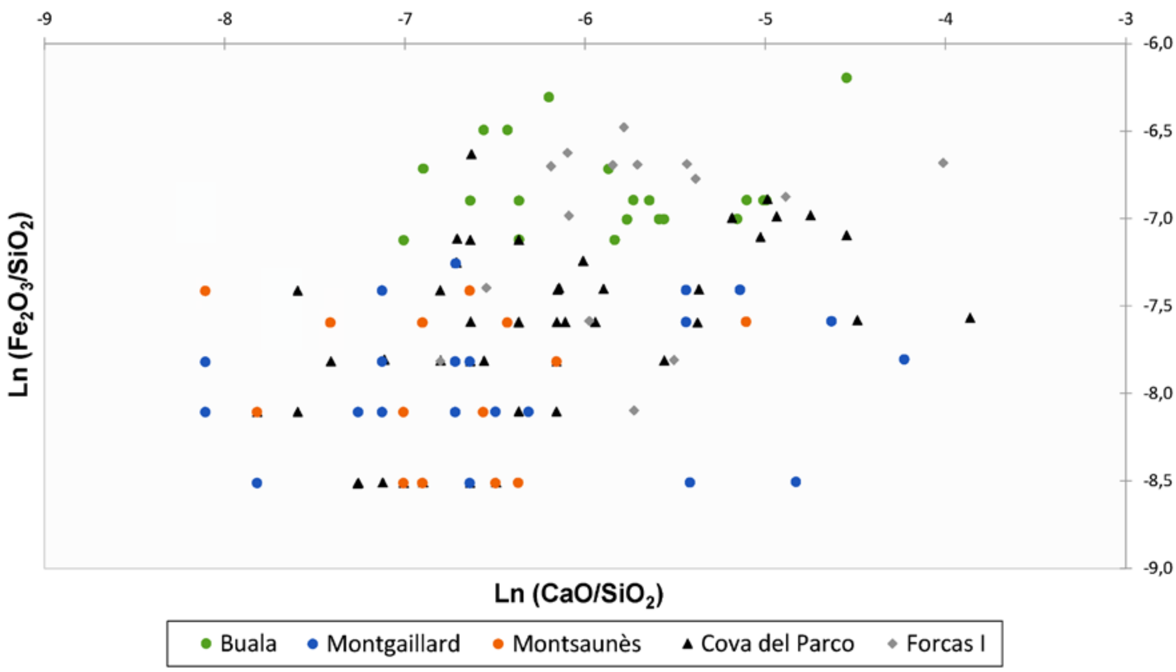

Figure 2. Scatterplot with the three analysed chert outcrops (Buala, Montgaillard and Montsaunès) and the archaeological artefacts from Cova del Parco and Forcas I rock-shelter concerning Ln Fe_2O_3/SiO_2 vs Ln CaO/SiO_2.

	Mg	Al	Si	Ti	V	Cr	As	Rb	Sr	Y	Zr
Buala	72.54	1071.7	460541	125.31	7.051	22.75	8.91	1.29	13.51	0.77	4.195
Montgaillard	147.88	2003.4	463833	160.08	5.481	12.87	4.19	3.28	30.10	1.29	2.192
Montsaunès	111.71	1692.4	464412	254.25	11.79	16.97	7.39	3.68	7.952	1.09	5.741

	Nb	Cs	Ba	La	Ce	Pr	Nd	Sm	W	Bi	Th
Buala	0.41	0.09	30.06	0.74	1.65	0.23	0.85	0.21	3.58	0.16	1.30
Montgaillard	0.43	0.23	44.84	1.14	2.31	0.28	1.13	0.26	1.06	0.29	0.44
Montsaunès	0.85	0.28	16.22	2.35	2.49	0.49	1.88	0.34	2.45	0.22	0.87

Table 3. LA-ICP-MS analytical median values (in ppm)
for each analysed geological outcroup.

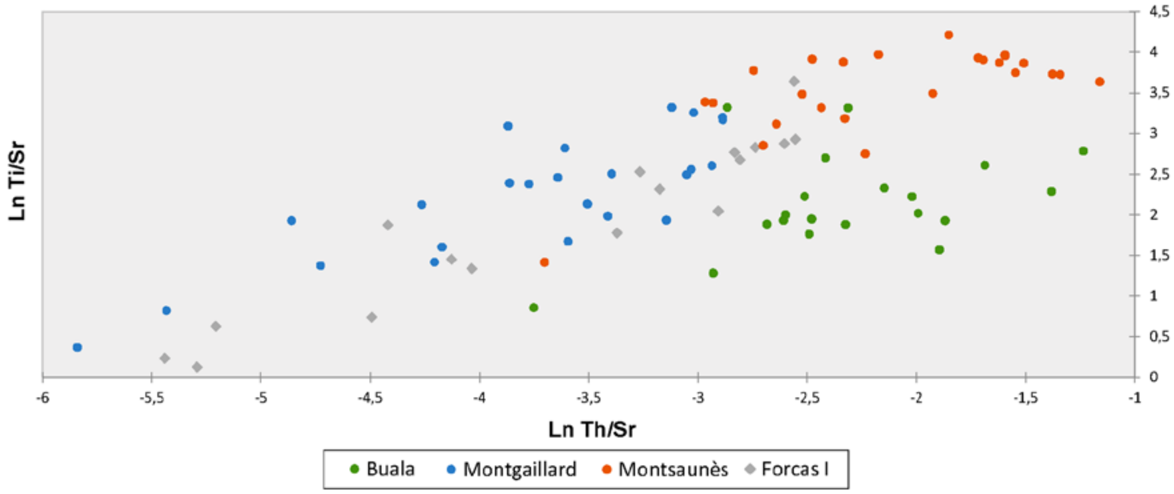

Figure 3. Scatterplot with the three analysed chert outcrops (Buala, Montgaillard and Montsaunès) and the archaeological artefacts from Cova del Parco concerning Ln Th/Sr vs Ln Ti/Sr.

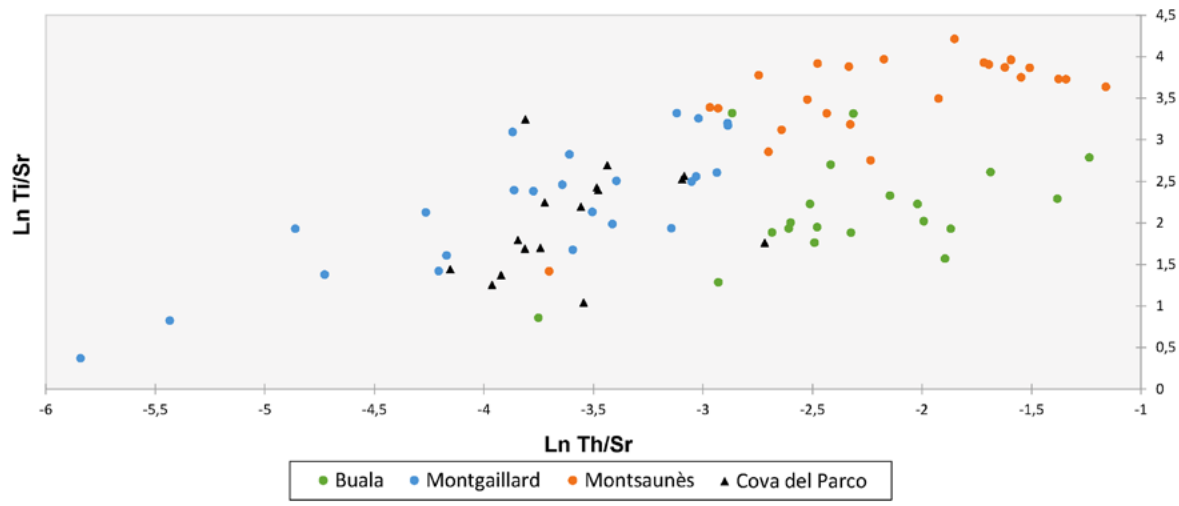

Figure 4. Scatterplot with the three analysed chert outcrops (Buala, Montgaillard and Montsaunès) and the archaeological artefacts from Forcas I rock-shelter concerning Ln Th/Sr vs Ln Ti/Sr.

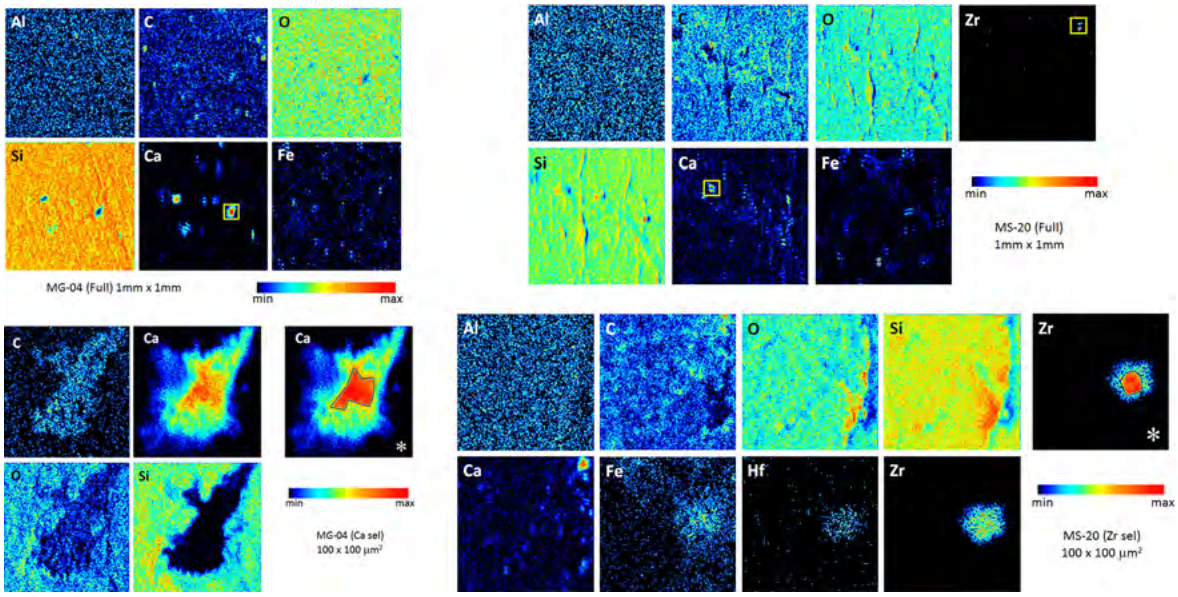

Figure 5. PIXE elemental mapping for Montgaillard MG-07 (left) and Montsaunès MS-20 samples (right) with a full 1 mm² area (top) and a Ca (bottom left) a Zr (bottom left) selected 100 µm² area. In full Ca and Zr areas, the yellow squares indicate the zoom selected area. *Selected raster on Ca and Zr maps.

During PIXE analyses, three types of inclusion were consistently detected within the geological cherts of Montgaillard, Montsaunès and Buala, of which surfaces of about 1000 x 1000 µm were selected for analysis and mapped. The most common inclusions were essentially composed of Ca, Fe and Zr. While Ca and Fe inclusions were detected in the three chert sources, Zr inclusions only appear in Montsaunès samples (Figure 5). Thus, mapping analysis combined with quantitative data show that there are correlations between certain elements. Therefore, Na, Mg, Al, Mn and Cu are elements regularly present in the Si matrix, while also occurring in some inclusions. Instead, K, Ca, Fe and Zr usually make up inclusions rather than occurring in the Si matrix. Concerning specific analyzed areas, some trace elements are frequently related with Ca or Fe inclusions, as S, V, Cr, Ni or Sr. As and Pb have only been identified in association with Fe inclusions, while W is present in Fe and Zr inclusions and Y, Hf, Th and U are always related to Zr inclusions.

4. Discussion

With this multi-method study, after developing macroscopic and petrographic analyses, three geochemical techniques have been used to examine the same types of chert. Once observed that for this case study macroscopic and petrographic analyses were not sufficient to distinguish between these so-close textural and micropalaeontological chert sources, ED-XRF, LA-ICP-MS and PIXE were applied to determine whether it is possible to identify differences in the main geochemical content. Once the variables were established, the three presented techniques have produced different results with the same types of chert, thus offering complementary data.

ED-XRF is a non-destructive technique that offers quantitative data and is good to measure major and minor elements. However, it is a limited technique for this archaeological case study due to the high Si rates present in this type of chert, always up to 98 wt%. Therefore, trace elements cannot be detected with ED-XRF, as they are always present in quantities below the instrument's detection limit.

LA-ICP-MS presents several advantages when analyzing chert. It is a good technique to quantify major, minor and trace elements, a result which could be achieved thanks to the facility in Orléans. Since it is a fast technique, LA-ICP-MS is characterized by good accuracy and precision. In addition, given that the spectrometer is associated with an ablation device, there is no need to destroy the sample for analysis. The only inconvenient is that an ablation device is required. Nevertheless, due to the small ablation spot size – about 100 µm in diameter, the result is not visible to the naked eye. In the present case study, LA-ICP-MS proved a valuable technique to distinguish between the three chert sources, as some trace elements are present in different averages. It was thus possible to correlate the archaeological samples of Cova del Parco and Forcas I rock shelter with a specific geological source.

With regard to the PIXE potential and limitations, and its application to the study of the Montgaillard-Montsaunès cherts, while it is not the best technique to quantify elements due to the large acquisition time taken for quantification, it can analyze most of the elements. Furthermore, it is one of the few techniques able to determine the spatial distribution of elements in a sample thanks to mapping.

5. Conclusions

The three geochemical techniques used in this study have produced valuable data for the present archaeological case study. First, ED-XRF analyses have revealed that no differences exist between the Montgaillard and Montsaunès-Buala cherts in terms of major and minor elements, showing that both marine formations exhibit similar SiO_2, K_2O, CaO and Fe_2O_3 values. Secondly, LA-ICP-MS has revealed that both formations and the three outcrops can be distinguished based on the occurrence of specific trace elements concentrations, i.e. V, Cr, Sr and Th. Moreover, it has also been possible to relate the archaeological cherts from Cova del Parco and Forcas I rock shelter particularly with the Montgaillard geological cherts, thus providing valuable data for the archaeological interpretation. Finally, PIXE analyses have determined whether the elements are associated with the Si matrix or with the inclusion content, showing differences between formations, as Zr inclusions were only observed in the Montsaunès cherts.

Using this multi-method approach, the present study has shown that geochemistry can be useful in solving some archaeological problems that routine macroscopic and petrographic analyses cannot tackle. In the specific case, differences between the two geological formations have been noticed after applying LA-ICP-MS. Further, after the analysis of specific trace elements, it appears clear that most of the archaeological cherts from Cova del Parco and Forcas I rock shelter are related to the Montgaillard flysch cherts, thus lending support to the hypothesis that these archaeological cherts derive from that geological formation. From the archaeological point of view, this data supports the idea that the Pyrenees were not a barrier for human groups at the end of the Upper Palaeolithic; rather, they are an example of long-distance procurement across a mountain range.

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Studies on the Palaeolithic of Western Eurasia presents the papers from Sessions XVII-4 and XVII-6 of the 18th UISPP World congress (Paris, June 2018). The geographic areas discussed in the Session 4, Central and Eastern Europe, are prehistorically strongly articulated, their cultural successions are highly similar, and they share several common archaeological issues for investigation. The papers disseminate a wealth of archaeological data from Bavaria to the Russian Plain, and discuss Aurignacian, Gravettian, Epigravettian, and Magdalenian perspectives on lithic tool kits and animal remains. The papers of Session 6 are concerned with lithic raw material procurement in the Caucasus and in three areas of the Iberian peninsula.

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