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Based in part on presentations from the
International Symposium on Chert and Other Knappable Materials
Iași, 2013

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Front cover image: *Flint mining* (by Georgeta Simion).
Title image: *Modern aboriginal knapper in Kimberley, NW Australia* (by Val Waldorf, based on a photograph).
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Journal of Lithic Studies

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2014

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Off to a good start: Publishing the first volume

Otis Crandell

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The journal is off to a very good start. In this first volume we have published a total of thirty four articles - twenty six research articles, two summary and synthesis articles, one biography, two book reviews, and three event reviews. Already we have several more articles that are being prepared for the upcoming second volume and we have several special issues planned for 2015. I would like to express my sincere gratitude to the Editorial Board, the technical editors, and the reviewers who contributed their time and expertise and, most of all, the authors themselves.

This issue we have a nice variety of topics presented. Geographically most are from Europe, but we also have our first article from South America, and an article regarding finds from Mesopotamia. In fact, the article about Mesopotamia is also our first article related to gemology or decorative stone objects. The article by Aimola *et al.* is very interesting in that it presents finds from one of the earliest occupied sites in Brazil and some of the artefacts themselves are associated with layers that pre-date the main peopling of the Americas and thus makes a valuable contribution to the discussion of the when the New World was first populated. Tarriño *et al.* have provided us with updates on the research at the Treviño flint mines in Spain. This research is of particular importance not only because it is one of the few prehistoric flint mines on the Iberian Peninsula but also because it gives us a general look into the early stages of the Chaîne opératoire of knapped stone industries. Most of the research articles in this issue were based on presentations from the International Symposium on Chert and other Knappable Materials which was held in Iasi, Romania in the summer of 2013.

On the topic of symposia, we would like to take this opportunity to remind our readers about two up-coming events in 2015 whose proceedings will be published in JLS. The first is the international *Ground Stone Artifacts and Society* workshop in July, at the University of Haifa, Israel. The second is the *International Symposium on Knappable Materials 'On the Rocks'* hosted this time by the University of Barcelona, in September.

As some of you will have noticed, in this issue we have started publishing book and event reviews. The journal's website also contains a list of books that were recommended for review. JLS is open to publishing reviews of any books that are about a lithics related topic or which contain a large number of articles related to lithics research. We are particularly interested in reviews of non-English books as we feel that this will help to disseminate local or regional research to a wider audience. Likewise we are interested in publishing reviews of lithics related events including symposia, training workshops, and public demonstrations. If you have attended an interesting event, we would like to hear about it.

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If you are interested in writing an article, report or review, please let us know. Although issues are released twice a year, the individual articles are published on an ongoing basis as soon as they have been reviewed, revised and accepted.

As mentioned previously, JLS is run by a staff of volunteers. If you feel that you have the time, a relevant skill or an interest in the technical side of publishing, send us a message to introduce yourself and tell us about your interest in volunteering.

Until our next issue, I would like to thank everyone again for their contributions to our success and wish you all good luck in your research. I look forward to reading about it – perhaps here in the Journal of Lithic Studies.

Otis Crandell

Editor-in-Chief
Journal of Lithic Studies

Research articles

Final Pleistocene and Early Holocene at Sitio do Meio, Piauí, Brazil: Stratigraphy and comparison with Pedra Furada

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Abstract:

Sitio do Meio, in southern Piaui, Brazil, is the second rock shelter presenting fully Pleistocene dates and artefacts after Pedra Furada. Despite the anthropogenic origin of Pedra Furada artefacts has been questioned, SDM has better chances to be accepted by the scientific community because of the absence of the most relevant stone breaking agents in this kind of site, i.e. waterfalls. This paper presents a critical revision of the history of excavations (1980-2000), stratigraphy, chronology, and the archaeological content of the site (sector 2). At least 98 stone tools have been identified and described, all of them being older than 12,500 BP, i.e. belonging to the Upper Pleistocenic phase of Pedra Furada 3, as defined in the close reference site. The lithic industry of Serra Talhada phase (lower Holocene) is also presented and compared with paleoindian sites of North-Eastern and Central Brazil.

Keywords: Upper Pleistocene; Lower Holocene; Brazil; lithic industries; excavations; radiocarbon dating**;** first peopling of the Americas

Resumé:

Le Sitio do meio, dans le Piaui méridional (Brésil) est le deuxième abri sous roche de la région ayant livré des dates pléistocènes en dehors du site de la Pedra Furada. L'article présente une révision critique des fouilles (1980-2000), la chronostratigraphie et le contenu archéologique du secteur 2. Une centaine d'outils lithiques sont décrits, ils sont plus anciens de 12,5 ka BP et correspondent à la phase Pléistocène Pedra Furada 3 définie dans le site éponyme de référence. On présente aussi l' industrie lithique de la phase Serra Talhada (Holocène ancien) en la comparant aux industries paléoindiennes du Nord-Est et du centre du Brésil.

Mots-clés: Pléistocène supérieur; Holocène inférieur; Brésil; industries lithiques; fouilles; radiocarbone

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1. Introduction

For a long time Pleistocene peopling of the Americas has been the focus of possibly the most copious and inconclusive debate in the field of prehistory. In the last twenty years, the issues on the top spot of this important but yet unsolved chapter of human and natural history range from the genetic background of the ancestral stock(s) which originated the first Americans (Anderson & Gillam 2000, Perego *et al.* 2009), with the associated issue of the number and timing of peopling events (Lanata *et al.* 2008), the palaeogeographic and palaeoclimatic conditions for such events (Pitblado 2011), as well as the "routes" of peopling (Bryan & Ghrun 2003, Dillehay 2008). At the very core of these hypothesis, theories or simply conjectures is - in the ultimate level - the humble nature of artefacts and the stratigraphic context of each site.

Brazilian *lowlands* have been for almost two decades at the centre of action for the Southern continent because of the presence of several sites with radiocarbon dates > 12,000 BP and the debated nature of the associated cultural material. Since 1980, in South-Eastern Piaui, the franco-brazilian team led by Niéde Guidon conducted many research projects on rock-art chronology (Guidon 1985), "pre-Clovis" archaeological sites (Guidon & Delibrias 1986, Guidon & Arnaud 1991), as well as palaeontological (Guérin & Faure 2008) and palaeoenvironmental data (Chaves *et al.* 2008). The longest chronological sequence in the region is Boqueirão da Pedra Furada (BPF) rock-shelter which has been published in details (Parenti 2001, Santos *et al.* 2003) after an harsh debate (Meltzer *et al.* 1994, Parenti *et al.* 1996). The final Pleistocene layers at BPF (PF 3) show a slight evolution in lithic tool-kit, although a gap in the radiocarbon sequence between 14,300±210 (GIF 6159) and 10,400±180 (GIF 5862) has been recorded. This gap, as shown below, is partially represented in another rockshelter, named Sitio do Meio (SDM), located in Figure 1 in relation with the reference site of Pedra Furada.

In this paper we present the available data on past excavations at SDM, obtained on the basis of published data (Guidon & Andreatta 1980, Guidon & Pessis 1993, Pinheiro de Melo 2000) and four unpublished dissertations (Aimola 2008, Andrade 2010, Mota 2010, Pinheiro De Melo 2007), focusing both on the existence of cultural remains in the final Pleistocene and on the significance of lithic tool-kit in early Holocene, in the context of the prehistory of North-Eastern Brazil (Martin 1997).

2. Regional setting: Serra da Capivara National Park, Sítio do Meio rockshelter and the archaeological excavations

Southern Piaui is dominated by the contrast between the wide pre-Cambrian plain and the Palaeozoic *plateau* of Piaui-Maranhão basin. The bulk of more than 1,300 sites actually recorded in the *Serra da Capivara* National Park and its surroundings are sandstone shelters with rock paintings, mainly dated to early and mid-Holocene. As usual in Northern Brazil, the shelters are mostly created by differential erosion of the *cuesta* cliffs, as in the close (1,500 m) reference site of Pedra Furada, incised in a silty layer interbedded in the Silurian sandstone of *Serra Grande* formation.

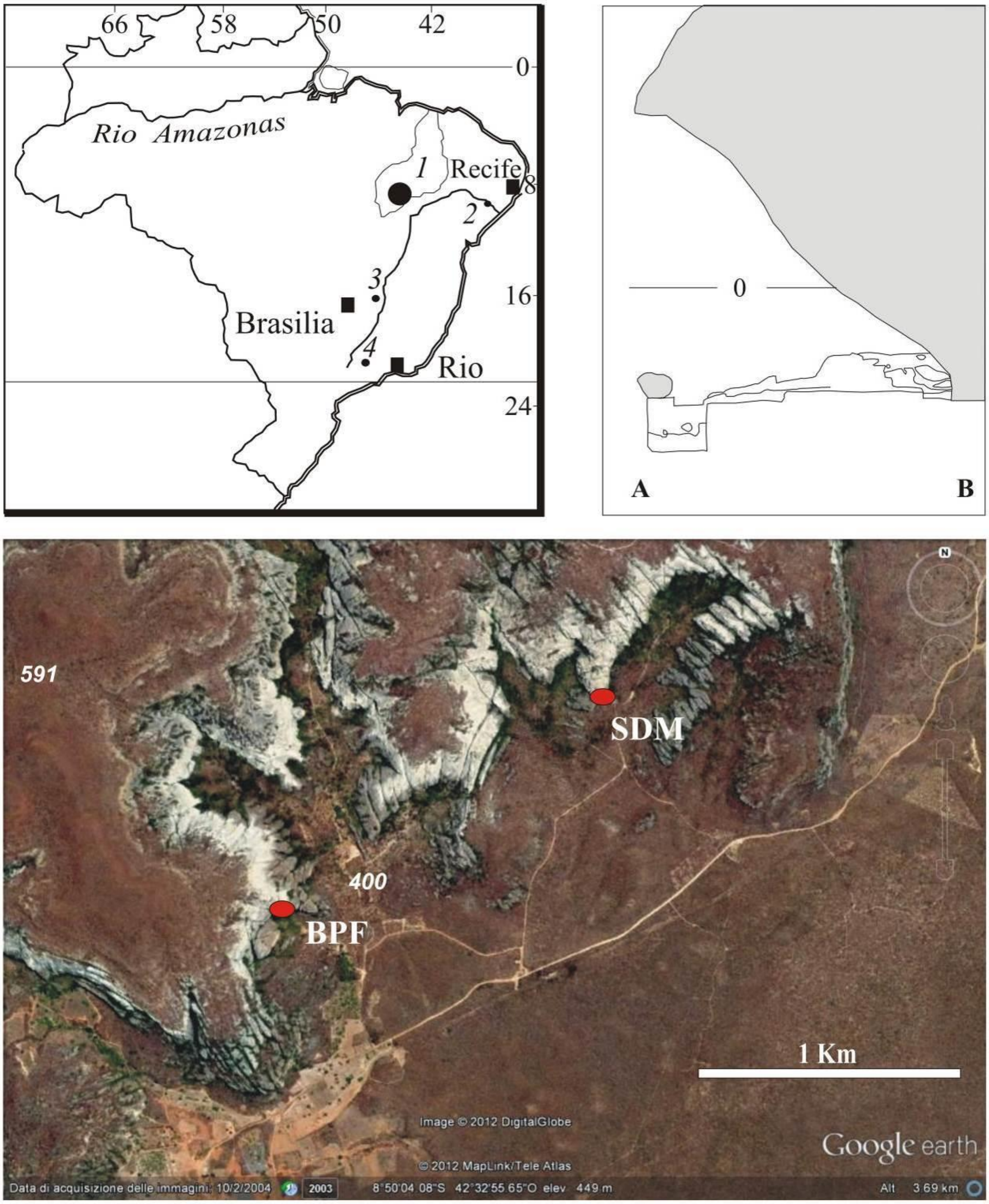

Figure 1. Position of sites: Sitio Do Meio (SDM) and Boqueirão da Pedra Furada (BPF.). Aerial image from Google Earth (2014).

At SDM the available surface is defined by an impressive talus of collapsed sandstone blocks, noticed as soon as the site was discovered (Guidon & Andreatta, 1980). Behind the blocks is the most protected portion of the sheltered area (86 m^2), with red-painted panels of *Serra Talhada* tradition on the wall and engravings on some blocks (Cisneiros 2008). During past excavations hundreds of these blocks have been removed, their length ranging from 0.4 to 18 m. The shelter is 64 m long, its width ranging from two to 17 meters due to the irregularities of the sandstone wall. The maximum elevation of the roof is about 29 m, which allows the most intense rainstorms penetrate the outer part of the site, as in BPF (See Figure 1). The conventional limit between "inner" and "outer" sector of the site adopted in past excavation reports is almost parallel to the drip line (See Figure 2). Collapsed blocks were found in both sectors, excavations in the inner part often had to be interrupted because of the presence of such blocks. The deposition of these is the main agent of the filling of rock-shelters in semi-arid landscapes, as documented also in the case of BPF. In the majority of shelters in Serra da Capivara area, the filling is usually not older than lower Holocene, but in some cases it has been protected from erosion, which was stronger in the final Pleistocene moister conditions.

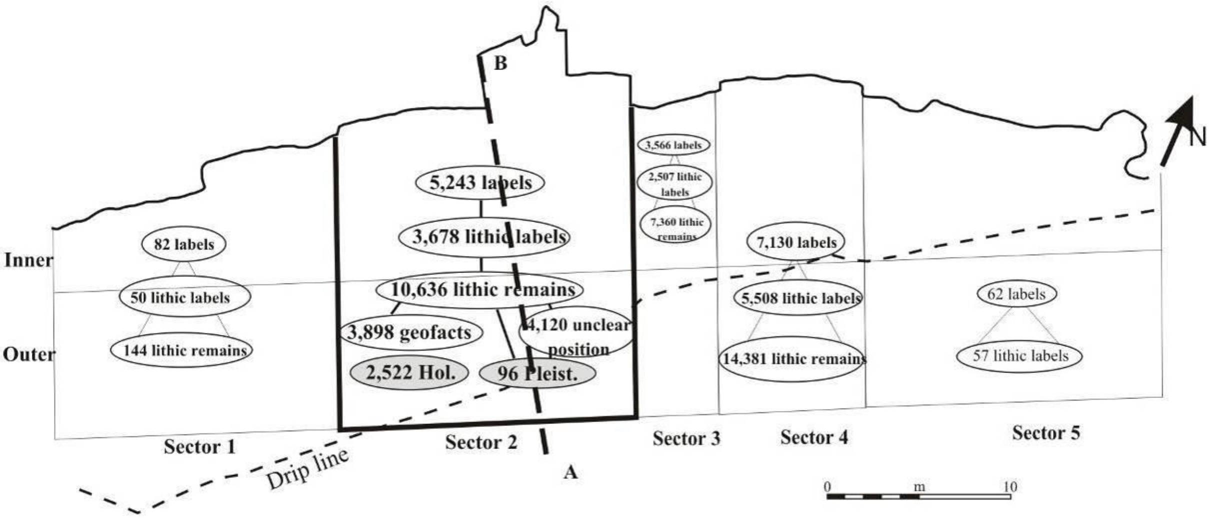

Figure 2. Site plan with labels and artifacts per sector, comprising both inner and outer part.

The interpretation of data from Sitio do Meio is a difficult task, mainly because of the complicated history of its excavations (sectors and materials are represented in Figure 2). About 80% of the upper layers of the site have been excavated, but the lowermost Pleistocene units have been unearthed only in the central part of the sheltered area. More recent soundings have been conducted in 2012 by Eric Boeda and co-workers in the eastern portion of the shelter (Boeda *et al.* 2013, fig. 24.1).

From 1973 to 2000, six field campaigns have been undergone (listed in Table 1), all coordinated by Niéde Guidon, but in collaboration with several field-leaders, in different sectors or -sometimes- in the same sector, but employing different data recording techniques and with different scientific goals. The most difficult task the archaeologists faced in this site was the recognition, definition and removing of each -supposed- sedimentary unit. This is mainly because the lateral discontinuity of sandy lenses in rock-shelters, an old nightmare for prehistoric archaeologists (Bordes 1975), but also because of the abundance and heterogeneity of fallen blocks. For these reasons, the similar numbers observed in the field reports of SDM does not have any stratigraphic meaning and does not imply any correspondence or correlation. Therefore, each specific object or structure considered in this study has been submitted to a careful verification of its position before its inclusion in the database with a firm chronological attribution.

In order to reconstruct the sequence of excavations, to have a reliable synopsis of the stratigraphy and to clearly identify the Pleistocene units of past excavations, one of us (GA) conducted a detailed philological reading of the documentation available in FUMDHAM archives in 2008, proceeding as follows: 1) control of the dip of sedimentary units recorded in the sections; 2) synopsis of field notebooks; the most complete for stratigraphic remarks and topographic details are those of 1978 and 1980 campaigns, which served as a basis to reconstruct a stratigraphy with the dip of each excavation campaign.

Table 1. Excavation campaigns at SDM: 1978-2000

Year	Days	Leader	Survey equipment	Dimensions	M³	Progressive M³	Sectors
1978	13	Guidon	Grid, transit level	5x5x2.5	62.5	62.5	2: abcde squares
1980	14	Guidon	Grid, transit level	3x5x4	60	122.5	2: fgh squares
1980		Guidon	Grid, transit level	4x3x2.1	25.4	147.9	4
1991	47	Team	Grid, transit alidade	2x7;2x3	20	167.9	2
1991		Team	Grid, transit alidade	2x2;5x2	14	181.9	4
1992	12	Team	Grid, transit alidade	4.5x3x5;9.2x2x 2;3x2x5.6	135.5	317.36	2
1993	6	Team	Grid, transit alidade	5x4x2.4	48	365.36	4
2000	?	Pinheiro	Total station	5x5x1.6	41.25	406.61	3
2000	?	Pinheiro	Total station	5x4x1.6	32	438.61	4
Tot	>92					2210.64	

The site was discovered in 1973; in March 1978, a small trench measuring one by two meter and 1.1 meter deep was opened, stopped by sandstone blocks. In July 1978, excavations were extended up to an area of 5 x 7 m, with the same depth in each square, except on F and G sectors, because of the presence of collapsed blocks. Two radiocarbon dates were obtained from charcoal: 12,200±600 BP (GIF 4628) and 13,900±300 BP (GIF 4927). In 1980, a trench of 3 x 4 m was dug, one meter deep. At the end of this campaign, an assemblage of 79 lithics (30 on siltstone small slabs) was collected and another two dates were obtained: 12,440±230 (GIF 5403) and 14,300±40 (GIF 5399).

Although yielding interesting dates from the Pleistocene-Holocene boundary, the excavations at SDM were interrupted for over a decade, due to the much older chronology observed at BPF. In fact, the quite old Pleistocene dates obtained there in 1978 and 1980 called for larger surface excavations from 1982 onwards. It is not unreasonable to say that from 1984 to 1988, BPF drew almost any effort by Guidon's team, with one of us (FP) coordinating the main campaigns from 1987 to 1988. Sitio do Meio excavations were resumed in June 1991 in order to try to confirm the very old dates obtained from BPF (Figure 3). In those days, the huge sandstone blocks at the entrance of the shelter still protected the sections of older excavations, the sequence of which was - obviously - used as reference for the new ones. Modern surface was completely surveyed, and the site was subdivided in inner and outer parts and in 5 sectors: sectors 1, 3, 5 remained preserved and new research was undertaken in sectors 2 and 4, the same ones of the earlier excavations. After the removal of larger blocks, in sector 2 (17 x 16 m) and 4 (17 x 8 m) a new metrical grid system was established and excavation was (supposedly) conducted by natural layers (french *décapages*), and each *décapage* was subdivided in excavation phases. Due to the granulometrical homogeneity combined with a lateral discontinuity of the sediment, sometimes this recording system lead to a lack of correspondence between the excavations units (*décapage* or phase) and the sedimentary bodies effectively recorded in final sections. In sector 2 (comprising an area of 272 m^2, the largest one), a surface collecting of re-worked remains was undertaken: post-contact ware, lithics, bovids and equids remains, charcoal and modern feces. Below the disturbed sediment, the first true *décapage* was performed: a rich lithic industry, charcoal, ochre and two fragments of painted sandstone were recovered; moreover, a fireplace was identified and excavated. Two trenches for stratigraphic control were opened in this sector. Afterwards the entire sector was excavated and all blocks removed. Although charcoal and lithics were recovered in the lower layers, no datings were obtained in this campaign. In sector 4, two trenches were opened when the excavated surface was at 4th phase of the second *décapage*, in order to attain the same level of 1980 trenches (named - unfortunately - as in sector 2, “Trench 1” and “2”, 1991). In 1993, the bottom in sector 4 was finally reached and the outer portion of sector 2 was explored with a trench which was perpendicular to the sandstone wall. Below another collapsed block, more archaeological layers with charcoal fragments and lithics were discovered. On July 29th, the excavations reached the sandstone at the bottom, just below a sterile layer of fine sand, with comminuted (probably natural) charcoal fragments dated at 20,280±450 (Beta 65350) and 25,170±140 (GIF 9542) uncal. years BP. During the 1993 campaign almost the entire sector 4 was excavated; in its North-eastern part, at 1.3 m from the top-soil, a fireplace was uncovered and dated at 8,800±60 (Beta 47494) uncal. years BP, and it was not excavated. Despite the loss of some of field notes, we know that one hearth was found, dated at 9,200±60 (BETA 65856) uncal. years BP and (apparently) associated with a polished axe (Guidon & Pessis 1993).

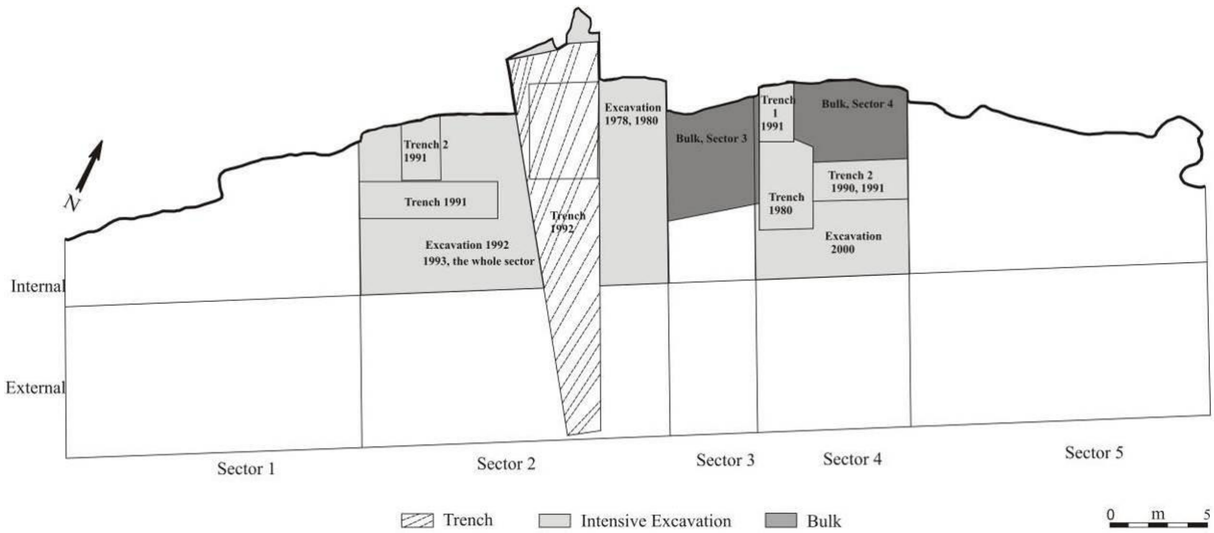

Figure 3. Succession of excavations 1978-2000.

Excavations were interrupted at an (archaeologically) "sterile" layer at 2.4 m of depth. In 1999 and 2000, P. Pinheiro de Melo carried out new research in sector 4 where the preserved blocks were excavated till the bedrock, providing six fireplaces, the precise position of them, however, is unclear. Sector 3 (6 x 5 m) was also excavated in order to link the previous sections of sectors 2 and 4; but the term *décapage* was, in this case, referred to natural strata, *i.e.* units of variable thickness, instead of regular excavation phases inside each stratum. After the usual cleaning of modern sediments, 12 fireplaces were unearthed. One of them is morphologically remarkable and dated to 8,805±50 (LY 10138) uncal. years BP. (Discussed further in Section 5.) Just below, another structure with sandstone slabs and an ochre *plaquette* with a string of graminaceous seeds were recovered along with human teeth from a four to nine years-old individual. This funerary structure was dated at 8,920±50 (LY 10134) uncal. years BP. The excavation continued until the *in situ* sandstone, but the available documentation is not very informative and, therefore, it will not considered here. All 14C dates are listed in Table 2.

In 2012 a new excavation project took place at SDM, leaded by Boeda and co-workers (Boeda *et al.* 2013). In this paper, the short chapter dedicated to SDM (p. 457-459) is mainly devoted to lithic technology and is not as informative as necessary in order to understand the relationship between new and old excavations. In the few lines devoted to the stratigraphy of the shelter, it seems that Boeda and co-workers adopted the stratigraphic synopsis proposed by of Pinheiro de Melo (2000), without assessing its reliability: A- Holocene unit, B- undated, C -half a meter dated at the bottom between 23,000 and 25,000 BP. It is exactly this subdivision that we carefully re-considered and checked in the Master thesis of one of us (Aimola, 2008), concluding that, because the lack of homogeneity of excavation techniques and documentation, it is not as firm as proposed. Starting from this stratigraphically unfirm terrain, Boeda and co-workers, on the basis of a small trench, announce the "surprising discovery" of a stone blocks structure "filled with a large number of small cobbles". The issue of stone structures at SDM is well known and it has been considered since a long time; in FUMDHAM deposits are stored 517 sandstone blocks or slabs and 238 quartz cobbles from 57 recorded structures which, according to field notes (when available) are described as clearly of anthropic origin, sometime polished, with percussion marks and, often, associated with charcoal. But also for these important remains the previous documentation is cryptic, even if in this case almost all structures have been drawn. One of us (CA) has provided a careful revision of this documentation for her dissertation (Andrade, 2010). Moreover, one of these structures, a fireplace romantically called "stonehenge", is the most expressive example of B3 structure type of existing classification (Parenti 2001, p. 116; fig. 11); it is on display at the *Museu do Homem Americano*. May be Boeda and co-workers did not gain access to the available reports on this crucial matter (Pinhero, 2000, 2007; Andrade 2010) as long as to the many shelves in FUMDHAM deposits full with sandstone blocks and cobbles from SDM structures.

3. Stratigraphy and chronology

Below the disturbed surface sediments (30-40 cm), the sub-horizontal Holocene layers are composed mainly by colluvial sands and quartz pebbles with sandstone or siltstone *plaquettes* from the wall. Based on sections available at FUMDHAM files, on notes by J. dos Santos (Santos 2007: 93) and on personal field observations, the sediment can be described as follows, from bottom to top: I) Palaeozoic sandstone of *Serra Grande* formation; II) very thin layer of fine sands, thickening close to the outer portion of the shelter; III) sand with rounded quartzitic cobbles and siltstone fragments; IV) fallen heterometric sandstone blocks; V) small gravel with angular and sub-angular quartz pebbles in matrix of poorly sorted medium sand. Units III-IV are visible in Figure 4.

Throughout the 1978-2000 campaigns, a total 29 radiocarbon dates have been obtained, all from charcoal. Among these dates, only 16 (13 in sector 2) have a precise position and will be considered here (shaded in Table 2). In any case, beneath the 12,640±210 uncal. years BP (GIF 9541), -2.40 m below *datum*, all samples resulted in fully Pleistocene dates, therefore all the associated material from sector 2 will be retained in this analysis. At the very bottom of the sequence a date of 25,170±140 (GIF 9542) uncal. years BP was obtained from a charcoal fragment from the unit 2, a possible fluvial sediment thicker in the outer part of the shelter, not associated with any artifact. This is the *terminus post quem* for the archaeological presence at the site (Figure 5).

4. Lithic industry

According to our revision of FUMDHAM collections, sector 2 has yielded a gross total of 10,636 inventoried lithic remains, collected in 3,678 topographic points, according to which a label number was attributed (Figure 2). The vast majority of these remains are splitted pebbles of quartz without any intentional flaking evidence (collected either for comparative purposes or because they present evidence of heating) or sandstone slabs that belonged to purported fireplaces or other structures. We should note, however, some sampling bias between different field seasons: in 1978 and 1980 only purported artifacts had been recovered, whereas in following campaigns all lithic remains were collected. Out of these 10,636 remains, 96 are from Pleistocene and 2,522 from Holocene layers (here defined by elevation), 3,851 were classified as geofacts by Pinheiro De Melo (2007) and the remaining 4,167 have uncertain stratigraphic position and therefore were excluded from this analysis. Moreover, sector 2 - the largest one - has been extensively excavated and roughly 130 m^2 are outside the drip-line and, because of this, more exposed to the intrusion of geofacts from the outer stream.

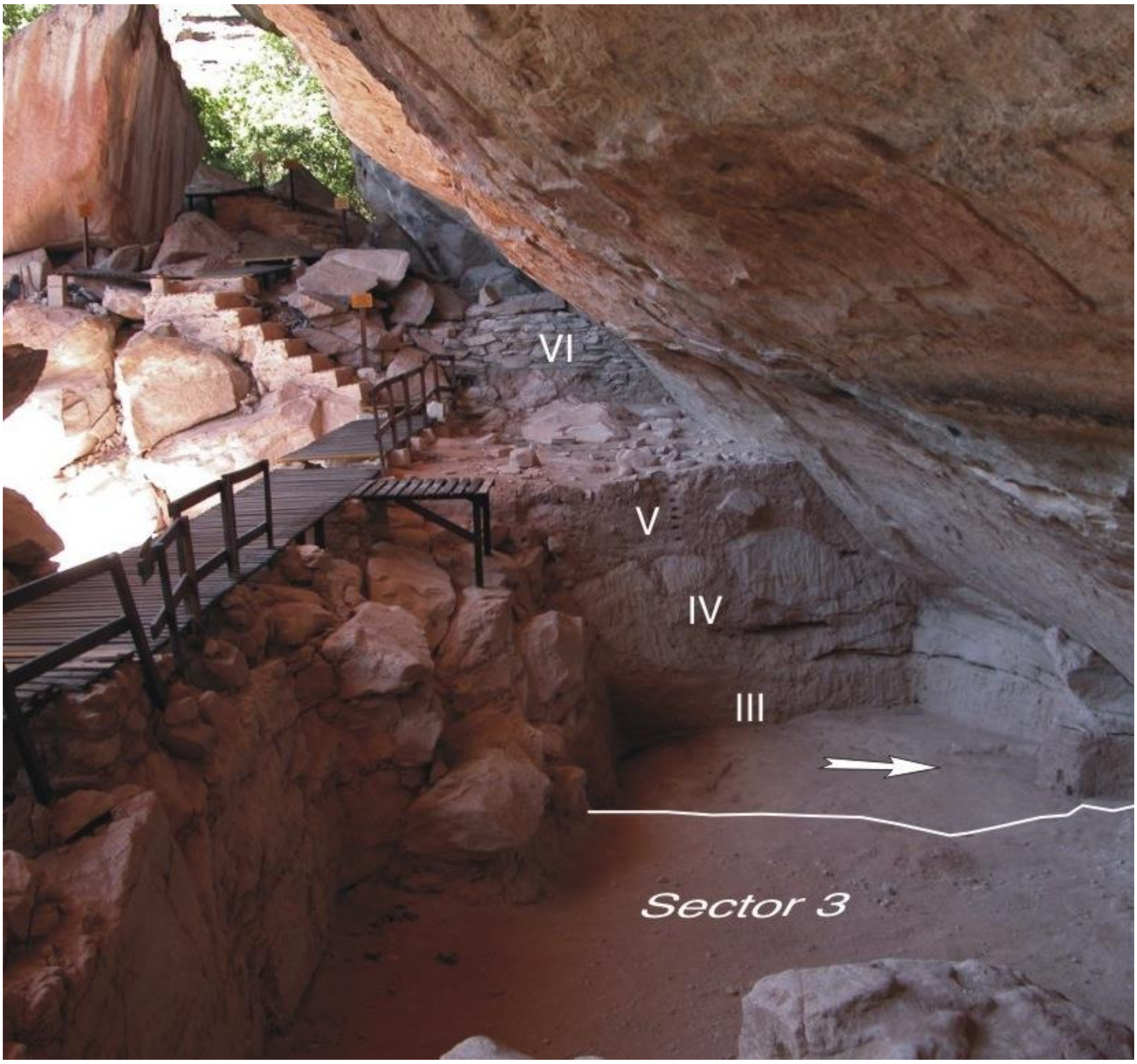

Figure 4. Sector 2 and main section, looking West. (Photo by G. Aimola.)

Given this sampling context, the selection of lithics, both from Pleistocene and Holocene units, has been conducted on the base of the natural gravitative fractures observed in BPF site (Parenti 2001: 135-150). This decision took into account the fact that both, topography and sedimentology at SDM and BPF share similar conditions: both sites lay at the bottom of the *cuesta* and are located between two canyons; SDM, however, is different because: 1) it does not present any active talus of quartz cobbles and pebbles originated by near waterfalls as BPF (however SDM was probably flooded before the first block collapse); 2) the outline of *cuesta* in front of SDM is convex and narrow, unlike that of BPF, which is large and concave; this probably leads to a lesser water volume during rainfalls; 3) finally, differently from BPF with its East-West average dip of 10°, sedimentary units at SDM have a sub-horizontal dip; this means that the entry of pebbles inside the drip-line is much more uncommon than in the outer portion of the shelter, as documented by the fine matrix of sedimentary unit V (see Figure 4). In sum, we included in this study any flaked pebble with at least two adjacent flake-scars >10 mm and any flake with striking platform angle < 90°.

Table 2. 14C dates from SDM, shaded considered dates with a precise position. Calibration with Calpal

Dates	+/-	Calibration	N° Lab.	Label	Year	Sector	Elevation
97	0,7		AMS- Ua18143	29386	1991	2	Top
7.240	45	6.216-6.009	LY 10137	58758	2000	3	
8.100	90	7.411-6.669	GIF 9409	41069	1992	2	
8.760	100		GIF 8988	34302/34340	1991	2	
8.800	60		Beta 47494	39603	1992	2	-1,3
8.804	53	8.200-7.655	LY 10138	58026	2000	3	
8.920	50	8.260-7.925	LY 10134	59201/59226	2000	3	
8.925	55	8.262-7.923	LY 10136	58530	2000	3	
8.960	70		Beta 47493	38219/38210	1992	4	-1,64
9.080	60	10.370-10.330	Beta 148099	59244/59261	2000	3	
9.110	60		LY 10141	59663/59724	2000	4	-2,12
9.110	80	8.342-7.982	GIF 9407	40664/40663	1992	2	-1,60
9.150	60	10.480-10.205	Beta 133792	50225/50226	1999	4	
9.200	60		Beta 65856	41542/41540	1993	4	-2,05
9.270	100	8.584-8.063	GIF 9408	40758	1992	2	-1,67
9.400	60		GIF 9027	36837	1991	2	
9.450	70		Beta 65349	41278	1993	2	
9.826	55	9.345-9.220	LY 10135	59181/59481	2000	3	
10.110	55	9.993-9.361	LY 10139	58275	2000	3	
12.200	600		GIF 4628	2618	1978	2	Lev. V
12.440	230		GIF 5403	45	1980	2	Lev. XV
12.640	210	13.595-12.289	GIF 9541	40961	1992	2	-2,41
12.870	40	13.553-12.941	GIF 9540	40959	1992	2	-2,57
13.100	50	13.905-13.338	GIF 9410	40904	1992	2	
13.180	130		LY 6094	40952	1992	2	-2,51
13.900	300		GIF 4927	2623	1978	2	Lev. VI
14.300	400		GIF 5399	83	1980	2	Lev. XVIII
20.280	450		Beta 65350	41302/41304	1993	2	-4,91
25.170	140		GIF 9542	41145	1993	2	-5,88 ext.

The distribution of the 96 confirmed Pleistocene artifacts of sector 2 is: three choppers, 23 cores , 39 flakes, eight retouched pieces, and 23 fragments (see Figures 6, 7, 8, & 9). All raw materials are from local origin: quartz and quartzite (66%) and – interestingly – the softer siltstone (32%). The absence of chalcedony and flint in final Pleistocene layers has already been described in BPF and it represents one of the most intriguing archaeological problems in this region (Parenti 2001). No clear hammerstones have been recovered from the Pleistocene units. Core tools (choppers + cores) presented an average of 3.9 flake scars, (compared to only 2.3 at BPF), pointing, along with a remarkable number of flakes, to a possible function of SDM as flaking stand or – at least in sector 2 - to the presence of a lithic workshop. Flaking is quite expedient also at SDM as in the Pleistocene layers of BPF, because cores have no prepared striking platforms and flakes have mostly (38%) cortical butts. Ten retouched tools have been recorded: three choppers and seven flake tools.

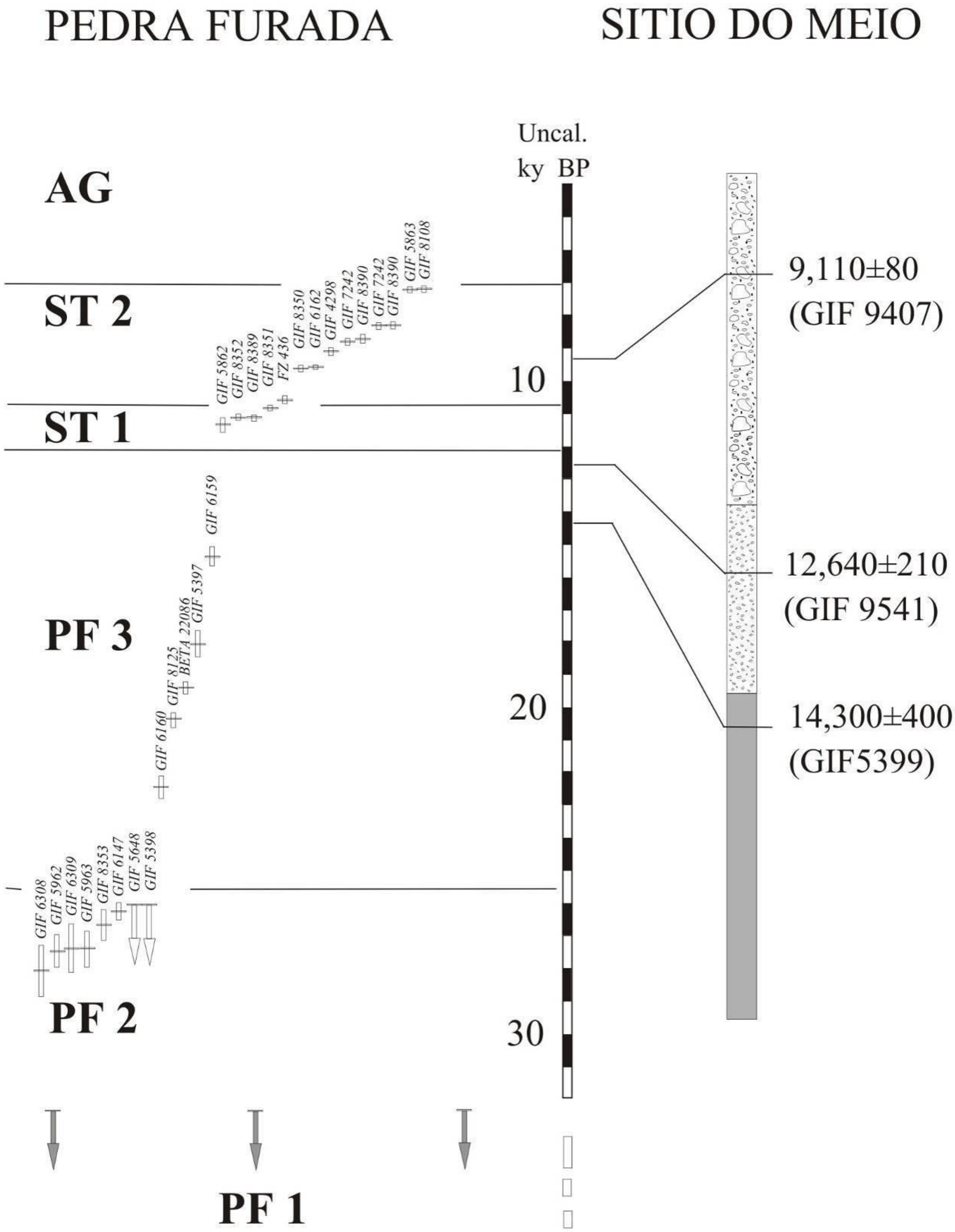

Figure 5. Stratigraphy and chronology of SDM, compared with BPF.

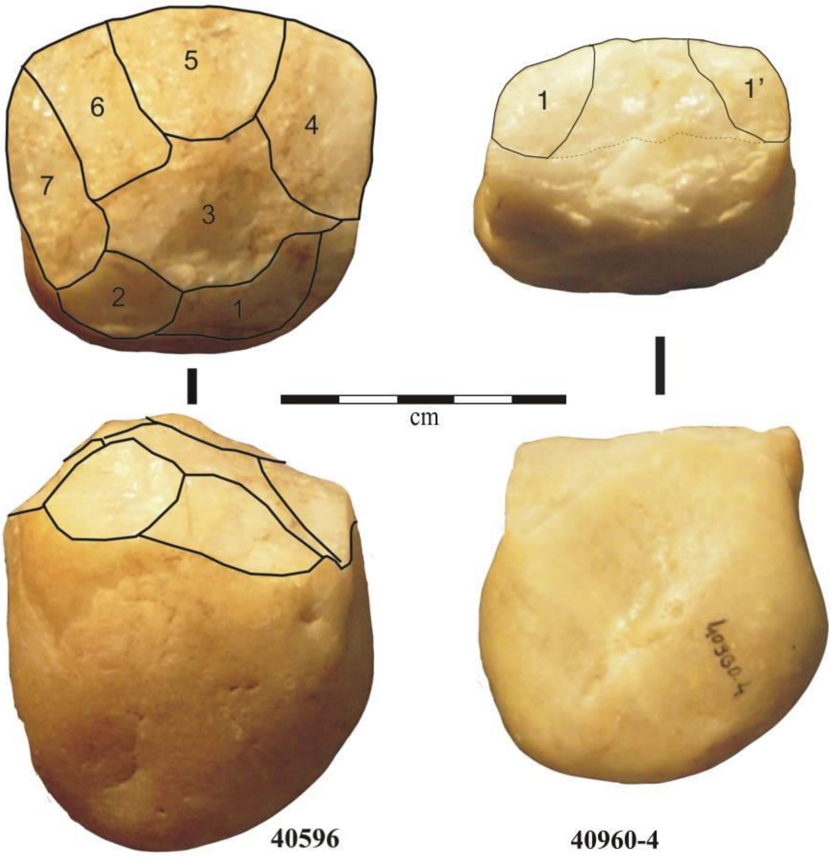

Figure 6. Core tools on quartz pebbles from Pleistocene layer of Sitio do Meio, Pedra Furada 3 phase, older than uncal. 12,640 BP. Numbers refer to FUMDHAM inventory. (Photo by G. Aimola.)

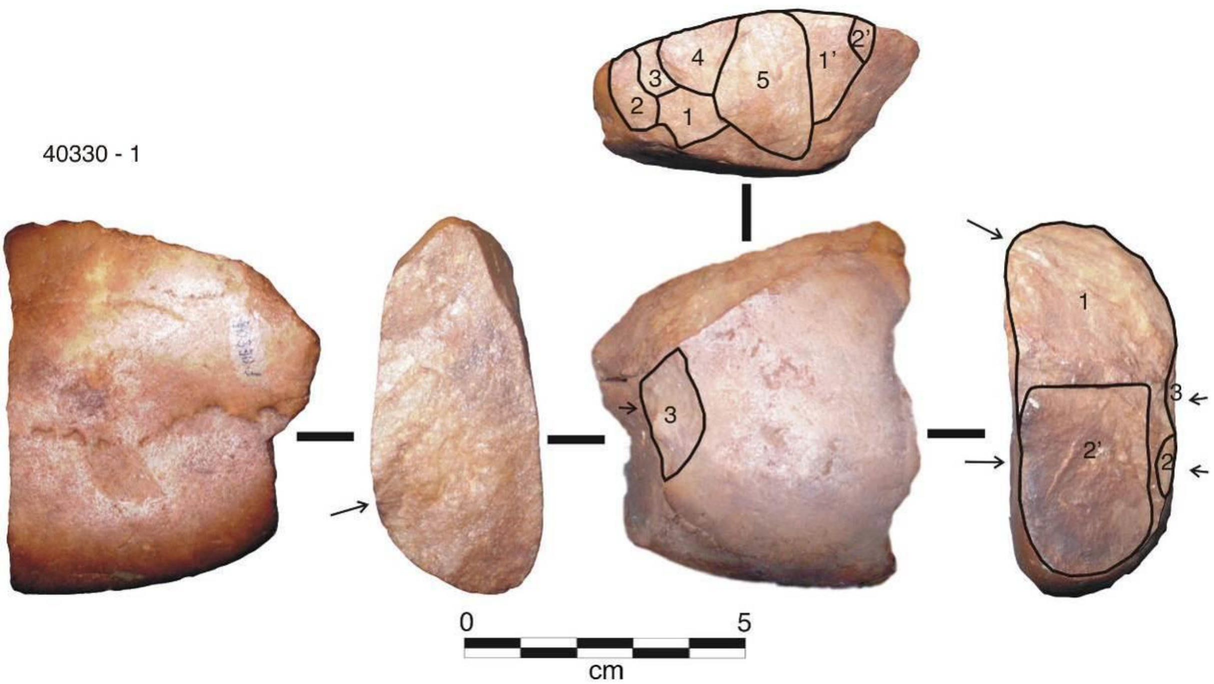

Figure 7. Core on quartz pebbles from Pleistocene layer of Sitio do Meio, Pedra Furada 3 phase, older than uncal. 12,640 BP. Note the high number of flake-scars. (Photo by G. Aimola.)

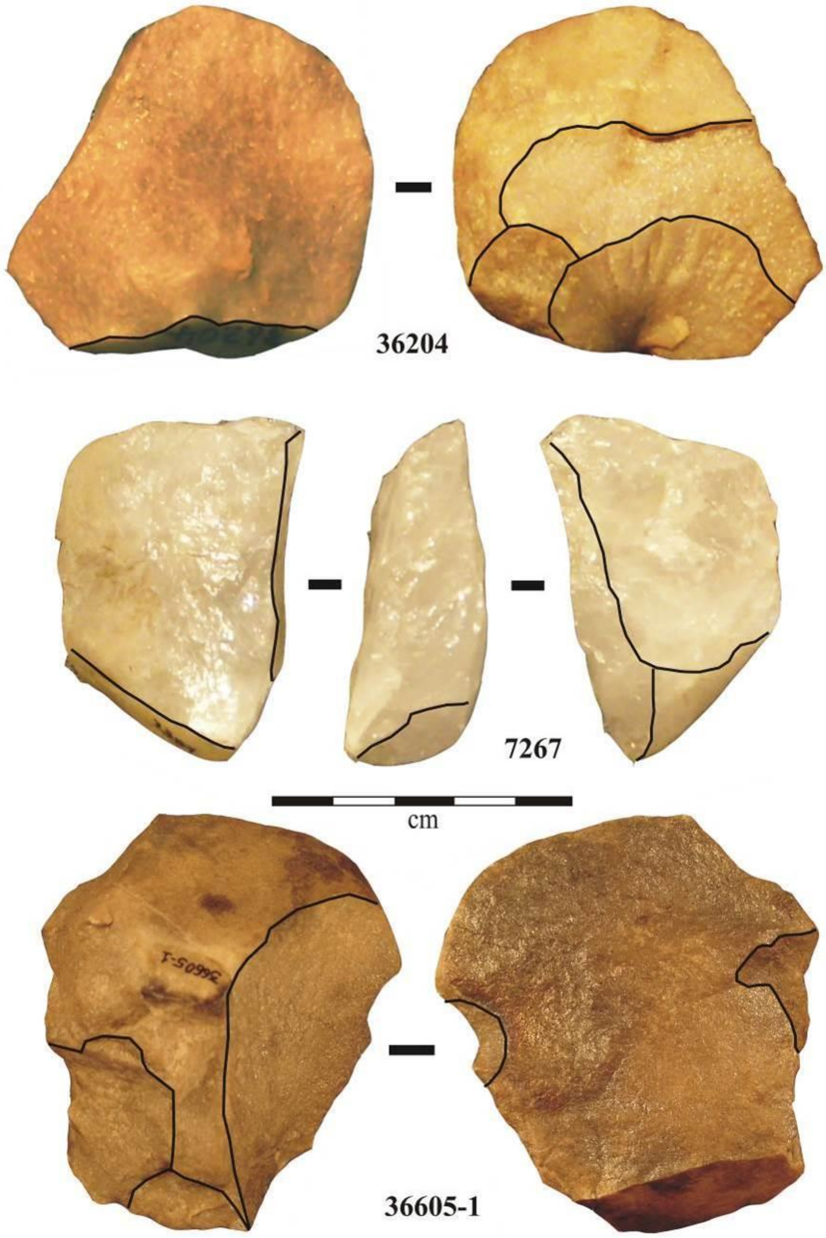

Figure 8. Flakes in quartz and quartzite from Pleistocene layer of Sitio do Meio, Pedra Furada 3 phase, older than uncal. 12,640 BP. Numbers refer to FUMDHAM inventory. (Photo by G. Aimola.)

In the Holocene units of sector 2, 2,522 lithic artifacts have been recovered (sampled in Figure 10), all from the inner portion, in sedimentary units comprised between 9,400±60 (GIF 9027) and 8,100±90 (GIF 9409) uncal. years BP, subdivided as follows: two hammerstones, 29 choppers (1,1%), 207 cores (8,2%), 579 flakes (23%), 1,549 chunks and small flakes (42%). Quartz and quartzite, locally available, sum up to 95%, with some artifacts made on silicified sandstone (1%), chalcedony (2%) and siltstone (2%) (Figure 10). The 207 cores present an average weight of about 200 g and they retain 6.5 flake-scars each, almost twice of the observed in the Pleistocene layers. Flakes have mostly cortical butts (61,3%), but plane (36,2%), facetted (0,35%), and punctiform butts (1,6%) were also observed. Eleven flakes have been made by bipolar technique.

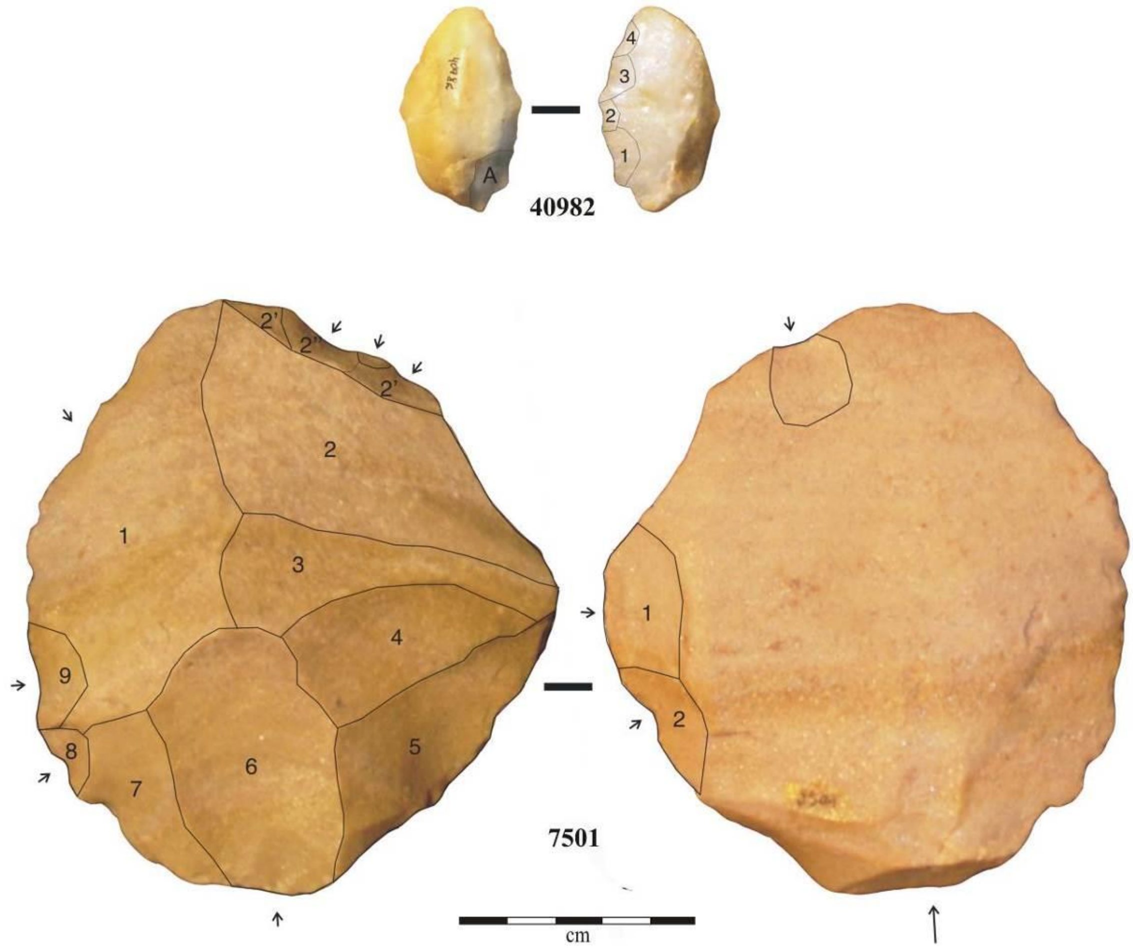

Figure 9. Flakes in quartz and quartzite from Pleistocene layer of Sitio do Meio, Pedra Furada 3 phase, older than uncal. 12,640 BP. Numbers refer to FUMDHAM inventory; retouched pieces: 40982 end-scraper in quartz; 7501: retouched flake in siltstone. (Photo by G. Aimola.)

In such rich deposits as the ones observed during the lower Holocene in Brazilian Northeast, morphological typology still makes sense, mainly for comparative purposes. For this reason we have organized the 82 SDM Holocene retouched artifacts according to the type-list previously adopted for BPF: 1) half of the artifacts (40) were made from flakes, mainly quartzitic flakes; 2) core tools sum up to 35% 3) only one *limace* is present; this is a completely retouched unifacial scraper traditionally considered as the reference tool for the lower Holocene in Brazilian *Planalto* (Lourdeau 2010). It is worth noting that only five tools were made from chalcedony, the prized raw material from which the majority of finished tools have been usually obtained in the rock-shelters toolkit of Southern Piaui. The majority of small flakes have been struck from quartz and quartzite, meaning a greater use of endogenous rocks in comparison to the BPF Holocene layers.

5. Stone structures, paintings, palynological and faunal remains

A total of 57 structures, including fireplaces, cairns and lithic workshops, have been recorded at SDM, but reliable documentation is available for only 10 stone structures from sector 4 and five structures from sector 2 (all structures from sector 2 were dated). Structures were made mainly of small fallen sandstone slabs and quartz cobbles. The majority of such structures has no clear borders and do not show any evident difference in their surface as observed in BPF. However, some of the structures are impressive, clearly structured hearths (as the one presented in Figure 11) or – sometimes – possible funerary cairns. Remarkably, the dating of one structure (n° 1/18, 1992) gave a final Pleistocene age: 13,180±130 (LY 6094).

Figure 10. Artifacts from lower Holocene of Sitio do Meio, Serra Talhada I phase. Numbers refer to FUMDHAM inventory. 40631-3: chopper, 34109-1: flake, 36635-3: denticulate, 29094: simple scraper, 29085: flake, 31444: chopper, 29060: convex scraper. (Photo by L. Mota.)


Figure 11. Hearth 32, sector 3, 8,804+/-53 (LY 10138) (Photo by Fumdham Archive)

A very peculiar and popular artifact from SDM is a kind of anvil, unifacial or bifacial, obtained from large siltstone slabs; 115 of them have been recovered, almost all in sector 2, and 77 attributed to Pleistocene layers (Pinheiro De Melo 2007). Optical analysis using a binocular microscope suggest they have been used as polishers or grinders for seeds, nuts and pigments, the last ones frequently recovered as red or yellow ochre. In this regard, parietal art at SDM (paintings and engravings) is attributed to the Nordeste tradition, dated to lower Holocene (Cisneiros 2008), based only on stylistic ground. Some figures have been engraved on fallen blocks after 8,100±90 years BP (GIF 9409). Finally it is worth mentioning that a polished axe in granodiorite has been described (Guidon & Pessis 1993) as coming from a layer dated at 9,200±60 years BP, in sector 4 (Beta 65856) as well as a fragment of coarse ware from sector. 2, dated at 8,960±70 years BP (Beta 47493). Both remains, although relevant, need to be considered with caution because of the complex stratigraphy of the site, as well as the problems associated to the documentation and field recording of the excavations.

Palaeoenvironmental data from SDM come from studies on palynological and faunal remains. Pollen has been obtained from 30 coprolites and the most relevant result (Chaves 1997) shows that, between 12,000 and 8,000 BP, vegetation was typical of *Cerrado* (arboreal savanna of northern South America), and around 7,000 BP a *Caatinga* formation (shrubby savanna, as the current one) took over, pointing for a moister climate at the Pleistocene-Holocene transition. Because of the sediment acidity, faunal remains have been recovered only in the upper layers. They consist in about 2,150 remains of small mammals, very similar to the current faunal composition (Schmalz 1998).

6. Discussion and conclusion: Sitio do Meio in its context

With regards to stone tools, it seems that SDM did not play the central function that BPF did in the regional settlement system. If the lithic industry in the last millennia of Pleistocene at SDM can be reliably compared only with that from BPF, between 11 and 8,000 BP, an overview at a macro-regional scale can be established. Both SDM and BPF share main technical traits of the Palaeoindian so-called *Itaparica* "tradition" of Brazilian *Planalto,* present on a wide area, from Goiás to Pernambuco states (Lourdeau 2010). This tradition has been characterized by generally unifacial flaking with occasional occurrence of bifacial projectile points, as observed in Lapa do Boquete, Santana do Riacho, Perna I, and BPF. In some cases, like SDM, Santana do Riacho and Sítio do Justino, bipolar flaking has been observed (Fogaça 2001).

In this context the palaeoanthropological evidence, for the period encompassed by SDM sequence, can be summarized as follows: 1) at the very end of the Pleistocene an archaic and robust human morphology is present in the region, as documented by the cranial and dental remains from Garrincho, a limestone cave just 15 km SW from SDM (Peyre *et al.* 1998). The remains have been dated at 12,170±40 uncal. years BP (Beta 1366204), dating just after the first preserved occupations at SDM (Guidon *et al.* 2000); 2) at Toca do Paraguaio, another sandstone shelter close to SDM with funerary evidence, two penecontemporaneous burials (dated at 8,800-8,500 uncal. BP) presented two distinct cranial types, one of Austro-Melanesian/African morphology and the other much more similar to present mongoloid forms (Bernardo & Neves 2009). The authors of this study propose that in Lower Holocene two different human groups were present in Northern South America at the same time, probably the product of two different migration waves. This is exactly the period in which all the sites in the region show an impressive change regarding essential cultural traits such as lithic toolkit, rock-art and burials.

In this paper we presented the revision of the available information on the stratigraphy and archaeology of SDM, presenting analytical data on its lithic industries and showing that a considerable amount of evidence from the main sector can be reliably exploited. A minimum of about one hundred artifacts can be undoubtedly associated to the layers dated from the Late Pleistocene, deserving to be attentively considered in the debate about the earliest peopling of South America.

Just close to Pedra Furada, Sítio do Meio is the second archaeological Late Pleistocene site in North-Eastern Brazil with stone tools associated with structures. Just because the anthropic origin of BPF artifacts has been questioned, SDM is extremely important because of the absence of the main physical force pontentially creating geofacts in this kind of site, i.e. waterfalls. Certainly, we should have more data on the sedimentary history of the deposit and on the taphonomy of lower units, which could still be possible on sector 1. The next research goal, in our opinion, should be the comparison of the artifact sample we presented here, surely Pleistocene in age, with both the artifacts recovered from Boeda team in 2012 and 2013 campaigns and the assemblage of PF3 phase of BPF, along with the toolkit from the recently published Vale da Pedra Furada and Tira Peia sites (Lahaye *et al.*, 2013). For so doing, it is essential to adopt a common methodology and a clear-cut classificatory toolkit. In any case, SDM not only confirm the presence of humans in Northeastern Brazil well before the bewitched chronological boundary of the end of Pleistocene, but it also provides the first step for a systematic intra-site analysis of the Southern fringe of the *Cuesta* of Serra da Capivara.

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Chert raw materials and artefacts from NE Bulgaria: A combined petrographic and LA-ICP-MS study

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Abstract:

In the present study two analytical methods are applied to characterize chert artefacts and raw materials from northeastern Bulgaria (Ludogorie region): petrographic observation and laser ablation inductively coupled plasma mass spectrometry). Archaeological samples from 12 Chalcolithic sites from Bulgaria are analyzed as well as raw material from 6 outcrops in northeastern Bulgaria are identified and documented during a survey in 2012 when many raw material samples were collected. The chert raw material mostly occurs in various Quaternary secondary deposits, originating from destruction and disintegration of the Lower Cretaceous (Aptian) limestones in the area. The paper is aimed at tracing the provenance of the artefacts based on their petrographic characteristics and geochemical composition. The archaeological evidence shows a wide distribution of the Ludogorie chert throughout the country.

On the basis of micropetrographic observations, Gurova and Nachev (2008) described two main chert types (Ravno and Kriva Reka). Our petrographic study confirmed the previous results and an additional chert type was distinguished, originating from primary and secondary deposits (quarries in Koprivetz and Krasen villages) and is represented by silicified limestones (bioclastic-peloidal packstones or grainstones). It is noteworthy that the first two types of chert were largely used for prehistoric artefact manufacturing while the last one is not attested among studied assemblages at all.

Keywords: Chalcolithic; northeastern Bulgaria; Ludogorie; Ravno; Kriva Reka; petrogpahy; LA-ICP-MS; super-blades; workshops

1. Introduction and archaeological background

The present study is focused on the prehistoric chert raw material originating from northeastern Bulgaria (Ludogorie region). The abundant and high quality deposits of siliceous rock in this part of the country, often referred to as Dobrudzha, has been the focus of archaeogeological studies for decades. The first scholar to formulate and highlight the importance of a systematic approach to the chert raw material in the context of intensified archaeological research in prehistory was Kancho Kanchev in his publication on problems and purposes of chert studies (Kanchev 1978). His surveys, carried out with the

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sedimentologist I. Nachev, led to the identification of 224 raw material outcrops in Bulgaria. The biggest concentration of chert sources occurs in three districts in north Bulgaria: Razgrad – 32 outcrops, Russe – 27 and Pleven – 24 (Kanchev 1978: 87). A particular study was devoted to the numerous and abundant chert deposits in northeastern Bulgaria, which were primarily embedded in Lower Cretaceous (Aptian) limestones that were subsequently disintegrated and redeposited as Quaternary (secondary) placers with rounded chert concretions (Nachev, Kanchev 1984). In 1988 an instructive study was published about the siliceous rocks in Bulgaria regarding the correlation of their geographic, geotectonic and stratigraphic distribution, as well as their mineral and chemical composition, diagenesis and evolution. The authors, Ivan Nachev and Chavdar Nachev, both geologists, have been deeply involved in the research of rocks as raw material for prehistoric assemblages used by human populations and commonly referred to by archaeologists as 'chert' assemblages (Nachev & Nachev 1988). More recently, C. Nachev published a paper illustrating the characteristics and particular features of the four main geologically distinguished types of chert concretions on the basis of their comparative analysis (Gurova, Nachev 2008; Nachev 2009) (Figure 1). As described by C. Nachev, the silica concretions of Ludogorie (or Dobrudzha) chert were hosted in Lower Cretaceous (Aptian) micrite limestones with pale grey colour and are characterised by a white silica-carbonate cortex. The primary sources gave material for numerous secondary (placer) deposits with an eluvium-proluvium character. They are located mainly in the Ludogorie plateau (on the hills), hosted in soft sandy-carbonated masses (Gurova, Nachev 2008, 33; Nachev 2009). The Ludogorie chert has two microscopically distinct types: Ravno type (in the northern part of the region) and Kriva Reka type (in the southern part). In relation with its petrographic characteristics C. Nachev describes Ludogorie chert as the highest quality chert raw material in Bulgaria (and on a broader scale of southeastern Europe and Asia Minor) with large scale distribution and use in prehistoric chert assemblages (Nachev 2009, 11-12).

A significant number of studies have also been done on the prehistoric (Chalcolithic) chert assemblages from northeastern Bulgaria by the Russian specialist, Natalia Skakun, French specialist, Laurence Manolakakis (Manolakaksi 2005, Skakun 2006). Both scholars have concluded that the huge amount of the chert artefacts from northeastern Bulgarian tells (Goliamo Delchevo, Durankulak, Vinitsa, Smiadovo and Sava) and cemeteries (Varna, Durankulak) are made of Ludogorie (Dobrudza) chert. The same conclusion was reached by one of the authors of the present paper (Gurova 2001b) on the basis of investigations of Chalcolithic chert assemblages from settlements which belong to different cultures (Sava, Polianitsa, Varna) and to the of Kodžadermen–Gumelniţa–Karanovo VI cultural complex.

Both types of Ludogorie chert mentioned by C. Nachev possess favourable properties for lamellar (blade) production that determined its use for large-scale subsistence and household activities during the Chalcolithic period as revealed by studies of sites such as Karanovo, Drama-Merdzumekja, Varhari, Burgas, Karnobat, Kosharna, Bazovets, Ivanovo, Smiadovo, and Targovishte-Garata (Gurova 2005, 2010, 2011 a, b) (Figures 2 and 3). As for the most sophisticated knapping techniques (lever pressure) and the production of extra-long blades for ritual purposes in the mortuary domain (Varna and Durankulak cemeteries) and for hoard deposits (Tell Smiadovo), undoubtedly the Ravno type of chert was used (Figures 4 and 5).

In spite of the widely acknowledged quality and the broad distribution of the Ludogorie cherts, information about raw material extraction and supply in prehistory is still rather scarce. As well, it is still debatable as to how early in prehistory the exploitation of Ludogorie chert took place.

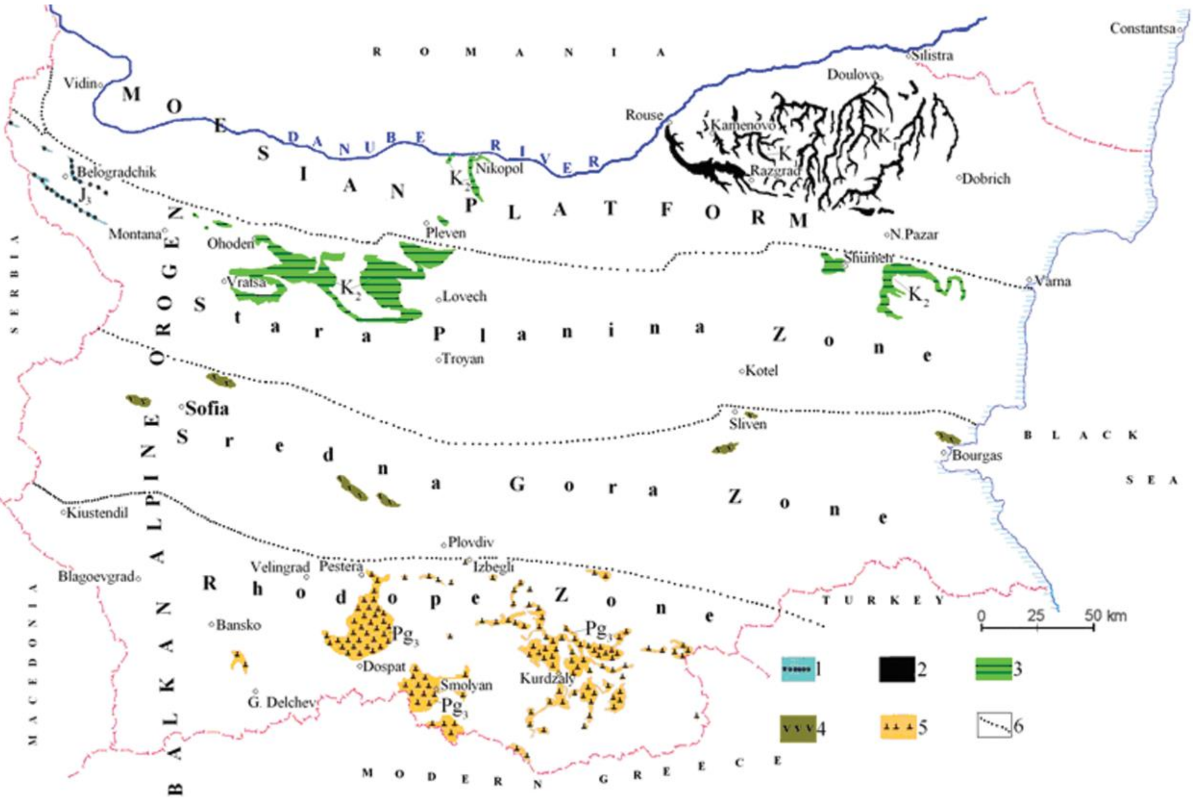

Figure 1. Geological map of the main types of flint-bearing rocks in Bulgaria: 1. Upper Jurassic limestones with siliceous concretions (J3); 2. Low Cretaceous (Aptian) limestones with siliceous concretions (K1); 3. Upper Cretaceous chalk and chalk-like limestones with siliceous concretions (K2); 4. Upper Cretaceous volcanogenous rocks with chalcedony veins in Sredna Gora Zone; 5. Oligocene volcanogenous rocks with chalcedony veins in Rhodope Zone (Pg3); 6. Boundary between tectonic zones (based on Gurova & Nachev 2008, fig. 5).

Regarding raw material procurement and the first stage of chert production, Manolakakis' prospections and trench excavations in the Razgrad area allowed her to identify a concentration of archaeological sites on the Sakaralan plateau. The most significant accumulation of chert material indicating workshops has been localized around Ravno village with three distinct sites (Ravno 1-3) (Manolakakis 2011, 229). Another workshop for chert production with evidence of long blade removal using indirect percussion and the lever pressure technique has been identified at the Tell of Kamenovo in close proximity to the excellent quality, large chert nodule outcrops of Ravno 3 (Manolakakis 2006, 11; 2011, 233). Advancement in this field was made recently through the systematic surveys in the Razgrad district area made by Mateva. She describes the secondary chert placers as being easy for access and nodule extraction from the soft loess layers. Several new workshops have been identified near the villages Ravno, Kamenovo and Kriva Reka, and as well in the locality Chakmaka (near Isperih), (Mateva 2010, 174). The Kriva Reka raw material is presented as significant amount of secondary chert deposits on the hill named Chakmaklaka (near the village). The earliest evidence of exploitation of the deposits dates back to the Chalcolithic (although it may have been exploited even earlier, further evidence is required to support the idea of exploitation prior to the Chalcolithic) and has continue up until the mid-20th century. The chert from Kriva Reka was certainly used for different purposes, but the most remarkable specialization of the local chert knappers consisted of the manufacture of threshing sledge (tribula) inserts which had a wide distribution throughout the country (for more on this subject, see Gurova 2011c)

Figure 2. Artefacts of Ludogorie flint from the Chalcolithic site of Bazovets (Russe district). Scale bars: 1 partition = 1 cm. (Photos by M. Gurova.)

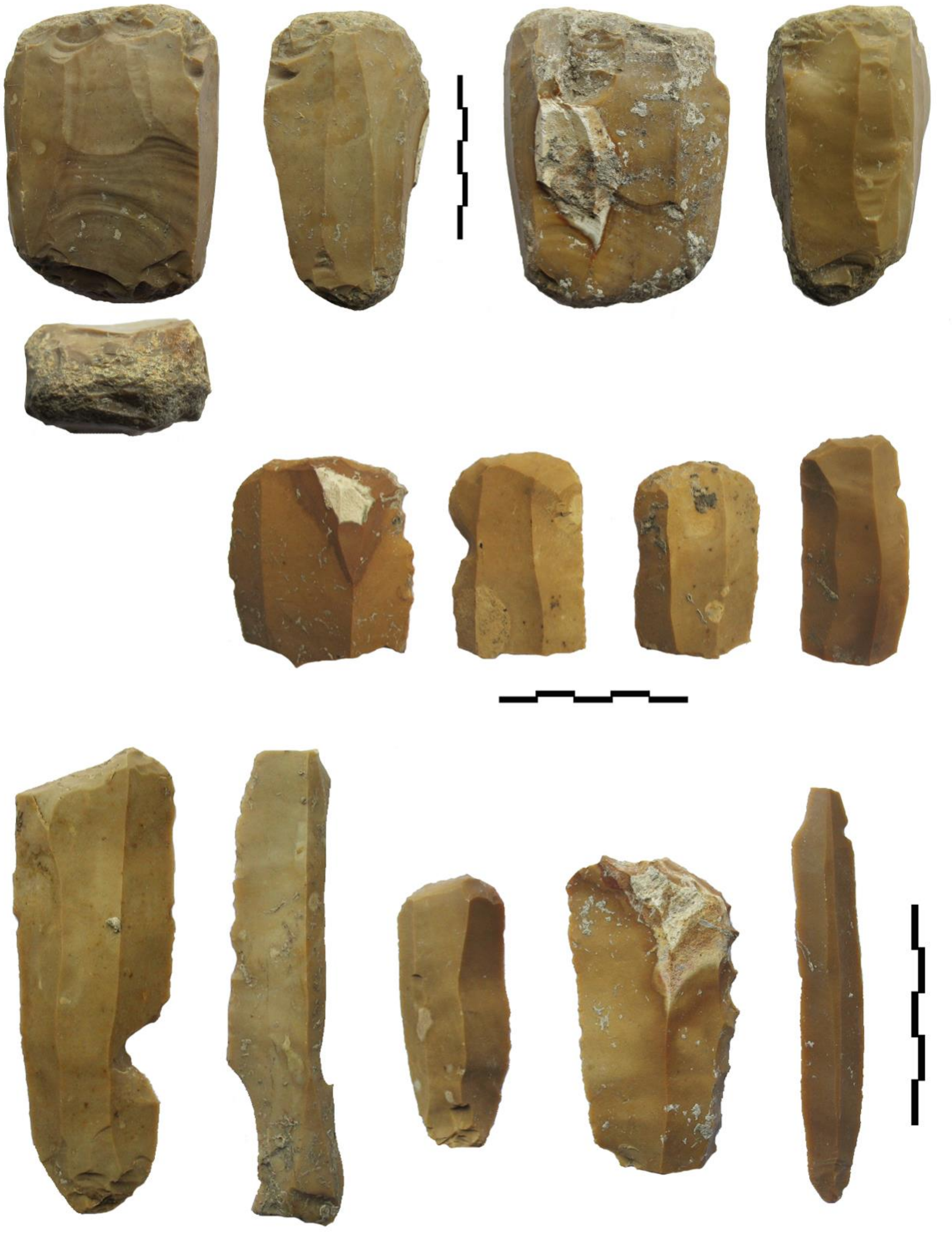

Figure 3. Artefacts of Ludogorie flint from the Chalcolithic site of Kosharna (Russe district). Scale bars: 1 partition = 1 cm. (Photos by M. Gurova.)

Figure 4. Long and extra-long (superblades) of Ludogorie flint from Varna cemetery (late Chalcolithic Varna culture). Scale bars: 1 partition = 1 cm. (Photo by M. Gurova.)

Figure 5. Long and extra-long (superblades) of Ludogorie flint from the Tell Smiadovo hoard I. Scale bars: 1 partition = 1 cm. (Photo by M. Gurova.)

1.1. New stage of the investigations of the Ludogorie chert raw material

The present paper summarizes the results of the survey and subsequent laboratory analysis performed as an extension of a project {("Prehistoric chert sourcing in NW Bulgaria and NE Serbia: Field survey and laboratory analyses", co-directed by Dr. Dušan Borić (Cardiff University) and Dr. Maria Gurova (NIAM-BAS)}, focused on northern Bulgarian chert raw materials. Two seasons of surveying in northern Bulgaria were carried out in relation to the project goals: discovering chert deposits, recording them using GPS and marking them on topographic and geological maps; preparing geological descriptions of the raw material deposits; photo documentation of the field conditions, and surface finds; identifying plausible archaeological workshops associated with the chert outcrops; and completing exhaustive collections of raw material samples for archaeometric analyses (thin-section petrographic analyses and LA-ICP-MS).

The second campaign (in 2012) extended the survey to northeastern Bulgaria – Ludogorie region (Russe, Razgrad and Shumen districts) (Figure 6). In this area 15 secondary chert deposits were registered as well as 5 archaeological sites, three of which were already known from the literature and the AMB (Archaeological Map of Bulgaria) system (Gurova et al. 2013 a-b). The workshops of prehistoric chert production in Ravno and Kamenovo were documented (Figure 7), as well as the long-lasting tribula insert production center at Kriva Reka village (Figure 8).

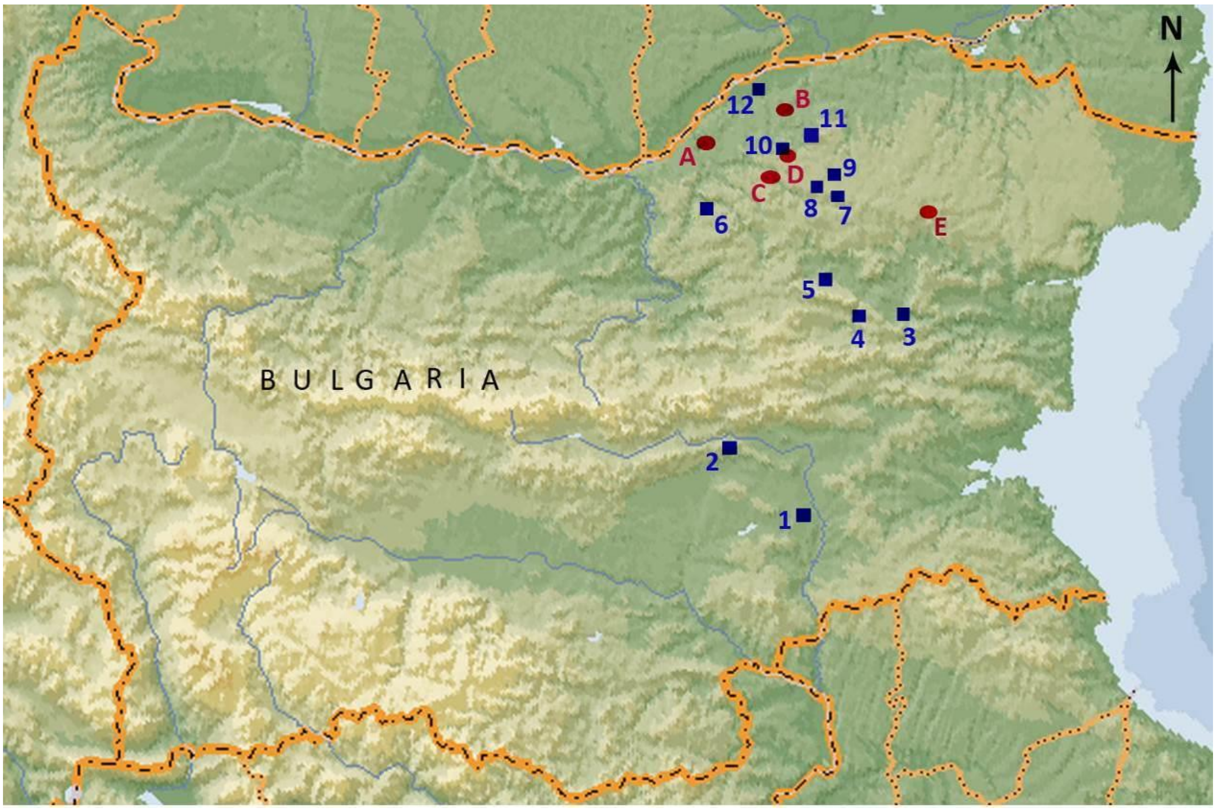

Figure 6. Map of Bulgaria showing the locations where geological (with letters) and archaeological (with numbers) samples mentioned in the article were collected. Geological sites : A. Krasen; B. Tetovo ; C. Krivnia; D. Ravno; E. Kriva Reka. Archaeological sites: 1. Drama-Merdzhumekja; 2. Karanovo; 3. Smiadovo; 4. Ivanovo; 5. Targovishte-Garata; 6. Bazovets; 7. Radingrad; 8. Nedoklan; 9. Golaim Porovets; 10. Ravno; 11. Kamenovo; 12. Kosharna (Created by M. Gurova.)


1
2
3
4
5

Figure 7. Archaeological evidence (cores and debitage) of a flint workshop at the site of Kamenovo (1. to 3.) and Ravno (4. to 5.) with secondary deposits of flint concretions – Ludogorie flint (Lower Cretaceous). Scale bars: 1 partition = 1 cm. (Photos by M. Gurova.)

Figure 8. Kriva Reka flint workshop: 1. and 2. cores and debitage at the secondary deposits on Chakmaklaka Hill (scale bars, 1 partition = 10 cm); 3. and 4. artefacts and debris from knapping activity in the village of Kriva Reka; 5. one of the few remaining witnesses of the *tribulum* insert production which took place until the 1950s of the 20th century. Scale bars: 1 partition = 1 cm. (Photos by M. Gurova.)

2. Material and Methods

In the present study we combined two analytical methods (petrographic observation and laser ablation inductively coupled plasma mass spectrometry) to characterize chert artefacts and raw materials from northeastern Bulgaria. Field work was performed in the districts of Russe, Razgrad and Shumen in order to collect Lower Cretaceous (Aptian) raw materials from various chert deposits.

Artefacts from the following Chalcolithic settlements in Bulgaria were analysed: Tell Karanovo and Tell Drama-Merdzumekja (Thracian plain); as well as Smiadovo, Ivanovo, Kosharna, Bazovets, Targovishte-Garata, Radingrad, Nedoklan, Ravno, Kamenovo and Goliam Porovets – all in the northeastern part of the country (Figure 9). The archaeological samples taken are very informative and significant from a raw material point of view (visually representing the main variants of Ludogorie chert). They are also important as being among the most frequently attested and diagnostic typological tools within the assemblages.

All chert samples were macroscopically described (colour, size, shape, texture, cortex, etc.). Thirty-four standard thin sections were also prepared from part of the chert raw material samples and artefacts and were examined under a petrographic microscope. The aim of this study was to describe microscopic chert characteristics (mineralogy, rock texture, limestone relics and fossil assemblages, relative proportion of siliceous and carbonate components, etc.) in an attempt to distinguish petrographically the various chert types.

Based on the macroscopic description and petrographic observations, 31 representative chert samples (raw materials and artefacts) were selected to be analysed by LA-ICP-MS analyses in order to determine their chemistry. Twelve raw materials and 19 artefacts were analysed. At least three analyses per sample were performed. If a chert sample had differently coloured parts, each part was analysed individually.

The LA-ICP-MS system used for analyses consists of a 193 nm ArF excimer laser coupled with a PE ELAN DRC-e ICP quadrupole mass spectrometer at the Geological Institute of the Bulgarian Academy of Science in Sofia, Bulgaria. For controlled ablation of the material, an energy density of about 10 J/cm2 on the sample surface and a laser pulse frequency of 10 Hz were used. Analyses were performed with a 75 µm beam diameter. External standardization by NIST 610 SRM glass provided relative element concentration ratios that were transformed into absolute concentrations by internal standardization. SiO2 content (99 wt.%) was used as an internal standard, applying the SILLS software (Guillong et al., 2008) for data reduction. In total 45 elements were measured.

3. Results

In northeastern Bulgaria the chert raw material occurs predominantly in secondary eluvium (Figure 10 a–e), diluvium and (paleo)alluvial (Figure 10 f–h) deposits. As mentioned above this chert is known as Dobrudzha or Ludogorie chert (Nachev 2009) and is characterized by Early Cretaceous (Aptian) age (Nachev, Kanchev 1984). Primary deposits are only sporadically present in the Aptian limestone sequence of the Kovachevo Formation (Nikolov 1969), where the chert occurs as layers and beds of variable thickness.

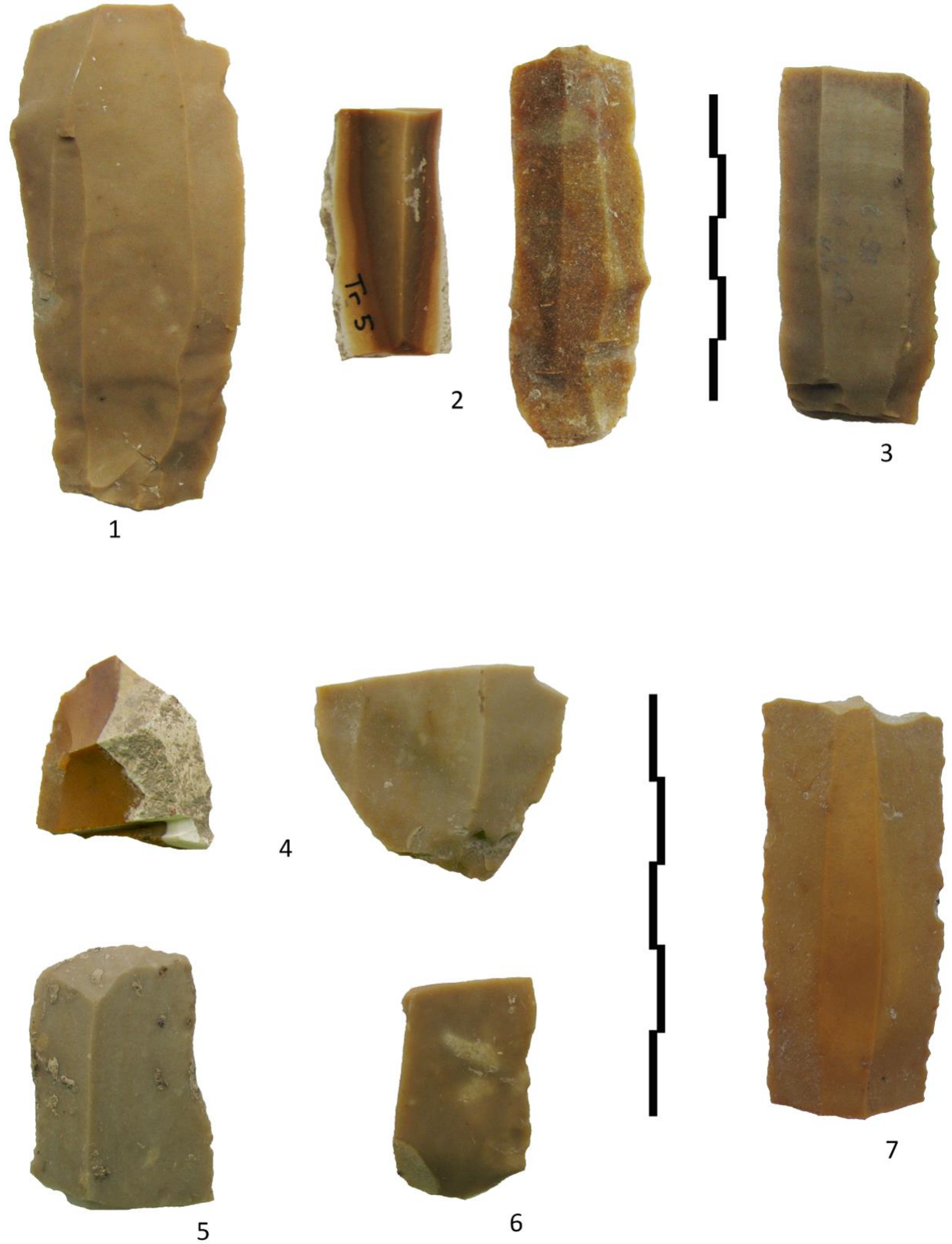

Figure 9. Archaeological samples from Chalcolithic sites in Bulgaria submitted to LA-ICP-MS and thin-section petrographic analysis. 1. Smiadovo; 2. Targovishte (Garata); 3. Goliam Porovets; 4. Bazovets; 5. Kosharna; 6. Ivanovo; 7. Karanovo. Scale bars: 1 partition = 1 cm. (Photo by M. Gurova.)

Figure 10. a) Eluvium deposits with flint pebbles and cobbles (Kriva Reka village, Shumen district); b) Flint cobble (black arrows) and artefact (yellow arrow) (Kriva Reka village, Shumen district); c) and d) Eluvium deposits with flint pebbles and cobbles (white arrows) (quarry near Tetovo village, Ruse district); e) Eluvium deposits containing flint cobbles (Ravno village, Razgrad district); f) Palaeoalluvial deposits containing flint pebbles (black arrows) (quarry in Krasen village, Ruse district); g) and h) Palaeoalluvial deposits composed almost completely of flint pebbles and cobbles (Krivnia village, Ruse district). Scale bars: 1 partition = 10 cm. (Created by P. Andreeva.)

3.1. Petrography

On the basis of micropetrographic observations, Gurova and Nachev (2008) described two main chert types (Ravno type and Kriva Reka type). The petrographic observations of the current study confirmed the previous results and distinguished an additional chert type. In this study, the sampled chert raw material from northeasternBulgaria originated mostly from secondary deposits. The latter occur near Ravno village (Razgrad district), in quarries in Tetovo, Krivnya and Krasen (Ruse district) and Kriva Reka (Shumen district). Primary chert deposits, although not suitable for tool preparations, occur only within the limestone sequence of the Kovachevo Formation, which outcrops near to towns Byala and Popovo.

Three main chert types are distinguished on the basis of the macroscopic and microscopic features observed. Type I (Figure 11 a–d) is characterized by a great variety of colours (mostly beige, ochre, light brown and dark brown, but light gray, creamy gray, dark gray, purple, and white also occur). The chert texture is homogeneous or sometimes zonal. This chert type is mainly oval shaped and is often distinguished by white cortex. It reaches up to 70 cm in size (mostly being between 10 and 30 cm). Microscopically, the chert is composed of microcrystalline quartz groundmass containing siliceous (chalcedonic) sponge spicules (Figure 11 e, f) and sporadic foraminifer tests, thin-shelled bivalves and ostracods replaced by silica minerals. Carbonate components and silt-sized clastic quartz grains are occasionally present in a few samples. The microcrystalline groundmass commonly contains abundant opaque minerals. Most likely, the replaced carbonate rocks were spiculite mudstones and wackestones. This chert variety is known as Ravno type (Gurova and Nachev, 2008) and is recognized in the raw materials studied in thin-section from Ravno and Tetovo and artefacts from Ravno, Kamenovo, Goliam Porovets, Radingrad (2) Ivanovo, Kosharna, Bazovets, Targovishte (2) and Smiadovo.

Type II consists of chert pebbles and cobbles between 5 and 15 cm in size. It is ochre, brown, beige or occasionally gray colour, commonly has white spots and has a white or ochre and brown (within the paleoalluvial deposits) cortex of variable thickness (Figure 11 g, h). The colour of the cortex is a result of oxidation processes (Figure 11 h, Figure 12 a). Under the microscope, the material consists of microcrystalline quartz and chalcedony groundmass containing common silicified skeletal grains (crinoids, foraminifers, bryozoans, brachiopods, etc.) and a variable amount (5-15%) of sand-sized clastic quartz grains (Figure 12 b–d). Siliceous sponge spicules are also presented. Relict carbonate components (5-15% of the rock volume) include bioclasts (Figure 12 e) and rare peloids and intraclasts. Most of them are strongly replaced by opaque minerals. Finely-crystalline quartz composed of polygonal crystals is alsoobserved (Figure 12 c). The replaced carbonate rocks were most likely bioclastic packstones or grainstones. This type is described by Gurova and Nachev (2008) as Kriva Reka type and is represented in the studied thin-sections from raw material in Kriva Reka, Krivnia, and Krasen as well as the artefacts from Kriva Reka, Nedoklan, Radingrad (1), Drama, Karanovo, Targovishte (1).

Type III has a dark brown to dark gray colour (Figure 12 f) and is represented by silicified limestones (possibly bioclastic-peloidal packstones or grainstones) (Figure 12 g, h). Silica components are composed of siliceous sponge spicules and chalcedonic groundmass. This chert occurs as separate layers within the limestone succession of the Kovachevo Formation (for example, at Koprivets quarry) or is represented as redeposited pebbles and cobbles in a secondary deposit in the quarry near Krasen village.

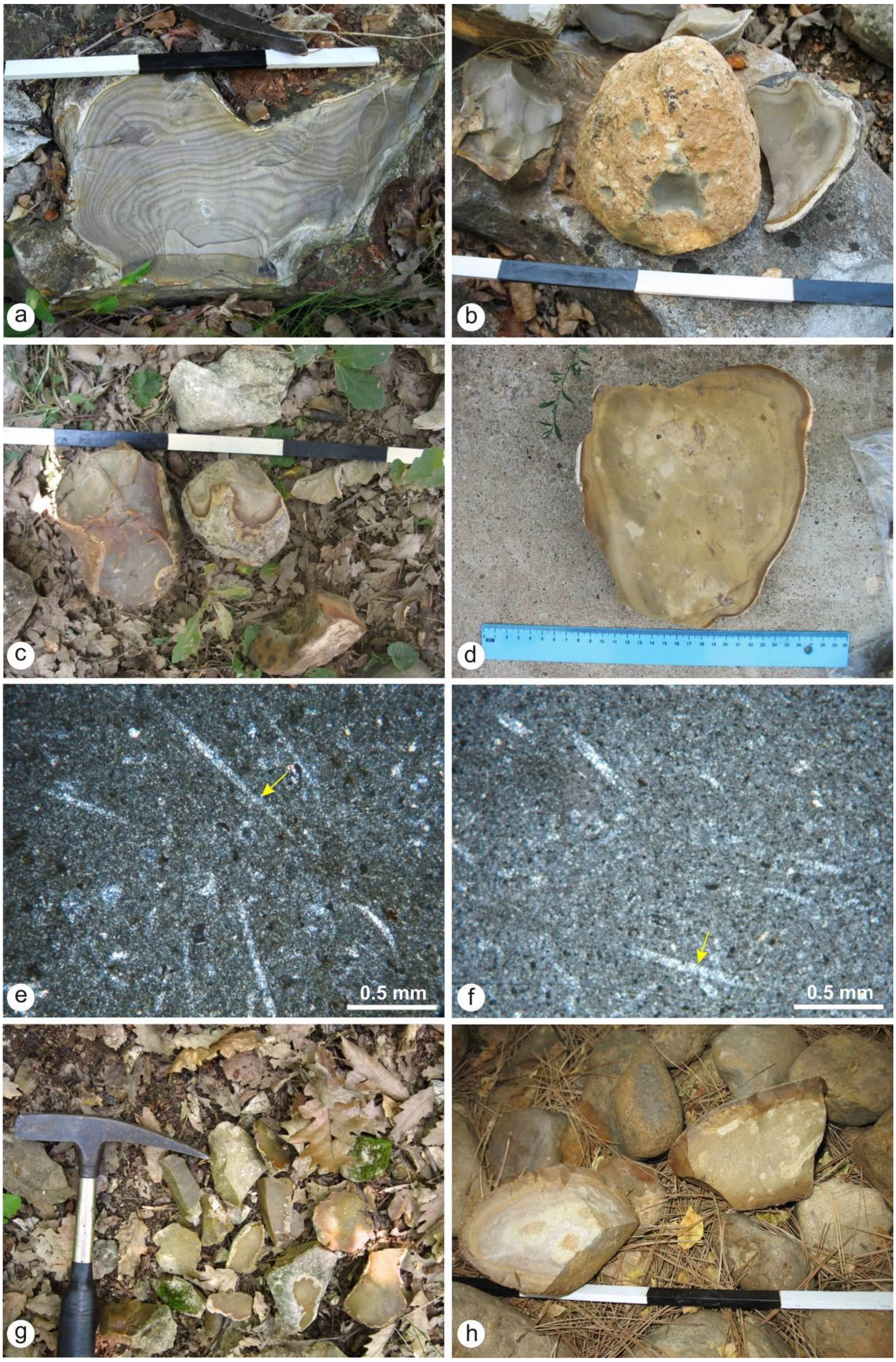

Figure 11 a) Large flint boulder with zonal texture (secondary deposit, quarry near Tetovo village, Ruse district); b) Flint cobbles with oval shapes and white cortexes (secondary deposits, quarry near Tetovo village, Ruse district); c) and d) Flint cobbles and boulders with various colours (secondary deposits, Ravno village, Razgrad district); e) Microcrystalline quartz groundmass containing siliceous sponge spicules (*yellow arrow*) (raw material, secondary deposit), Ravno village, Razgrad district, CPL (cross-polarized light microphotograph); f) Chalcedonic sponge spicules (*yellow arrow*) within microcrystalline quartz groundmass (artefact, Kamenovo, Razgrad district), CPL; g) Flint with ochre, brown and beige colours and frequent white spots (secondary deposits, Kriva Reka village, Shumen district); h) Flint pebbles with dark brown and ochre coloured surfaces (secondary deposits, quarry near Krivnya village, Ruse district). Scale bars: 1 partition = 10 cm. (Created by P. Andreeva.)

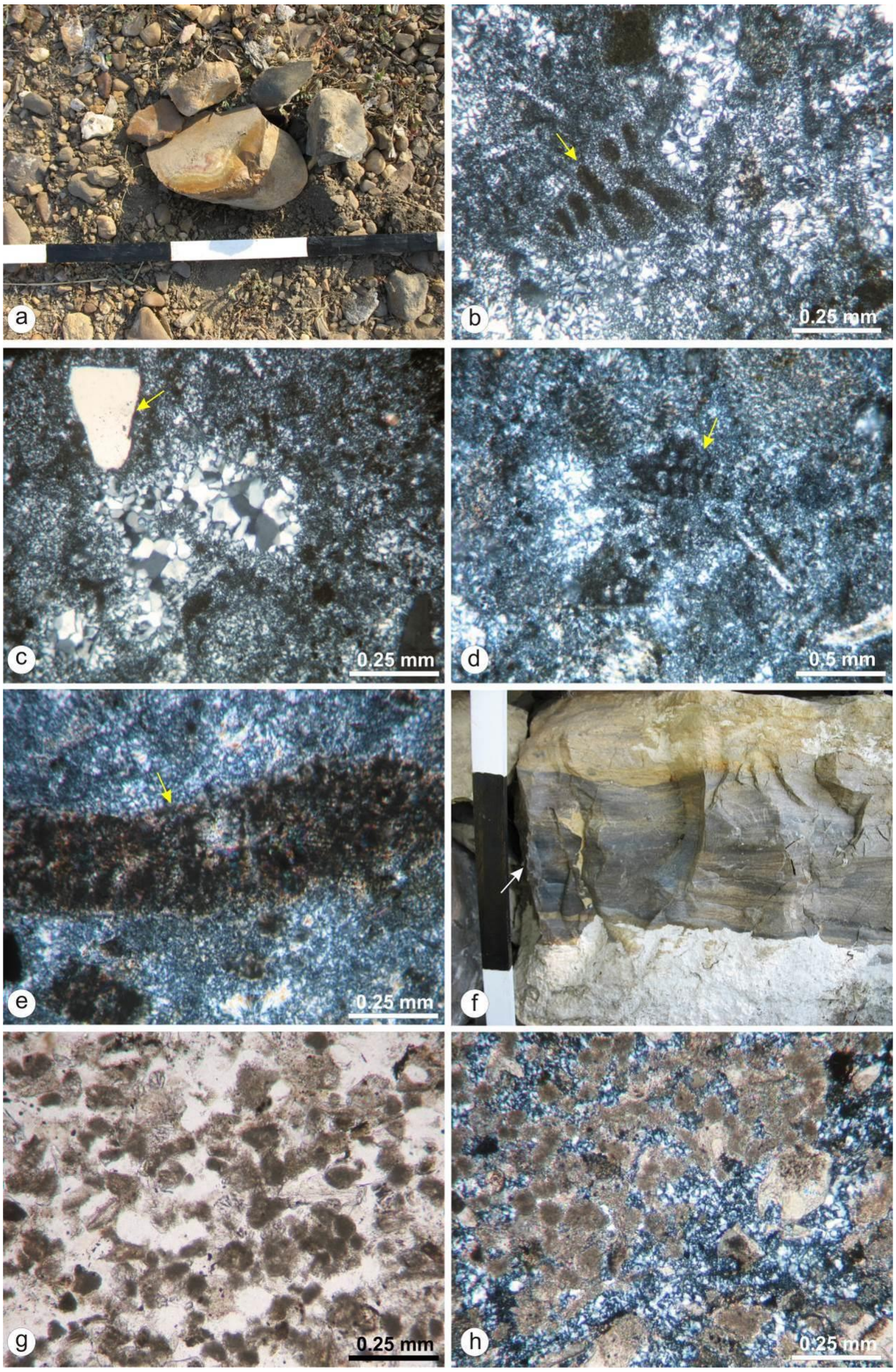

Figure 12 a) Flint pebbles with dark brown and ochre coloured surfaces (secondary deposits, quarry near Krasen village, Ruse district; b) Foraminifer test pseudomorphically replaced by microcrystalline quartz (yellow arrow). Chalcedony which has formed fibrous aggregates (light gray) and locally replaced the previous limestone groundmass (raw material, secondary deposit, Kriva Reka village, Shumen district, CPL); c) Finely-crystalline quartz composed of polygonal crystals, which usually forms mosaics. A clastic quartz grain (yellow arrow) is also observed (raw material, secondary deposit, Kriva Reka village, Shumen district, CPL); d) Pseudomorphically replaced by microcrystalline quartz and opaque minerals foraminifer test (yellow arrow) within quartz and chalcedonic groundmass (artefact, Nedoklan, Razgrad district, CPL); e) Carbonate bioclast (yellow arrow) replaced by opaque minerals (raw material, secondary deposit, Kriva Reka village, Shumen district), CPL; f) Silicified layers (white arrow) in limestones (primary deposits, Kovachevo Formation); g) and h) Bioclastic-peloidal packstones or grainstones (uncertain which) with a rock groundmass replaced by silica minerals (raw material, primary deposits, Kovachevo Formation, quarry near Koprivets village, Ruse district), PPL (plane-polarized light microphotograph) and CPL. Scale bars: 1 partition = 10 cm. (Created by P. Andreeva.)

3.2. LA-ICP-MS

The three petrographically distinguished types of chert artefacts and raw materials from NE Bulgaria (Type I – Ravno type, Type II – Kriva Reka type and Type III – raw materials from quarries near the villages of Koprivets and Krasen) were analysed by LA-ICP-MS. Based on Al, Na, K, and Mg contents, the Ravno type is divided into three subtypes. The first subtype is characterized by low concentrations of the four elements and includes mostly raw materials from the area of Tetovo village and an artefact from Kosharna (2) (Figure 13). The second subtype is represented by raw materials from Ravno village and artefacts from the same area (from Ravno, Kamenovo, Goliam Porovets, Radingrad, Ivanovo, Kosharna (1), Bazovets (2) and Smiadovo) that have average contents of the mentioned elements (Figure 13). The third subtype shows high concentrations of Al, Na, K, and Mg and is represented only by artefacts: from Targovishte (2), Karanovo and Bazovets (1).

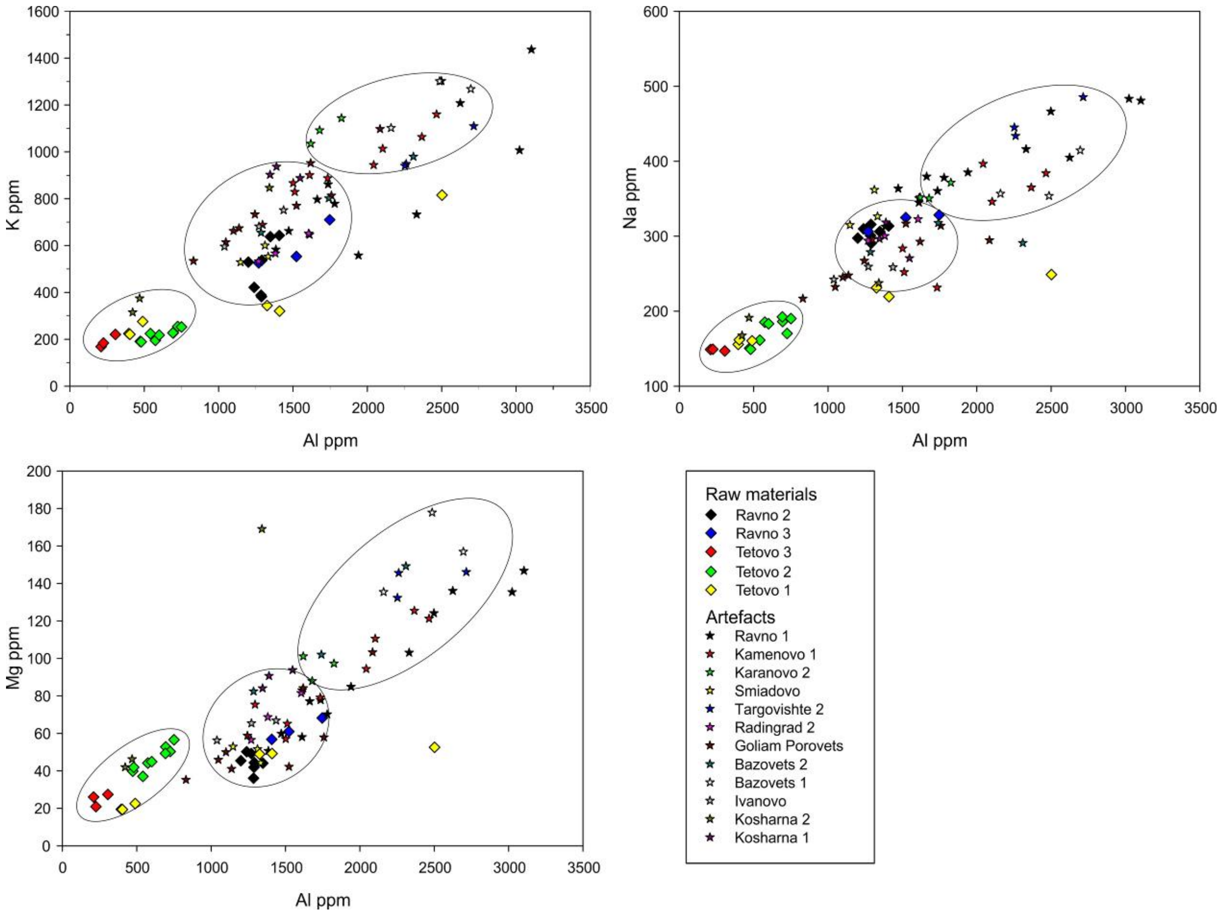

Figure 13. Trace element concentrations in raw materials and artefacts (Type I – Ravno type). Three subtypes are distinguished based on Al, K, Na, K and Mg contents. (Created by E. Stefanova.)

The Kriva Reka type has a wide range of these element concentrations due to its inhomogeneous petrographic composition. Nevertheless, the measured values of Al, Na, K, and Mg in raw materials overlap with those observed in artefacts (Figure 14).

The third chert type displays higher Ca and Mg concentrations compared to the Ravno and Kriva Reka types (Figure 15). This type is represented only by raw materials. None of the artefacts from Bulgaria which were analysed show such high Ca and Mg content.

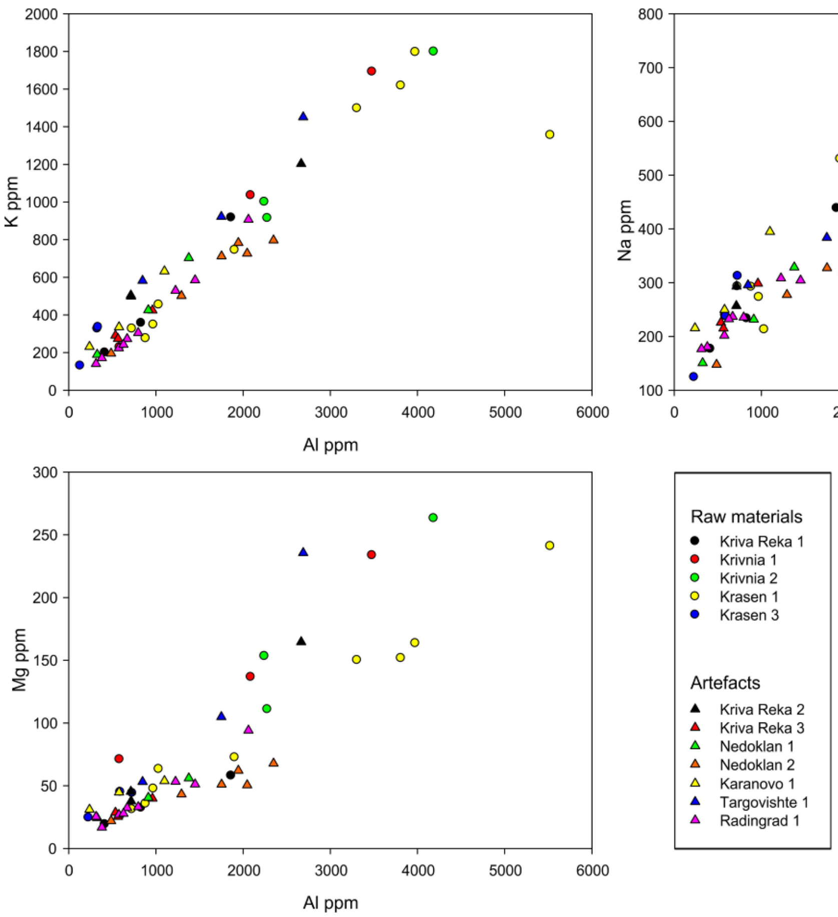

Figure 14. Trace element concentrations in raw materials and artefacts (Type II – Kriva Reka type). Al, K, Na and Mg contents are scattered and overlap in raw materials and artefacts of this material type. (Created by E. Stefanova.)

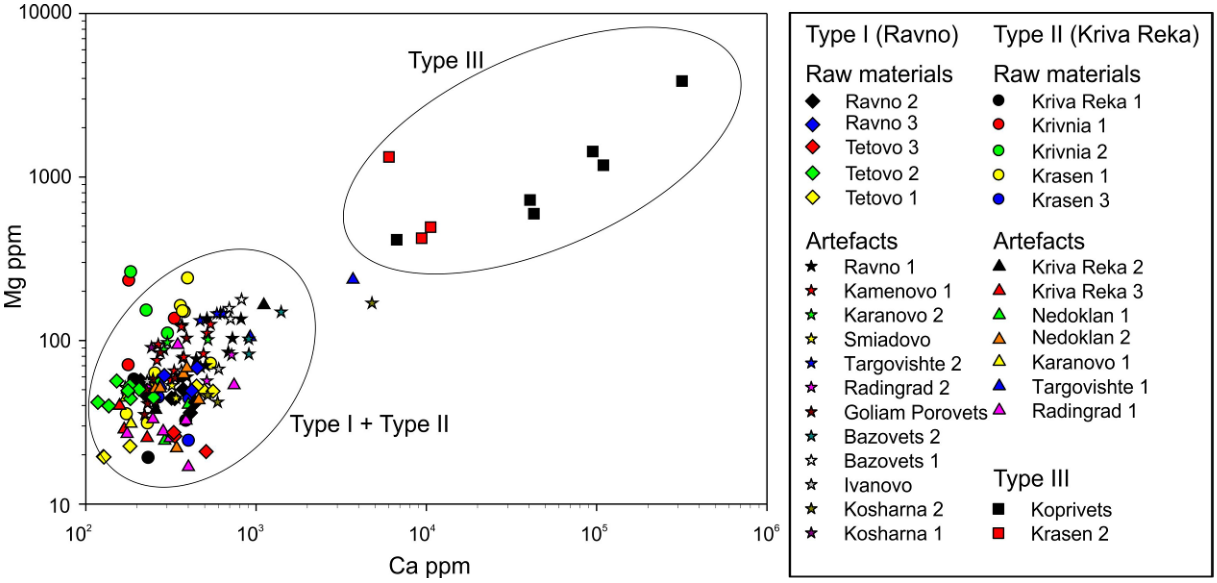

Figure15. Ca versus Mg plot that distinguishes between type I + II and type III materials. (Created by E. Stefanova.)

4. Discussion and Conclusion

Based on the petrographic study which was carried out, it could be suggested that the possible raw material source for the artefacts from Ravno, Kamenovo, Goliam Porovets, Radingrad (2), Ivanovo, Kosharna, Bazovets, Targovishte (2) and Smiadovo were secondary eluvium chert deposits such as those from near the vilalges of Ravno and Tetovo which were described. All of these cherts are referred to as Ravno chert (Type I). The evidence of this suggestion is the close similarity between the macroscopic and micropetrographic features observed in the raw material and those of the artefacts. The possible raw material source for the artefacts from Kriva Reka, Nedoklan, Radingrad (1), Drama, Karanovo, and Targovishte (1) were presumably secondary eluvium and paleoalluvium deposits such as those recorded near the villages of Kriva Reka, Krivnia, and Krasen. These chert raw materials and artefacts are referred to Kriva Reka chert (Type II).

It is also interesting to note that in some of the archaeological and geological sites which were studied (for example, Radingrad and Targovishte) artefacts from both chert types (Type I - Ravno and Type II - Kriva Reka chert) were distinguished.

A more precise correlation could be made by combination of both petrographic and geochemical data of the raw materials and artefacts studied. Although Ravno (Type I) and Kriva Reka (Type II) chert types are characterized by different petrographic features, we cannot distinguish them based on their chemistry because they have an identical chemical composition. However, several subtypes can be differentiated within the Ravno type (Type I) based on Al, Na, K, and Mg contents. The geochemical data obtained also allowed one to conclude that the possible provenance of the Kosharna (2) artefact was the area of Tetovo village while for the artefacts Ravno, Kamenovo, Goliam Porovets, Radingrad (2), Ivanovo, Kosharna (1), Bazovets (2) and Smiadovo was the area of Ravno village. The overlapping results from the Kriva Reka chert type (Type II) suggest that the raw materials studied could be potential sources for the artefacts from Kriva Reka, Nedoklan, Radingrad (1), Drama, Karanovo, and Targovishte (1). The last chert type (Type III) was not used for tool preparation and is not present among the artefacts which were studied.

Acknowledgements

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Knappable materials in the Criș Valley, Romania

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Abstract:

The purpose of this study is to identify and characterise some of the raw materials in the Criș Valley, in the Apuseni Mountains, Romania which are suitable for knapping tools. The materials cropping out in this area include: siliceous sinter, agate, and silicified wood. The basic characteristics of the materials, obtained by macroscopic and petrographic investigations, provide a reference database useful in provenance studies on individual artefacts or whole assemblages. An assessment of each material is made regarding its quality as a knappable material.

Keywords: knappable material; lithic tools; siliceous sinter; agate; silicified wood; lithotheque; Apuseni Mountains; Romania

1. Introduction

Knowledge of the potential geological sources for knappable materials in a certain area is of great importance in archaeology, in particular when studying production and trade of lithic tools in prehistory. In order to determine which artefacts were imported, it is first necessary to understand which artefacts could be of local origin, especially in the case of materials of similar appearance. In many cases though, the local raw materials are rarely described in details in the archaeological literature.

The aims of this paper are to identify and characterise materials of mineral origin outcropping out in the Criș Valley, within the Apuseni Mts., central-western Romania (Figure 1), which may be suitable for knapping tools. It is intended that the information and example images presented here will be of use in provenance studies of lithic assemblages from the study area. The data may be used as references to which artefacts can be compared. The samples collected during this study are part of a larger lithotheque and will also be of use in future sourcing studies. Being able to compare artefacts with samples of potential raw materials helps to narrow down possible sources (Turq 2005).

The geological background of this area has been covered in numerous other publications (for example, see Ianovici et al. 1969; Ianovici et al. 1976; Savu 1980; Cioflica et al. 1981; Ghiurcă 1981; Savu 1983; Săndulescu 1984; Mârza et al. 1989; Balintoni 1997).

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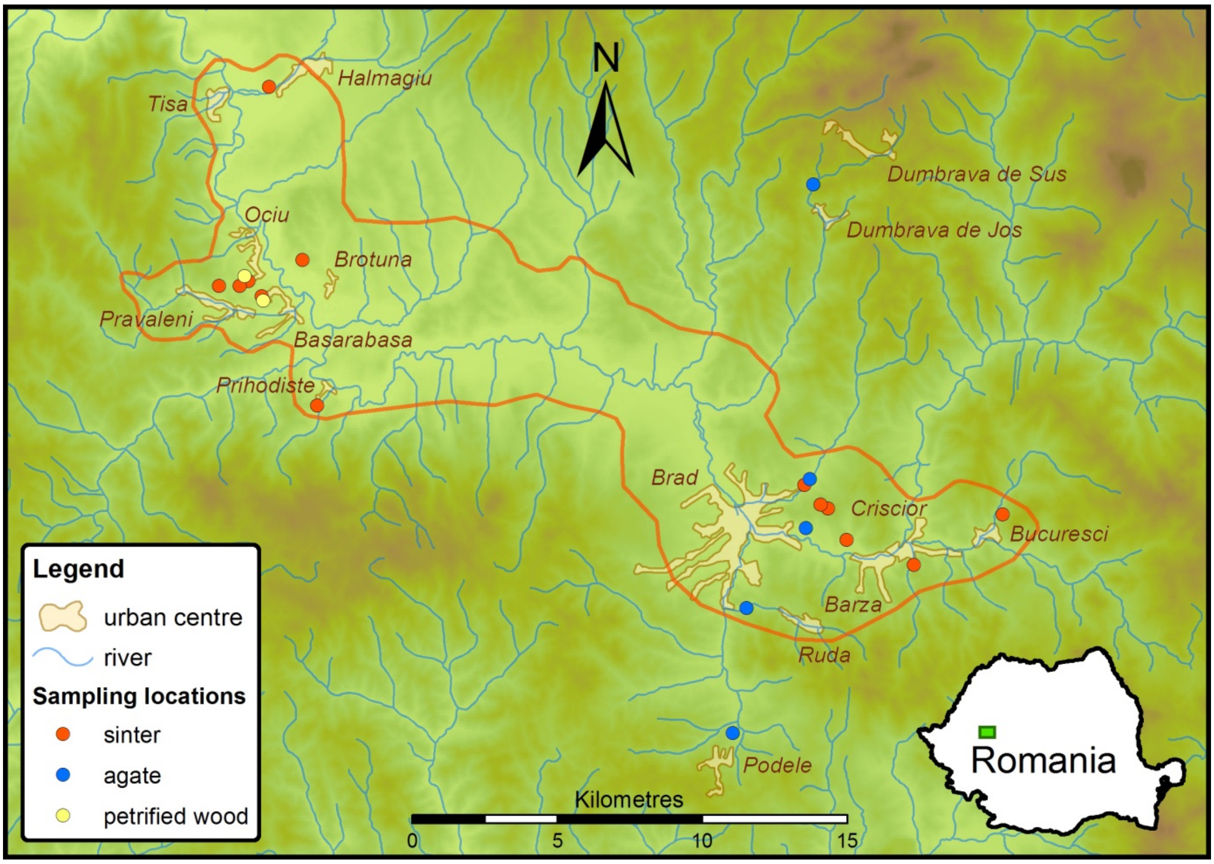

Figure 1. Map showing the study area. The general source area for Criș Valley sinter is outlined in orange. Locations where samples were collected are marked (see the legend for explanations). The inset in the lower right shows the location of the area within Romania as a green rectangle. Relief map produced from data provided by the SRTM (2000).

2. Materials

2.1. Criș Valley sinter

The origin of the Criș Valley sinter material is associated with the Neogene volcanics and their hydrothermal effect on the environment. Underwater, silica-rich, hot springs led to the deposition of a silica rich solution (epithermal) in small limnic basinets and the formation of a silica gel throughout the Brad-Hălmagiu depression, upper basin of the Criș Alba River. This is evidenced by the presence of fossilised mollusc shells and pond plants remains embedded in the silica and substituted by SiO_2. This material (opal-A) hardened and began to transform into opal-CT and eventually microcystaline quartz. The same silica rich waters also lead to the silicification of wood at some locations in the basin (Voitești 1934: 182; Socolescu 1944: 99; Dimitrescu 1958: 101-102; Ghițulescu & Borcoş 1966; Ghițulescu et al. 1968; Russo-Săndulescu et al. 1976: 168-171; Berbeleac et al. 1982; Ștefan et al. 1982: 146-150; Borcoş et al. 1986; Ghergari & Ionescu 1999; Ghergari et al. 1999; Mârza & Constantina 2000).

The most well-known source is north-east of Brad (Hunedoara County) on Măgura Hill (also known as Măgura Bradului Hill) near the sanatorium (Figures 1 and 2), where several lens-like deposits are found within a level of the Neogene andesitic pyroclastics (Ghițulescu et al. 1968; Ghergari & Ionescu 1999; Ghergari et al. 1999; Constantina & Pop 2003). This occurrence of the material is relatively large. The lenses are 10–30 m thick and range up to 0.01 km^2 in surface area (Ghergari et al. 1999). The environment rich in iron and manganese hydroxides with an uneven spatial distribution lead to a wide variation in colour of these rocks. The most common colours are varying hues of yellow and red, as well as greys and black. Green although uncommon is occasionally observed (Ghergari & Ionescu 1999; Ghergari et al. 1999; Mârza & Constantina 2000). The mineralogical composition of this material has been described in detail by Ghergari and Ionescu (1999) who showed that contained granular microcrystaline quartz, microfibrous quartz, and cristobalite-tridymite opal.

The same material can be found in the Neogene pyroclastic andesites level throughout that area of the Criș Valley (see Figures 1 and 2). Other than Brad, the material can also be found near Hălmagiu, Brotuna, Ociu, Basarabasa, Prăvăleni, Crișcior, Barza, Prohosdiște and Bucureșci. Smaller outcrops occur at many more locations (Bleahu et al. 1964; Bordea & Borcoș 1972; Mârza & Constantina 2000; Bulgariu et al. 2005). This material is also referred to as 'geyserite'.

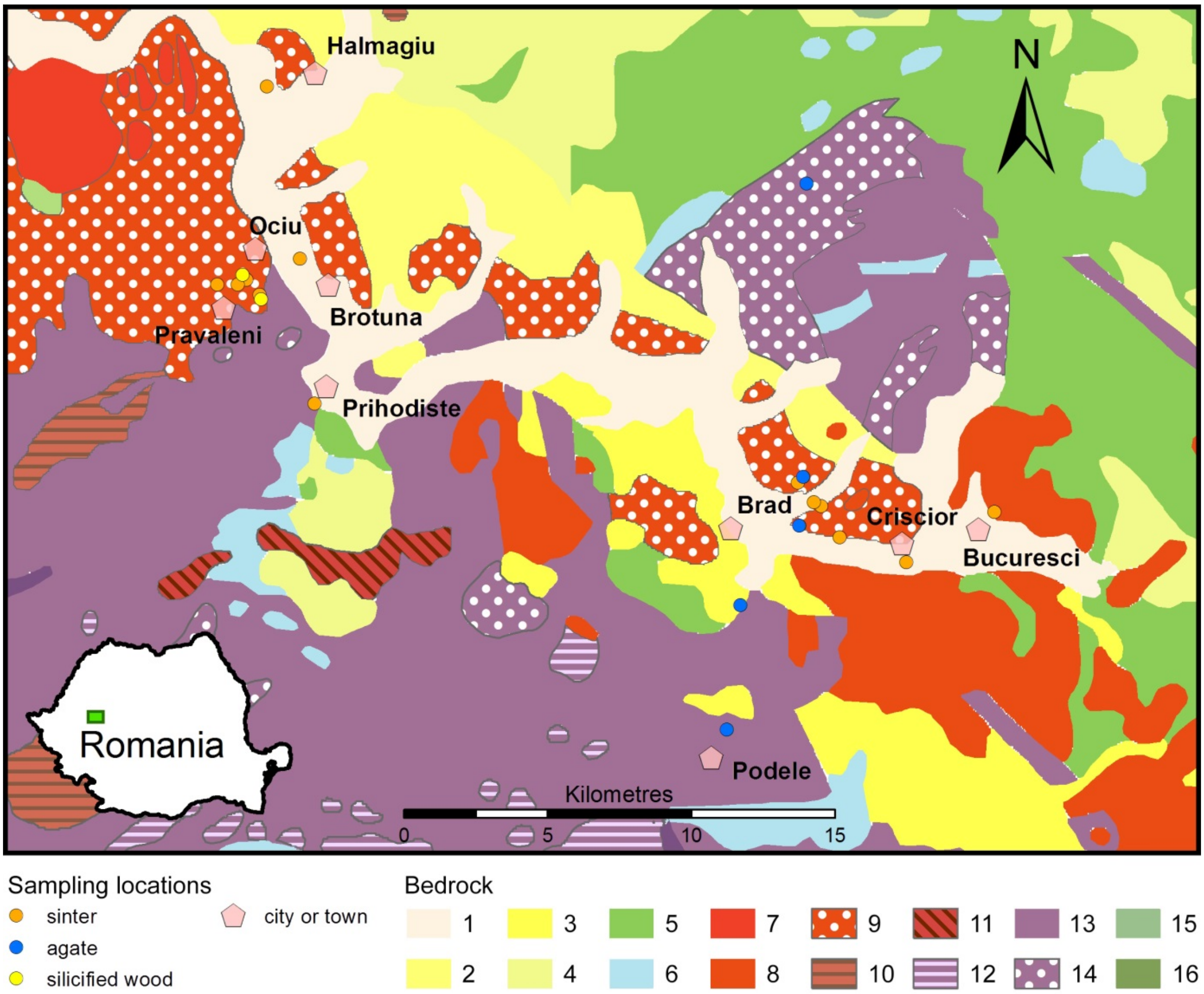

Figure 2. Simplified geological map of the Criș Valley and locations where raw materials were sampled. Bedrock legend: 1. Holocene; 2. Pliocene; 3. Miocene; 4. Upper Cretaceous; 5. Lower Cretaceous; 6. Upper Jurassic; 7. Permian; 8 & 9. Neogene andesites and andesitic pyroclastics; 10 & 11. Upper Cretaceous granodiorites, diorites & monzonites; 12. Upper Jurassic IAV; 13 & 14. Mid Jurassic ophiolitic basalts; 15. Paleozoic; 16. Cambrian. The inset in the lower left shows the location of the area within Romania as a green rectangle. Based on Săndulescu et al. (1978) modified by Tudor (2009) and the author of this study.

2.2. Other materials (agate and silicified wood)

Agate and silicified wood do not appear to have been used much (or at all) to make tools at archaeological sites in this area. For this reason, they will not be discussed in as much detail as sinter. They are mentioned here mainly for comparison with similar materials from other regions which may have been used for tool making and because it is also possible that artefacts of these materials might later be found in the area.

Agate

Banded chalcedonies (whether parallel or concentric) are called agates (Flörke et al. 1982; Graetsch et al. 1985; Heaney & Davis 1995; Moxon & Reed 2006; Moxon et al. 2007). Chalcedony, although technically a form of microcrystalline quartz, has a somewhat different micro-structure and may form differently. Chalcedony has a fibrous fabric, being formed of tiny bundles of fibres <1 μm thick, which radiate out from the surface where deposition started, as opposed to most chert which has a microstructure of interlocking grains or crystals randomly oriented. For an introduction and detailed discussion of particle shapes, see Zingg (1935), Sneed and Folk (1958), Graetsch (1994) and Blott and Pye (2008).

Many researchers have suggested that agate banding forms as a result of crystallisation from siliceous hydrothermal fluids with varying levels of silica saturation and trace element concentrations (Flörke et al. 1982; Heaney 1993; Heaney & Davis 1995). Folk and Weaver (1952) believe that chalcedony is usually directly precipitated into cavities and cracks, and that crystallization begins at a few centres spaced along such a surface. Banding may be caused by various factors such as fluctuation in trace element content (e.g., iron), pauses in the crystallisation process, changes in pressure and silica content and textural changes. The most common host rocks for agates are fine-grained volcanics, e.g., basalts, basaltic andesites, rhyolites, dacites.

There are various sources of agate within the study area but they are sporadic (see Figures 1 and 2). As with the above mentioned sinter, the agates are formed due to hydrothermal processes in the Neogene volcanics. Whereas the sinters were deposited in basins, the agates formed within cracks in their parent rocks. This material within the study area has been discussed by previous authors (see, for example, Ghițulescu et al. 1968; Ghiurcă 1981; Mârza & Constantina 2000). There are numerous samples of agate and chalcedony in general in the collection of the Museum of Mineralogy at Babeș-Bolyai University in Cluj-Napoca.

Silicified wood

There are remains of highly silicified wood in the area between Ociu, Prăvăleni and Basarabeasa (Figures 1 and 2), for example, at Culmea Cremenii – which means "Chert Peak" in Romanian - near the town of Prăvăleni). This material is of Neogene age (Lupu et al. 1966). The origin of this silicified wood is related to the geothermal events and the silica rich which formed the sinter from this region. This material occurred due to opal replacing the wood material and often filling in the micro-pores in the wood to create a more solid material. They are often found embedded in Neogene volcanic tuffs (Ghițulescu & Borcoș 1966; Ghițulescu et al. 1968; Borcoş et al. 1986; Mârza & Constantina 2000). This materials and its sources have been presented in detail by previous authors (for more details, see Nagy & Mârza 1967; Petrescu & Nuțu 1969; 1970; 1972; Givulescu 1997; Iamandei & Iamandei 1997; 1999; Ghiurcă 2000; Iamandei & Iamandei 2000; 2001; Alcalde-Olivares 2002; Nagy et al. 2002; Iamandei et al. 2004; Iamandei & Iamandei 2005; Iamandei et al. 2005).

3. Methods

All of the materials in this study were analysed macroscopically, by eye, hand loupe and a Nikon SMZ645 stereomicroscope. Representative samples of each material were thin sectioned and analysed by polarized light optical microscopy using a Nikon Eclipse E200 Pol microscope. Images were captured with a Nikon D3100 DSLR camera. In total 15 samples, from 16 sources, were analysed microscopically. The macroscopic and microscopic observations of the samples were stored in a database using standardised terminology and descriptions by Crandell (2005; 2006). One sample (from the Brad Sanitorium outcrop) was also analysed by Prompt Gamma Activation Analysis to determine its chemical composition (Crandell 2012).

4. Results and discussions

4.1. Sinter

At the source near Brad, the material has various colours, from white to yellow, red, brown or orange or even black. It is opaque, glassy or waxy (sometimes matt), with a very fine grained surface. The rock has either a very poor or a good conchoidal fracture (Ghițulescu et al. 1968). This characteristic varies significantly between samples. Still, a few hours of searching can reveal a large quantity of material suitable for knapping. The material is not as sharp as chert or jasper but is sufficient for use as a cutting or scraping tool. This material has been known about since as early as the 1800s (Zepharovich 1859: 304, 372-373) and was used up until the 1990s to produce decorative objects such as vases and bowls in workshops in the town of Brad (Ghiurcă 1981). At other locations, this material also varies in colour and lustre. At some locations it is whitish, translucent to opaque, often matt and sometimes waxy or glassy. Other samples observed were black, grey and shades of brown. The dark materials observed were almost always matt and opaque. Occasionally, materials have other combinations of visual characteristics, including some with a green colour and others with a dark, opaque, metallic, glassy appearance (See Figure 3) (Ghițulescu et al. 1968). The variations in colour are caused by the presence of Fe and Mn oxides (Ghergari et al. 1999; Pop et al. 2004; Crandell 2012). In addition to the microcrystaline quartz, this material was also observed to be comprised of microfibrous quartz, opal, and Fe oxyhydroxides (Figure 4). At all locations this material contains fossilised remains of molluscs and silicified remains of marshy plants, such as reeds. These remains may be visible with the eye as well as under the microscope (Figure 4 e-h).

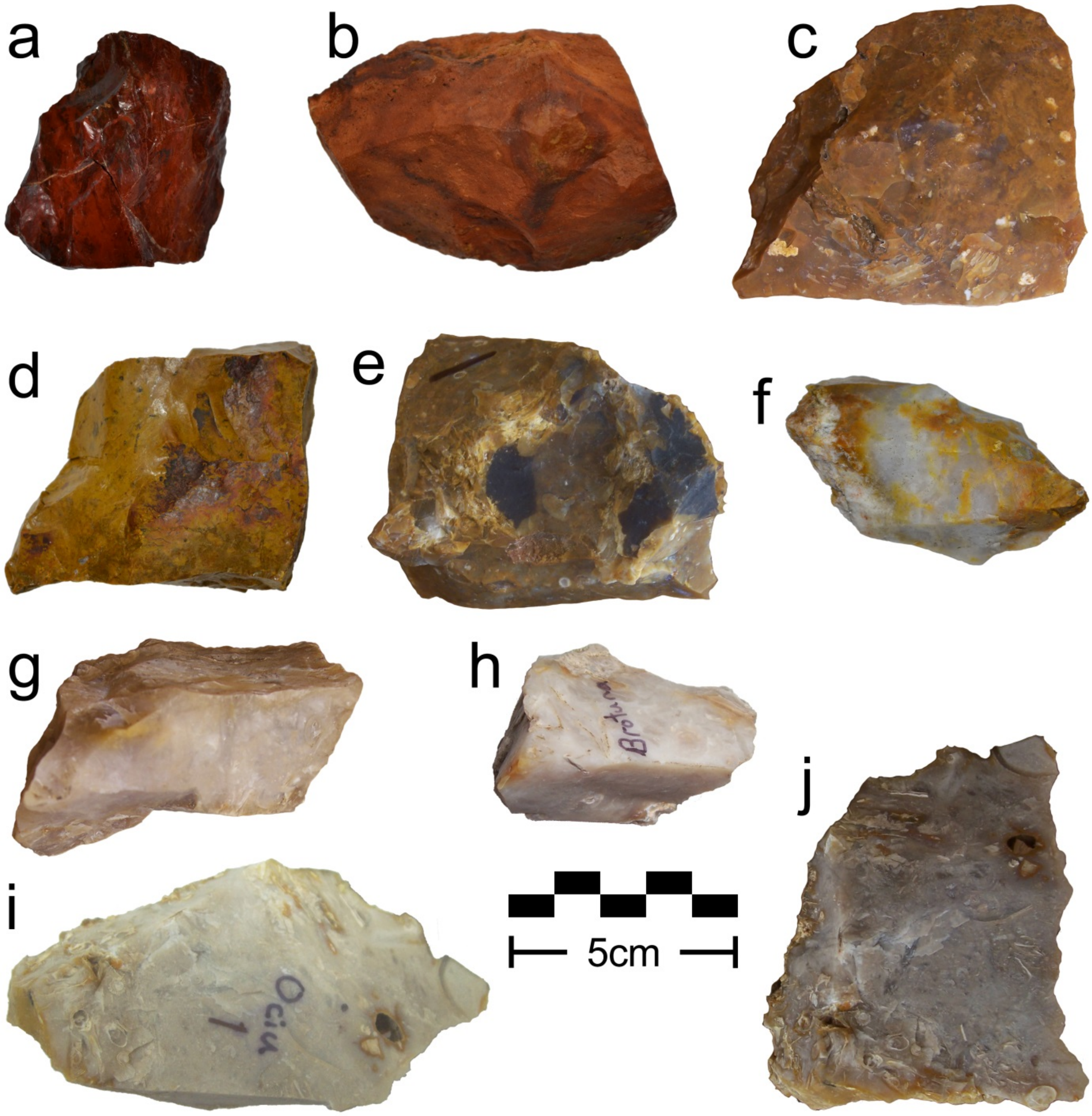

Figure 3. Photos of various colours of jasper from: a) to f) Măgura Hill (near the sanitorum), north-east of Brad; g) & f) Brotuna; i) & j) Ociu.

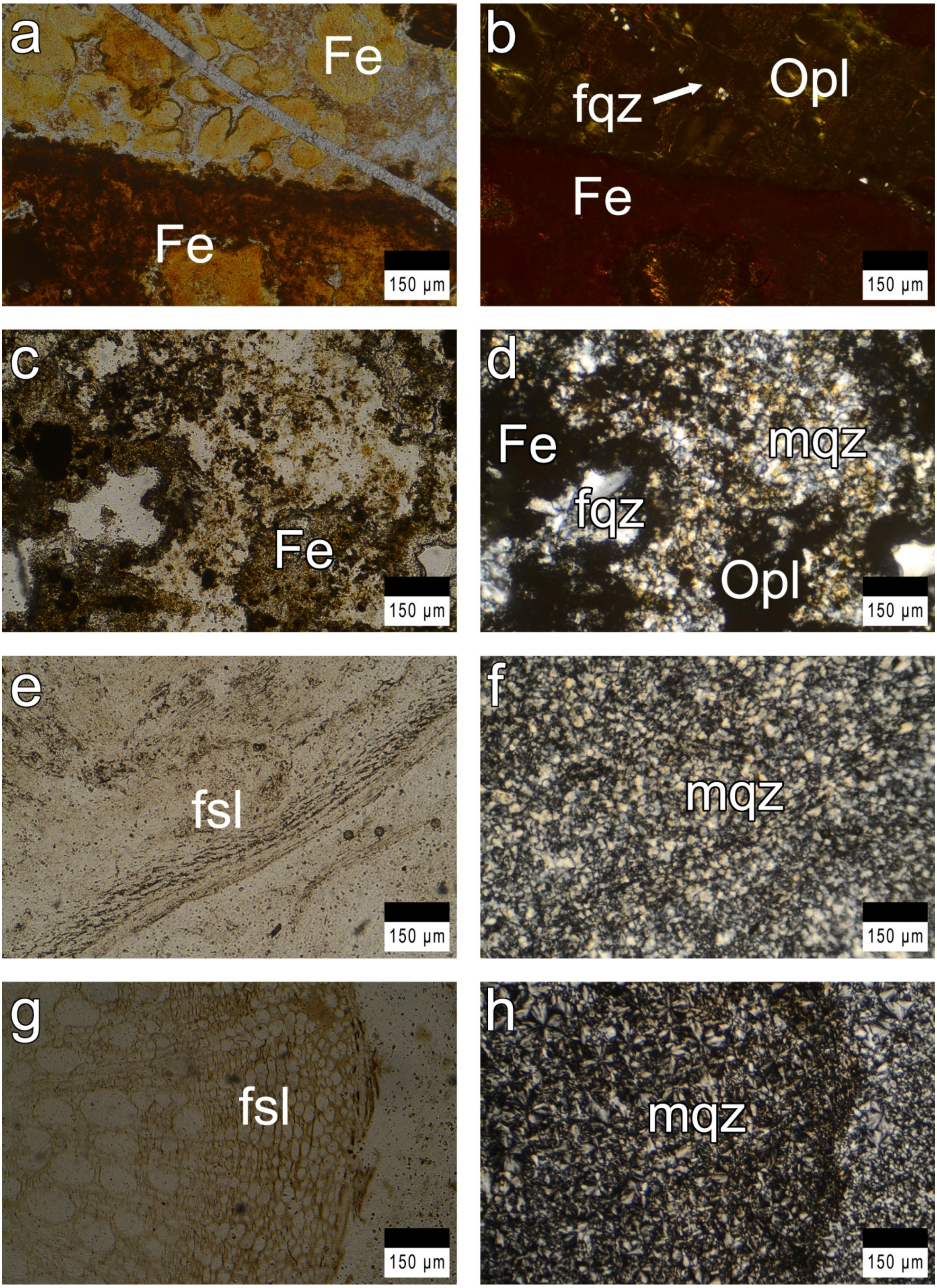

Figure 4. Microphotos (polarized light) of Criş Valley sinter (Brad jasper) from: a) & b) Brad; c) & d) Crişcior; e) & f) Brotuna; g) & h) Ociu. Left side, one polarizer (1P). Right side, the same with crossed polarizers (+P). Abbreviations: Fe for Fe-rich phase, Opl for opal, mqz for microgranular quartz, fqz for fibrous quartz, fsl for fossil (plant fossils in these cases). In e and f, relic vegetal tissue replaced by later microquartz (f and h) are seen.

4.2 Agate

There are numerous sources of agate within the study area but they are generally small in quantity. As well, most bands are less than a few centimetres thick and as such much of the material is unsuitable for knapping tools. Many of the agate samples from this study are housed in the Museum of Mineralogy at Babeș-Bolyai University. The agates from this area vary in colour but red is a common colour, followed by yellow. Translucency varies a lot but most pieces range from translucent to sub-translucent (for descriptions of terminology, see Crandell 2005; Crandell 2006). They may be banded in relatively flat lines or concentrically. The quartz grain size varies a lot from microscopic to macroscopic crystals. (See Figure 5.) Larger, visible crystals are more common in thicker pieces, some of which have empty areas in their centres (see Figure 5 c, for an example of large crystals). The size of the quartz crystals strongly influences how well the material breaks with a conchoidal fracture. Samples with a fine grain produce a better and more reliable conchoidal fracture. Some materials are fractured and may make the materials more difficult to knap. These last two characteristics are the main ones which determine the worth of the material for knapping.

From microscopic observations, one can quickly notice that this material is almost pure quartz (Figure 6). It appears mainly in the form of microfibrous quartz. Cracks in the material may be in-filled with larger quartz crystals or with further microfibrous quartz which formed on the walls of the crack and grew towards the centre of the crack. Banding may occur even on a microscopic scale (see Figure 6 a-d). Fe hydroxides were also observed under the microscope, with some bands containing more Fe than others, the likely cause of the variation of colour visible macroscopically in the samples.

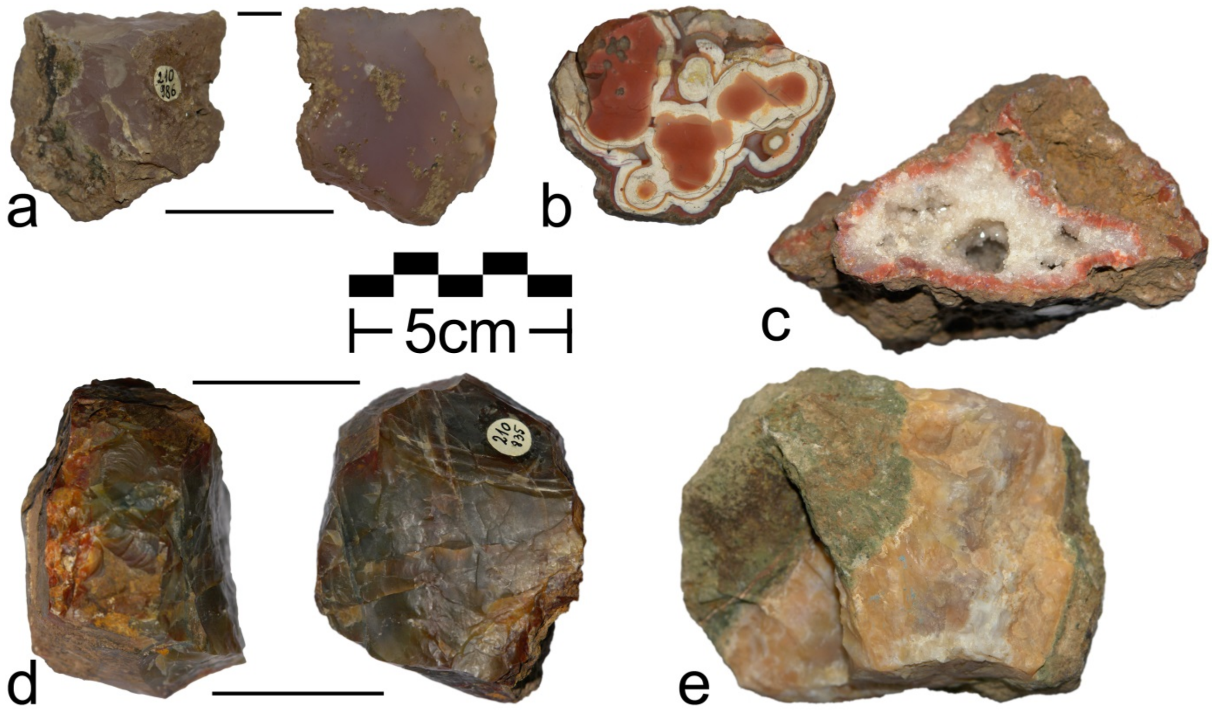

Figure 5. Agate samples from the study area. a) Brad Valley (north of Brad); b) at the edge of Brad; c) Dumbrava; d) near Brad towards Ruda; and d) near Podele.

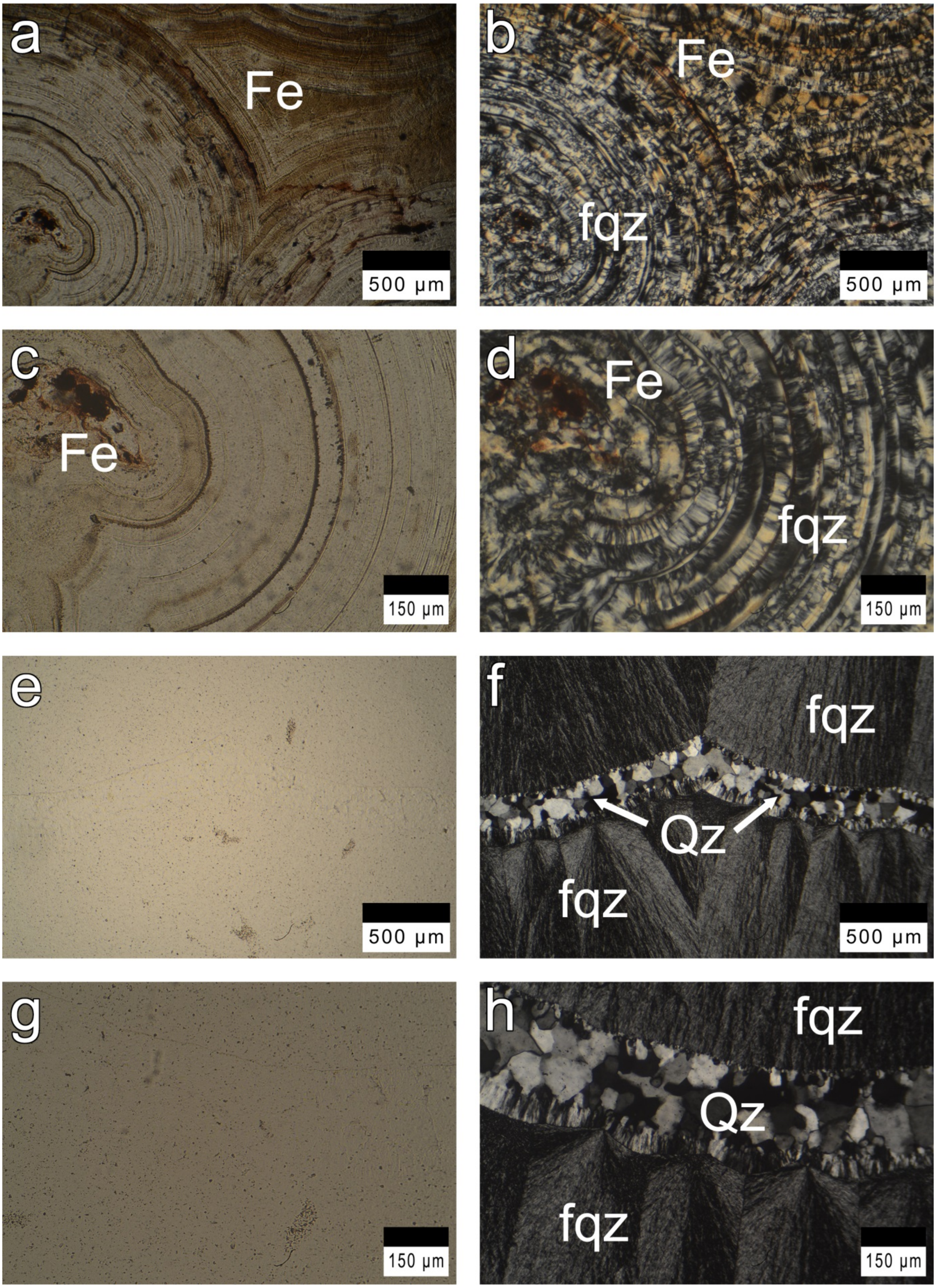

Figure 6. Microphotos (polarized light) of agate from a) to d) Brad; d) to f) Brad Valley. Left side, one polarizer (1P). Right side, the same with crossed polarizers (+P). Abbreviations: Fe for Fe-rich phase, fqz for fibrous quartz, Qz for quartz.

4.3 Silicified wood

The source of the silicified wood within the study appears to be limited to a very small area. Samples were found in situ within the remains of a petrified forest south-south-west of Ociu, at the edge of the town and the actual (living) forest. There were also found near Ociu in a valley which the local residents referred to as “Marinar” Valley, although this might not be an official designation of the valley. This valley opens to Ociu at the southern end of the town and is oriented SW-NE. It is very close to the petrified forest which is likely the source of the silicified wood found in the valley. Note that this same valley also contains sinter (Figure 3 i. and j.). Samples were also found north of the town of Prăvăleni at the location known as Culmea Cremenii (Chert Peak). Furthermore, a sample from near Basarabeasa, housed at the Museum of Mineralogy, Babeș-Bolyai University was also studied. (For locations, see the map in Figures 1 and 2.)

This material is generally poor quality for knapping tools. Some factures may be conchoidal but most area either along or perpendicular to the original grain of the wood. The edges produced by fracturing the sample were generally not sharp when compared to most other knappable materials. Many samples were also friable. (See Figure 7 for examples.) When viewed by petrographic microscope, the original structure of the wood (see Figure 8). The material is composed almost entirely of microcrystalline quartz, along with some voids filled in with microfibrous quartz (see Figure 8).

The quality of this material for tool making is low. It is described and pictured here mainly to illustrate what it is and to show why it is unlikely to have ever been used for knapping tools. Silicified wood may have been used in other areas where the material has developed more suitable characteristics.

Figure 7. Silicified wood from a) Basarabeasa; b) to d) petrified forest near Ociu; e) valley south-west of Ociu.

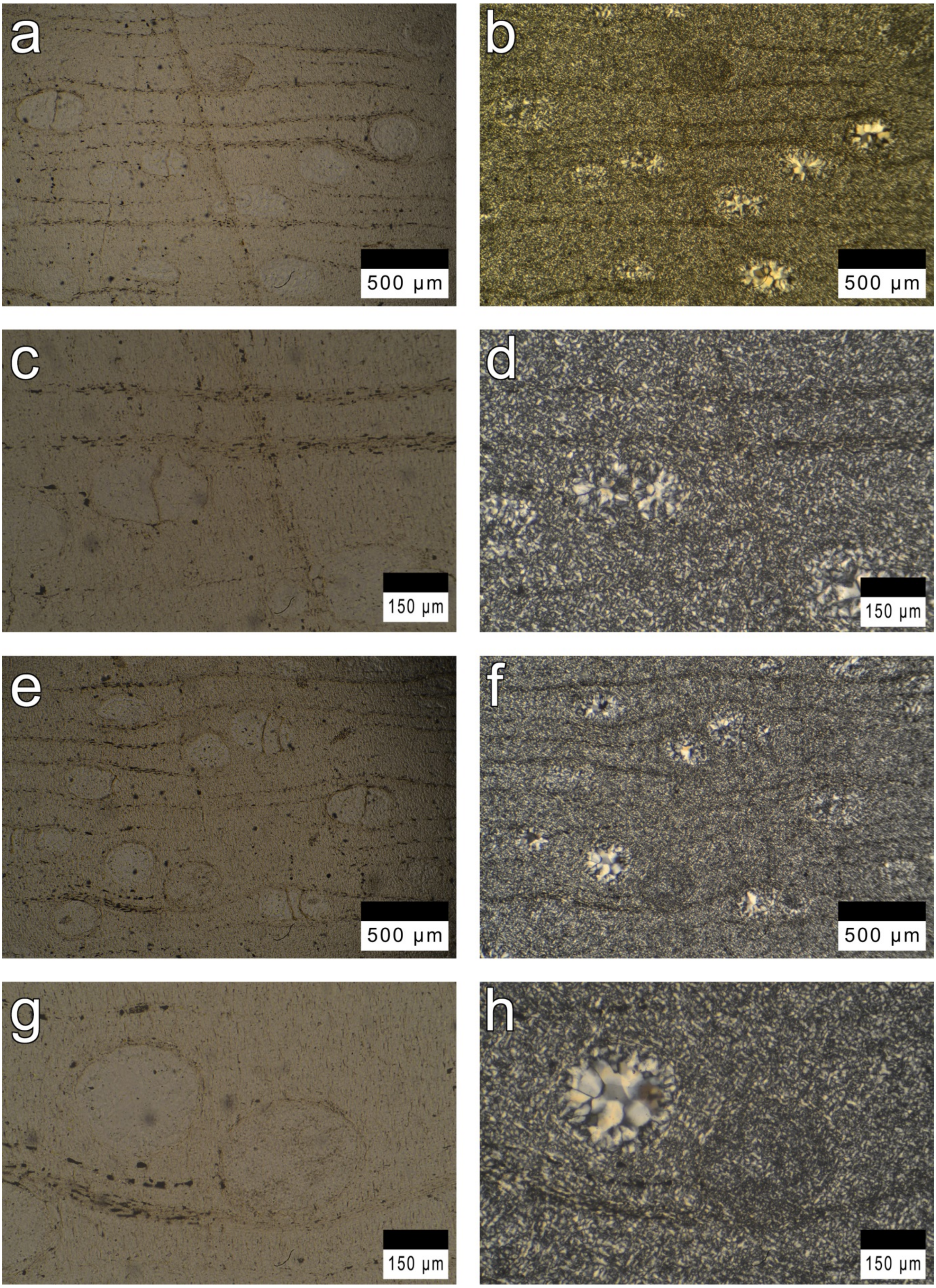

Figure 8. Microphotos (polarized light) of silicified wood from a petrified forest next to Ociu, Hunedoara county. Left side, one polarizer (1P). Right side, the same with crossed polarizers (+P). The 1P images show the structure of the wood. The +P images show that the material is comprised almost completely of microcrystalline quartz with a few spaces filled in with microfibrous quartz.

4.4. Lithotheque

The database of raw material sources is also available to researchers to compare artefacts and potential sources for provenance studies. Being able to source artefacts better will assist in determining trade routes and trade directions. In addition to recording the descriptions in of raw material sources and samples in a database, the representative physical samples collected in the field and the petrographic thin sections are included in the Romanian Lithotheque collection at Babeș-Bolyai University in Cluj-Napoca (Crandell 2009).

5. Conclusions

The combination of macroscopic features with microscopic features is important in any proper characterisation study of knappable materials. An objective description allows for sound interpretation in future archaeological research, in particular by assisting in identifying the sources of lithic artefacts. With the data presented here and the representative samples in the lithotheque, lithics researchers in the Criș Valley and nearby areas have reference materials which can be compared against similar characterisations of artefacts.

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The Mousterian lithic assemblage of the Ciota Ciara cave (Piedmont, Northern Italy): Exploitation and conditioning of raw materials

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Abstract:

The Ciota Ciara cave is situated in Monte Fenera's karst (Borgosesia – Vercelli), at 670 metres above sea level. It is the most important evidence of a Middle Palaeolithic settlement in Piedmont: the cave was used by *Homo neanderthalensis* during the OIS 5, in a mild-humid period, as proven by faunal remains. The environment was characterized by deciduous woodland and glades. The intersection between different habitats, the presence of lithic raw materials, the karst morphology and water sources were certainly the main factors that encouraged human settlement during the Upper Pleistocene period, between 80.000 and 70.000 BP.

In 2009 systematic excavations began in the cave by the University of Ferrara, in partnership with the *Soprintendenza per i Beni Archeologici del Piemonte e del Museo di Antichità Egizie*. Research focused on the cave's atrium where three stratigraphic units were investigated: 13, 103 and 14.

The exploited raw materials' characterization were made by the stereo-microscope observations and through the SEM (Scanning Electron Microscope). Several lithologies are represented in different proportion: quartz is the predominant exploited raw material, followed by spongolite, sandstone, mylonite and opal. The archaeological record consists of various typologies of quartz: macro-crystalline pegmatite quartz, micro-crystalline pegmatite quartz and hyaline quartz. All these types of raw materials have been found in the proximity of the archaeological site, within 5 km range.

The lithic assemblage is made of flakes, retouched tools, cores and *debris*. The raw materials exploitation was achieved through the direct percussion technique with various methods: *S.S.D.A.*, discoid and *Levallois*. The reduction sequences on quartz are complete, although no refitting was found. The reduction sequence is not complete for most part of the other raw materials. The *débitage* products are small-medium size (1-4 cm) and have different morphologies.

The use-wear analysis on quartz's artefacts was carried out using the low power approach. The preservation state of the lithic assemblage is very good and no chemical, mechanical or post-

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depositional alterations are evident. The use-wear analysis shows a predominance of medium-hard and medium-soft materials processing.

The lithic industries characteristics show the production strategies adaptation typical of the Middle Palaeolithic to the characteristics of the non-sedimentary raw materials.

Keywords: Mousterian; Ciota Ciara; quartz; lithic technology; supply areas; use-wear analysis

1. Introduction

The Ciota Ciara cave is located in Piedmont, Monte Fenera's karst, an isolated relief in north-western Italy, at 670 metres above sea level (Figure 1). It is an active karst cave developed over more than 80 metres on its principal axe. The cave is situated in the West side of Monte Fenera and, in addition to other caves of the mount, represents one of the most important and complete evidences of the Piedmont Palaeolithic.

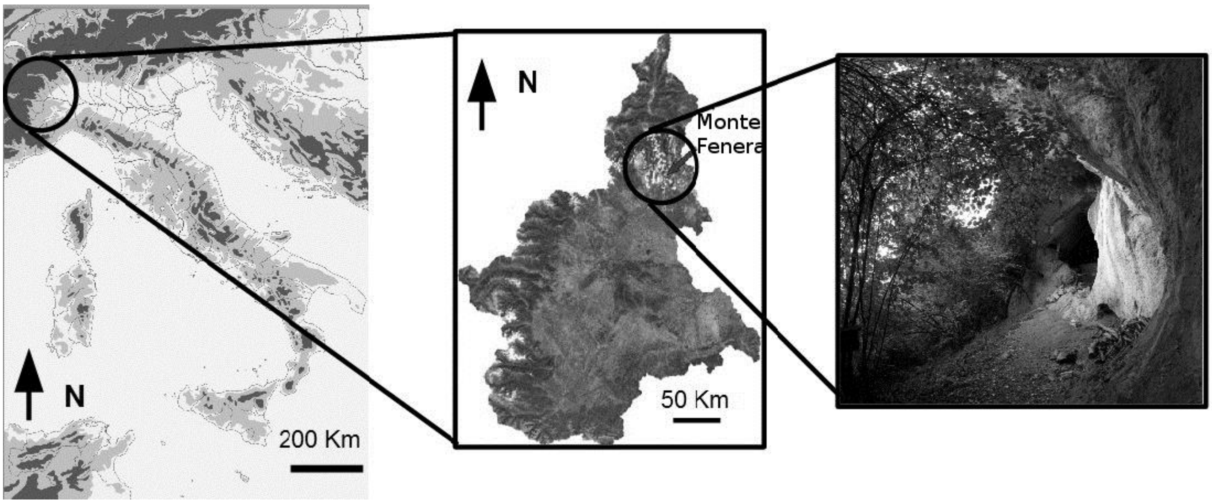

Figure 1. Left and centre: location of Monte Fenera and the Ciota Ciara cave. Right: photo of the Ciota Ciara cave by P. Ottaviano.

The first investigations, with a naturalistic intent, were carried out on Monte Fenera in the second half of the nineteenth century but the real research at the Ciota Ciara cave wasn't started until the post-war period. Over more than 30 years, several excavations were directed by numerous researchers, in particular by Francesco Fedele from the Anthropology Institute of the University of Turin who excavated in the Ciota Ciara and in other caves of Monte Fenera from 1966 until 1978 (Fedele 1966; 1984-85; Strobino 1992; Busa et al. 2005).

At the end of the 1970s, research at the Ciota Ciara cave was discontinued but restarted in the 1990s, for 3 years, with the scientific direction of the *Soprintendenza per i Beni Archeologici del Piemonte e del Museo di Antichità Egizie* (Busa et al. 2005).

In 2009 systematic excavations at the Ciota Ciara cave were restored, once again, by the University of Ferrara in partnership with the *Soprintendenza per i Beni Archeologici del Piemonte e del Museo di Antichità Egizie*. After a restoration of the previous excavations, the new researches were focused, principally, in the cave atrium, where were investigated three stratigraphic units: 13, 103 and 14 (Figure 2).

The three stratigraphic units have a horizontal disposition and are characterized by a reddish-brown clay-sand matrix with rare and altered centimetre-sized pebbles, more frequent in S.U.14. The stratigraphic units highlighted are extended over the whole area investigated (8 m^2), with the exception of the S.U.103 localized, exclusively, in an area of about 50 cm^2, probably as a result of the water percolation in the area along the rock wall. The spatial distribution analysis of lithic and faunal remains did not enable us to actually identify any particular spatial organization, probably due to the restricted area of investigation (Arzarello et al. 2012a; 2012b) (Figure 3).

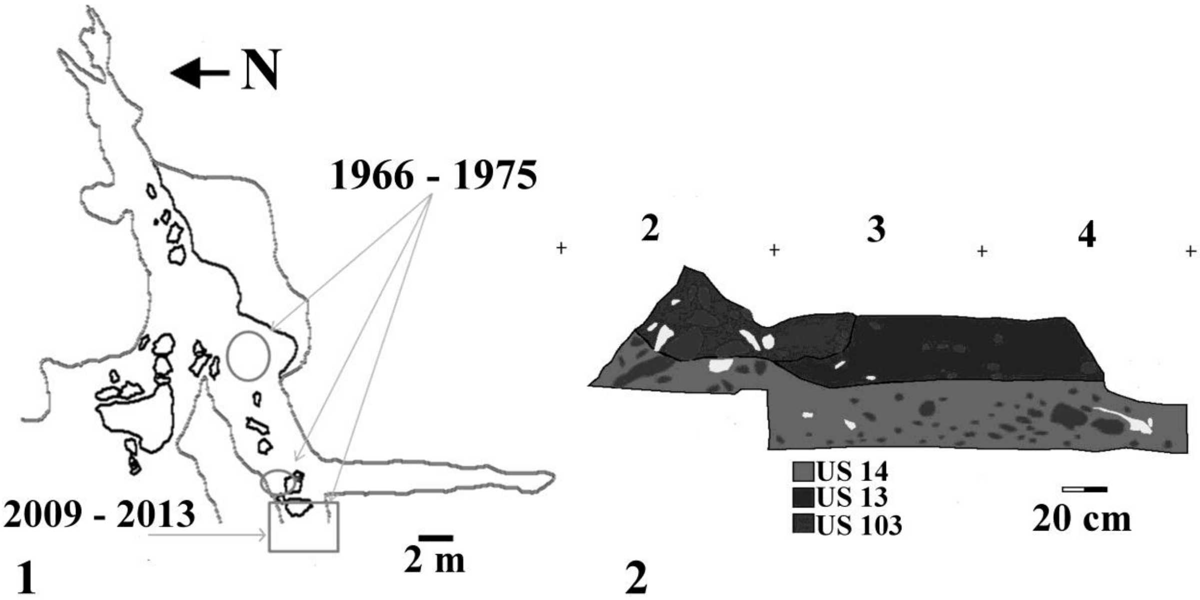

Figure 2. 1. Planimetry of the Ciota Ciara cave. 2. Longitudinal section G/F.

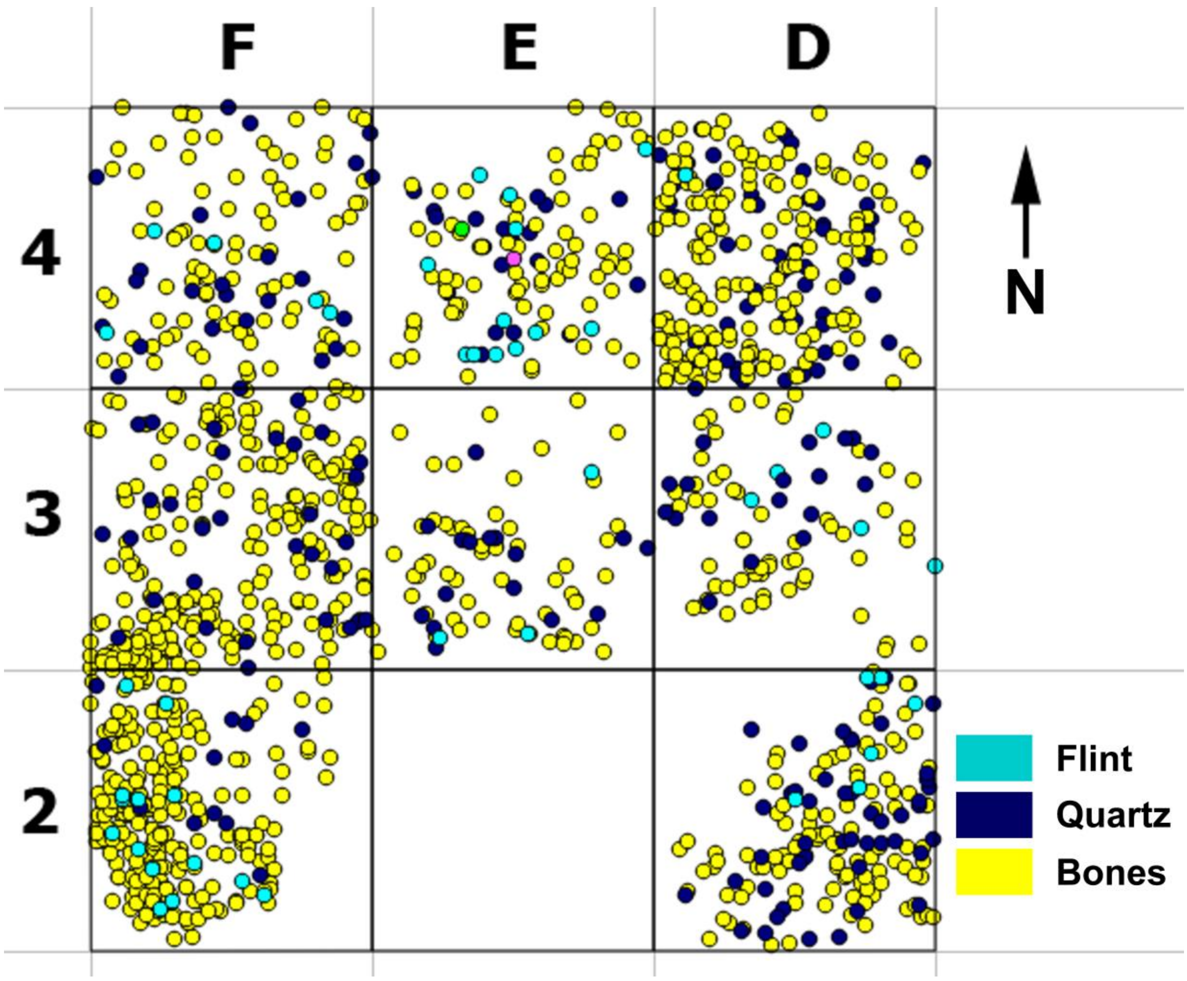

Figure 3. The Ciota Ciara cave spatial distribution of coordinate objects from the SU 14 (excavation 2013). 1 metre grid.

1.1. Palaeo-environmental reconstruction

The palaeo-environmental reconstruction has been achieved through the faunal analysis.

The macro mammals analysis was carried out on the remains coming from S.U.13 and 103. The total number of the remains is 1.620 of which 40% is not determinable from a taxonomical point of view. The faunal assemblage is characterized by: *Ursus spelaeus*, *Ursus arctos, Canis lupus*, *Vulpes vulpes*, *Meles meles*, *Lynx lynx*, *Panthera leo, Panthera pardus, Rupicapra rupicapra*, *Cervus elaphus, Bos* sp., *Bos* vel *Bison*, *Stephanorhinus* sp.and *Hystrix* sp.. The presence of herbivores in S.U.13 and 103 is numerically not representative (3,8% of determinable remains) but, even if no detailed analysis in the S.U. 14 has been made, it appears clear a significantly increase of the herbivorous remains (8,9% of determinable remains). The genus *Ursus* is the most abundant *taxon* found: 60% of determinable remains in levels 13 and 103, and 57% in level 14. The family Ursidae is represented by two species: *U. spelaeus* and *U. arctos*. The continuous presence of the cave bear is diagnostic that the deposit is former 28ka, because likewise this species disappears from the Alps. The presence of some faunal remains like *Cervus elaphus, Lynx lynx* and *Meles meles* suggests the existence of a deciduous woodland and the incidence of *Hystrix* is typical of a warm climate (Arzarello et al. 2012a; 2012b).

The small mammals' association from the Ciota Ciara cave (S.U. 13, 103 and 14) gives some information about the environment that surrounded the site and made it possible to establish the chronology of the site.

Species living in woodland environments are dominant: *Myodes glareolus* is the most frequent rodent, afterwards followed by another *taxon* living in woodland, *Apodemus (Sylvaemus),* represented by two species, *A. (S.) sylvaticus* and *A. (S.) flavicollis.* Less frequent in the assemblage, have been identified species typical of open grassland like *Microtus arvalis*. The presence of warmer indicators (i.e. *Erinaceus europeus* and *Histrix*sp.), together with mammals that live in closed environments, and the existence of *Pliomys coronensis* (= *P. lenki;* priority discussed by Terzea, 1983) allow a calibration of the site into a temperate period of OIS 5 (OIS 5c or 5a), even if not available a radiometric dating yet (Arzarello et al. 2012a; 2012b).

2. Materials and methods

The analysis of the lithic assemblage of the Ciota Ciara cave consists of a multidisciplinary study involving the study of the supply areas, the techno-typological and the use-wear analysis. The lithic assemblage is composed by 498 finds from S.U. 13 and 103 and by more than 4,000 finds from S.U. 14. The study of the S.U. 13 and 103 is complete, while the lithic assemblage from S.U.14 is still going on.

The study of the supply areas has been performed on the lithic remains coming from levels 13 and 103 and it has been carried out in several phases: the discovery of the raw materials outcrops in the proximity of the archaeological site; the cataloguing of the rock outcrops and their GPS tracking; the specimen of the raw material and the characterization of the exploited raw materials by stereo-microscope observations and, where necessary, through the use of a SEM (Scanning Electron Microscope) (Arzarello et al. 2012a; 2012b).

In order to carry out a study of the supply areas, it is important perform a careful analysis of the raw materials available in the area; therefore it is basic have a good knowledge of the geology of the region (Arzarello et al. 2011).

Monte Fenera is situated near the connection area between the Po Valley in subsidence and the rising Alpine chain (Fantoni et al. 2005a); the external areas of the chain, such as these, starting from the Oligocene (about 30 Ma) were affected by a compressive deformation with a general high level rising. Minor structures, related to this system of lithospheric fault, are fragile sectors that were activated in different periods, affecting the present physiographic and geological structure of the area (Fantoni et al. 2005a).

The base of Monte Fenera consists of Hercynian metamorphic rocks (ortogneiss, paragneiss and micaschist) belonging to the sub-units of *Scisti dei Laghi*, while on the northern, western and southern sides of the mountain there is a Permian formation extending throughout the surrounding area (Strobino, 1981). Subsequently the Mesozoic sedimentary rocks: a Triassic's sequence composed of sandstone, followed by the *Dolomia di San Salvatore* (i.e. a thick dolomitized carbonate series within which the karst system is developed) (Strobino 1981; Fantoni et al. 2005b); on that, there is the Jurassic's sequence, made of sandstones and rubble-stones and, subsequently, at the top of the mount, a spongolitic limestones sequence (Strobino 1981; Fantoni et al. 2005b).

The techno-typological analysis was carried out on the lithic assemblage of S.U. 13 and 103 while the data of S.U. 14 are still uncomplete. The identification of the technique employed for the exploitation of the lithic raw materials is based on the criteria listed by Inizan et al. (1995). The definition of the knapping methods are based on Forestier (1993) for the S.S.D.A. method (i.e. *Système par surface de débitage alterné)* and on Boëda (1993; 1994) concerning Levallois and Discoid knapping methods. The typological analysis is based on Bordes (1961).

The use-wear analysis was carried out on the lithic assemblage of S.U.13 combining the Low Power Approach (Semenov 1954) and the High Power Approach (Keeley 1980).

The identification of the worked materials' hardness was made according with Odell's classification (Odell 1981).

The low-magnification analysis was carried out using a Seben Incognita 3 (10-80x) stereo microscope and a Dinolight Am413T (5-230x) digital microscope. The high-magnification analysis was made using a AmScope ME300T-M (40-640x) metallographic microscope, equipped with an AmScope MD600 camera. The traces' presence recognized on the surface of the lithic tools is referred to in the scheme by Van Gijn (1989) and modified by Berruti (Berruti & Arzarello 2012).

In order to perform a correct analysis of the lithic assemblage, it has been necessary making an experimental collection, using all the lithic raw materials identified in the archaeological record. During the experimental activity the following operations were performed: skinning and butchering of a wild boar; processing of skin, bone and wood. By comparing the use-wear traces of quartz and flint tools, it was possible to point out how quartz tools are effective for processing soft and medium-soft materials, while being less suitable for the processing of hard materials.

The reason of such a different mechanical response is due to the high fragility of the edges that dramatically limits their use, especially during the processing of the hardest materials. The spongolite tools have poor mechanical property too. The crystals' particular morphometry, that forms the macro-crystalline pegmatite quartz, makes the high-magnification analysis of the lithic tools with this kind of raw material very difficult. This is due to the micromorphology of the surfaces that does not allow to bring into focus using the metallographic microscope (Berruti & Arzarello 2012; Sussman 1985). As indicated in literature, the lithic tools in hyaline quartz do not have the same problems because they have regular surfaces (Pignat & Plisson 2000; Berruti & Arzarello 2012; Sussman 1985).

3. The lithic assemblage

3.1. Supply areas

The archaeological record's analysis of the Ciota Ciara cave (S.U. 13 and 103) shows that many lithologies are represented (Figure 4). Quartz is the prevalent exploited material

(83,18 %), followed by spongolite (15,89 %), sandstone (0,56 %), mylonite (0,19 %) and opal (0,19 %). Concerning the quartz, many typologies are represented: macro-crystalline pegmatite quartz, micro-crystalline pegmatite quartz and hyaline quartz.

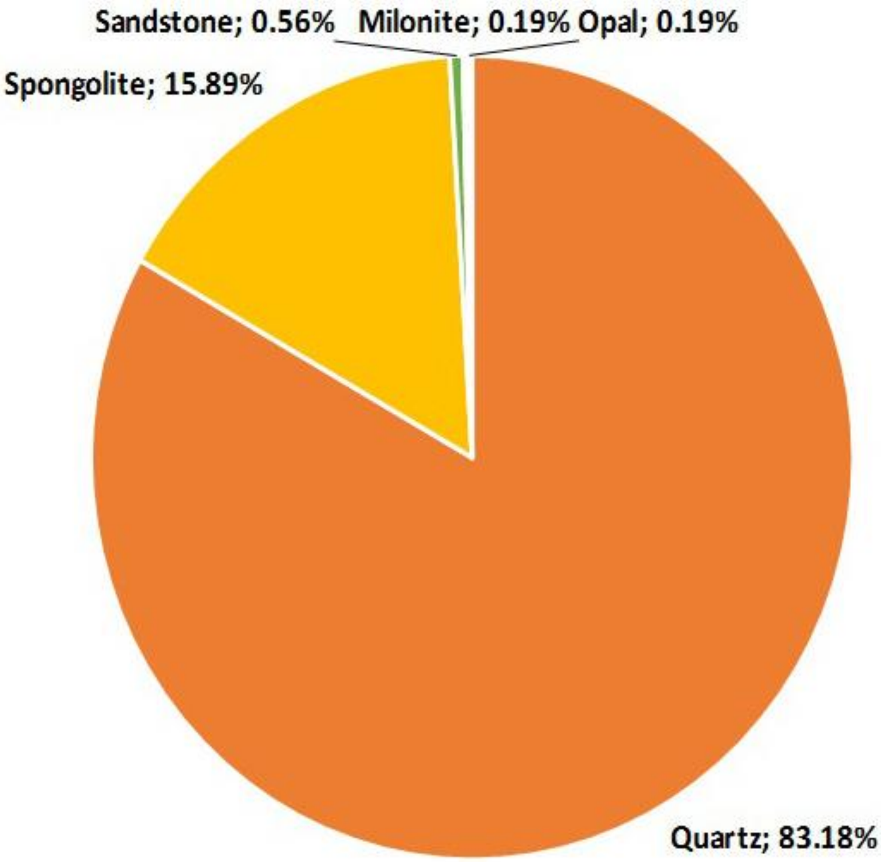

Figure 4.Graph showing the lithologies identified within the archaeological record at the Ciota Ciara cave, S.U. 13 and 103.

The quartz outcrops are concentrated, mainly, at te base of Monte Fenera, in hydrothermal veins, within both the Permian volcanic rocks and the Hercynian metamorphic rocks, besides being present, in a secondary position, as pebbles within rivers and Pliocene deposits. Spongolite is the most exploited raw material, right after quartz. It is represented by different typologies, more or less porous and silicified. Spongolite crops out in the highest part of the mountain, within the spongolitic limestones. Opal and mylonite have been found only in secondary position, between 50 and 450 metres away from the site.

The use of sandstone pebbles as hammers is also confirmed in the lithic assemblage: sedimentary rocks were readily available in the area, sometimes as an insertion within the spongolitic levels.

All the lithologies found in the archaeological record are present on Monte Fenera and, probably, they have been collected within a maximum range of 5 km from the site (Figure 5).

Reasonably, the human groups that occupied the Ciota Ciara cave, during the Middle Palaeolithic, collected lithic raw materials on Monte Fenera within a range of few kilometres (less than 1 km for spongolite, sandstone, mylonite and opal, and about 2.5 km for quartz), since the area is characterized by the lithologies represented in the archaeological record (Arzarello et al. 2012a; 2012b).

The extent of the supply areas recognised is completely coherent with the considered chronological period (Cliquet 2007; Depaepe 2007; Huet 2007).

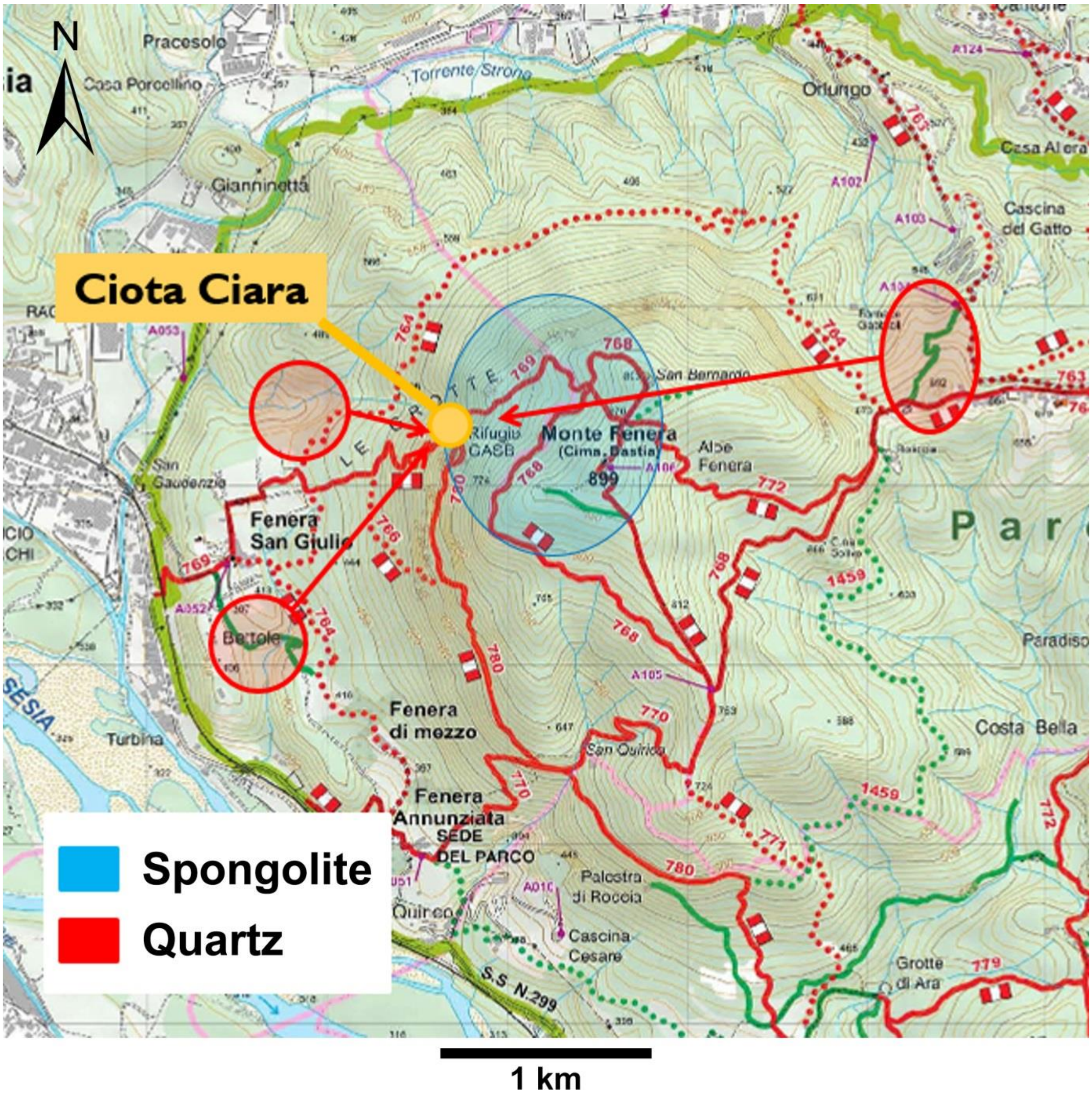

Figure 5. Map of the area around Monte Fenera with the supply areas location of quartz and spongolite.

The management of different raw materials, within the archaeological site, is sometimes related to the distance required to be covered for their collection (Depaepe 2007; Huet 2007; Vaquero 2007): usually the frequency of a lithology, in the archaeological record, is inversely proportional to the distance of its supply area (Depaepe 2007). “Exotic” raw materials are generally employed for the most complex knapping methods, while the local raw materials are often exploited with opportunistic knapping methods (Depaepe 2007; Huet 2007; Vaquero 2007).

Regarding the Ciota Ciara cave, the comparison between techno-typological data and those on the supply areas has not provide any evidences for differential management of raw materials, in relation to the *débitage* methods. Moreover, quartz is the dominant lithology in the archaeological record, although its worst *débitage* aptitudes and its bigger distance from the site. This could be attributed to the spongolite that is frequently fractured and, consequently, probably unusable (Arzarello et al. 2012a; 2012b). On the other hand, the latest excavations suggest that the importance of allochthonous flint is increasing and that the blanks were introduced within the site in the form of pre-cores or big flakes.

3.2. Technological analysis

Because of the characteristics of the raw materials, the opportunistic knapping methods are predominant within the lithic assemblage (Table 1) and the number of *débris*, fractures and knapping errors, almost all definable as *Syret* accidental break, is very high. The term *Syret* is used in a broader sense to indicate any kind of fracture, contemporary to the *débitage*, having as a starting point the flake impact point and leading to its breaking in two or more parts on the longitudinal axe (Mourre 1996).

Table 1. Ciota Ciara cave. Technological analysis performed for S.U. 13, 103 and 14.

	S.U. 13	**S.U. 103**	**S.U. 14**
S.S.D.A.	Flakes: 281 Cores: 20	Flakes: 17 Cores: -	Flakes: 470 Cores: 21
Levallois	Flakes: 2 Cores: 2	Flakes: - Cores: -	Flakes: 5 Cores: 3
Discoid	Flakes: 11 Cores: 4	Flakes: - Cores: -	Flakes: 8 Cores: 4
Kombewa	Flakes: 3 Cores: -	Flakes: - Cores: -	Flakes: - Cores: 3
Debris	179	18	264

Direct percussion by hard hammer is the only technique employed, while the methods are various: opportunistic/*S.S.D.A.* (Forestier 1993), *Levallois* and discoid (Boëda 1993; 1994).

Quartz was exploited using all these knapping methods, while spongolite, in S.U.13, was knapped using only opportunistic/*S.S.D.A.débitage*, probably depending on both its internal fractures and the morphology of the pebbles. In S.U. 14 the discoid method is used also for the spongolite exploitation.

In the Mousterian levels of the Ciota Ciara cave the use of fossil bones for the production of tools is also evident: a denticulate and a side-scraper come, respectively, from S.U. 13 and 14, while another denticulate was discovered during the 2009 excavation, within rehashed sediments (Figure 6).

Figure 6.Bone side-scraper from the Ciota Ciara cave. The scale bar is 1 cm wide.

This organic raw material has been exploited in the same way as the lithic raw material: on the edge of the tools are evident the marks of direct percussion by hard hammer.

The *S.S.D.A.* method has been employed to produce irregular and non-standardized flakes, all characterized by the presence of, at least, one cutting edge (Arzarello et al. 2012b). The huge number of natural butts and cortical flakes, together with the predominance of unipolar removal negatives on the flakes' dorsal face, suggest a first stage of *débitage* consisting in the exploitation of a natural convexity of the pebble by removing a cortical flake, followed by the removal of other flakes using the same striking platform until the exhaustion of the natural convexity.

The *Levallois* method was employed to produce artefacts with convergent edges or *Levallois* points and only two forms of this method are represented: recurrent centripetal and lineal (Boëda 1994). This knapping method was used only on pebbles with suitable natural convexities, in order to minimize the shaping out of the core (Figure 7). The lineal *Levallois débitage* is most used although the shaping out of the core is more difficult and expensive, in terms of raw material, compared with the recurrent *Levallois* methods. This choice is linked to the quartz characteristics that is problematic to manage with recurrent knapping methods, because of the knapping errors frequency.

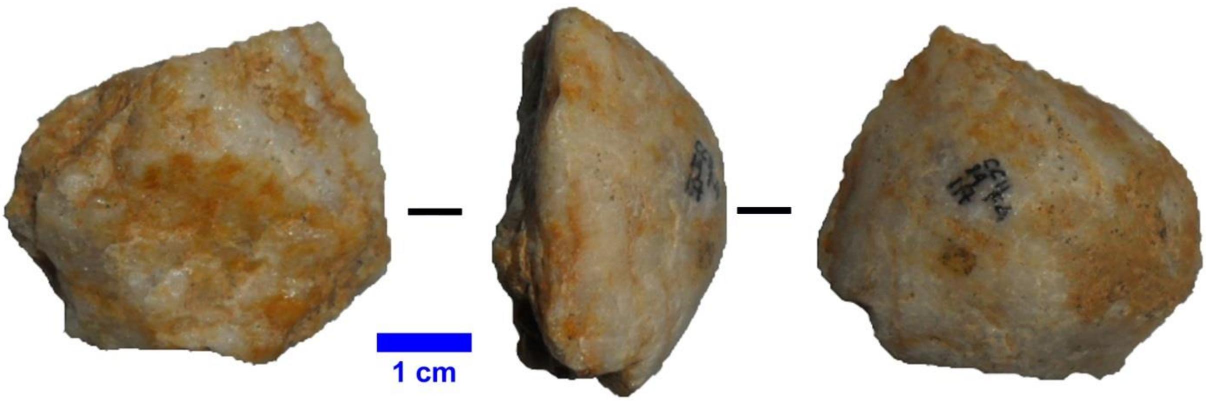

Figure 7. *Levallois* core with cortical striking platform from the Ciota Ciara cave. The scale bar in the image is 1 cm wide.

The discoid method (Boëda 1993) is represented by both bifacial and unifacial mode, depending on the more or less spherical morphology of the cores (Arzarello et al. 2012a; 2012b). The core's shaping out does never come first the stage of *plein débitage*: the discoid exploitation begins from the natural surface of the pebbles and continues through the detachment of debordant flakes, in order to preserve and manage the core's convexities. The discoid products have quadrangular or triangular shapes and are characterized by an important thickness in the proximal part. The debordant flakes often have the typical morphology of a pseudo-*Levallois* point (Arzarello et al. 2012b) (Figure 8).

Sometimes large flakes were used as cores. This kind of exploitation, although referred to a *Kombewa s.l.* knapping method (Owen 1938), has as its purpose the reduction of the technical investment and the maximum exploitation of the raw material.

The lacking number of retouched tools reveals a further adaptation to the characteristics of the raw materials: the retouch on quartz flakes is quite difficult and it does not permit to obtain stronger or more useful edges, compared to the unretouched (Mourre 1996). Among the retouched tools, most of them are side-scrapers, lateral or convergent, followed by denticulates and notches (Figure 9.)

The reduction sequences, especially those *S.S.D.A.*, are short and rarely reach the full exploitation of the cores (Figure 10).

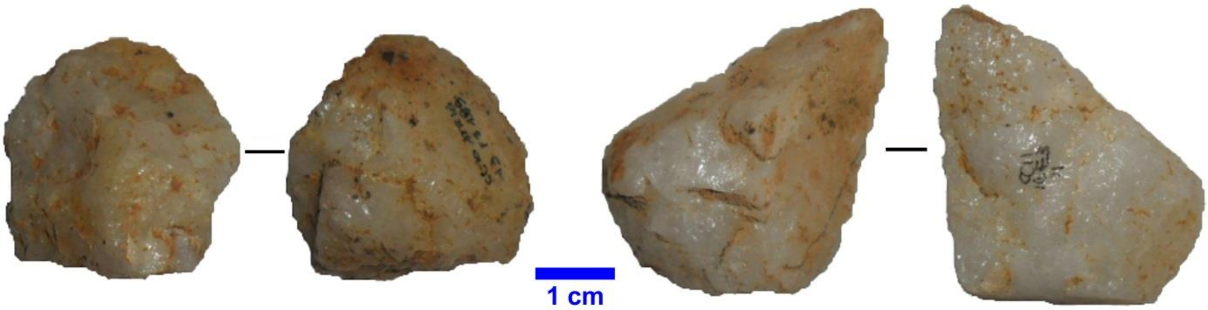

Figure 8.Discoid core (on the left) and side-scraper on pseudo-*Levallois* point (on the right) from the Ciota Ciara cave. The scale bar in the image is 1 cm wide.

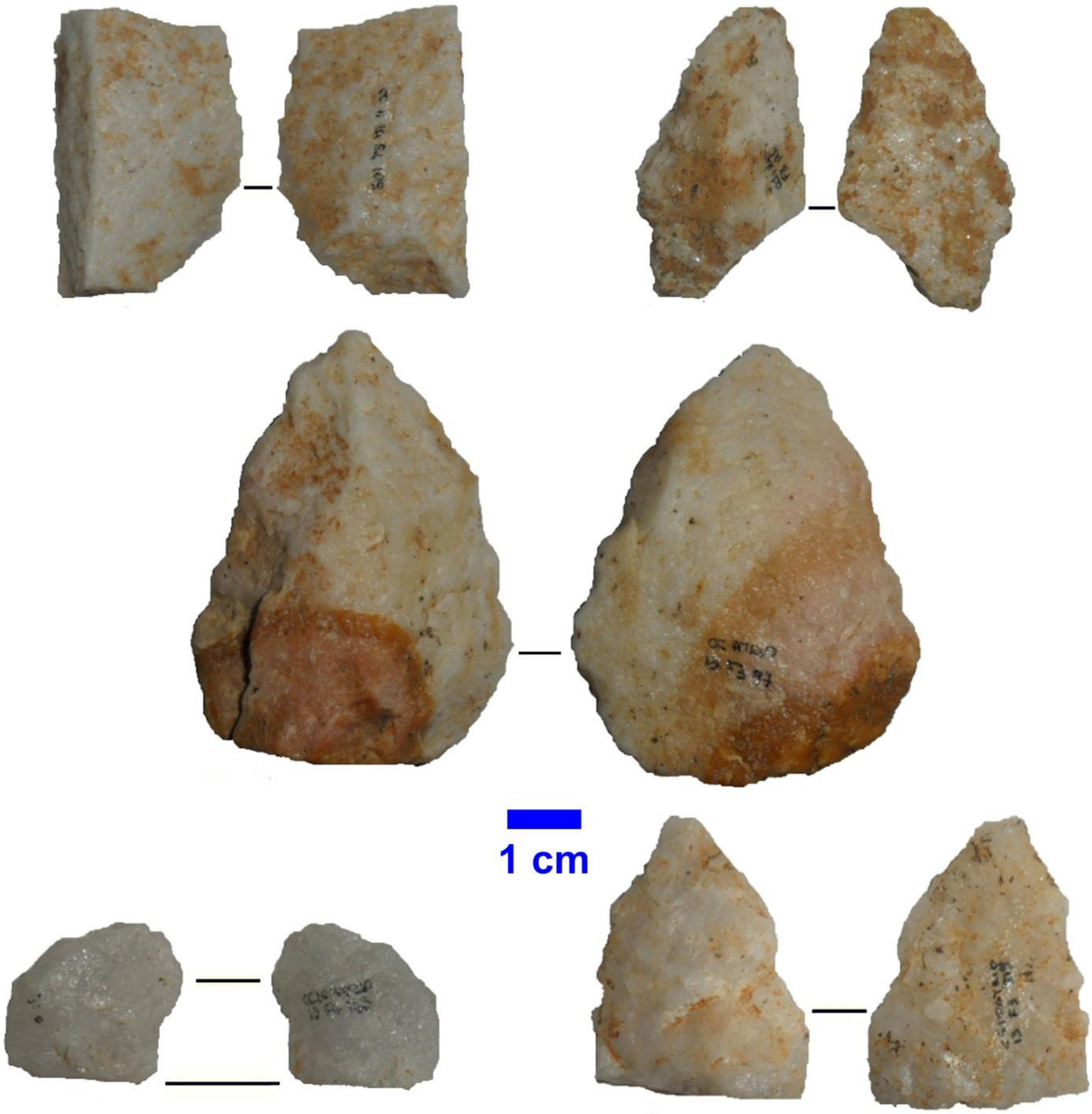

Figure 9. Retouched tools from the Ciota Ciara cave. Side-scraper and double side-scraper (top); Mousterian point (middle); notch and side-scarper (bottom). The scale bar in the image is 1 cm wide.

Levallois and discoid cores never show more than one phase of exploitation. This is probably due to the easy availability of the raw material, to the minimum dimensions required for the knapping products, to the characteristics of quartz that breaks easily during the *débitage*.

Figure 10. The Ciota Ciara cave. *S.S.D.A.* Core. The scale bar in the image is 1 cm wide.

Although no refitting has been found, because of the raw material characteristics and the presence of a huge number of fractures, the reduction sequences on quartz are complete: definitely the quartz exploitation has been carried out within the site. This does not apply to the siliceous rocks, as these have fragmentary reduction sequences that may reflect several factors: the management of one or more phases of the reduction sequence outside the excavated area or the import, within the cave, of finished tools (Arzarello et al. 2012a; 2012b).

3.3. Use-wear analysis

Almost all the quartz artefacts of S.U. 13 are made of local macro-crystalline pegmatite quartz, while two of them are made of micro-crystalline pegmatite quartz. Furthermore, in the lithic assemblage 43 small artefacts in hyaline quartz are also present: large, bright and transparent crystals, at times, make up the kind of macro-crystalline pegmatite quartz exploited in the Ciota Ciara cave and, probably, the artefacts classified as "hyaline quartz artefacts" can be attributed to the knapping of a single crystal of macro-crystalline pegmatite quartz.

The state of conservation of the lithic assemblage is relatively good and no chemical (white patina, bright spots) nor mechanical (soil sheen, trampling) post-depositional alterations are evident.

The use-wear analysis was performed for all the retouched tools, while among the unretouched flakes have been selected those with the following characteristics: presence of functional edges, absence of fractures and of evident post-depositional alterations. According to these criteria, 130 artefacts (124 on local quartz and 6 on spongolite) have been chosen for the use-wear analysis and 13 quartz artefacts show use-wear traces (Table 2).

There are four tools with use-wear traces: a bi-convex convergent side-scraper on *Levallois* point (i.e. Mousterian point); a side-scraper; a bi-convex convergent side-scraper; a notch plus a denticulate. On the Mousterian point have been identified two different areas of use, referable to a transversal action on medium-hard materials (Figure 11); the side-scraper shows one zone of use attributable to a transversal action on hard material; the notch plus a denticulate presents the typical traces of a longitudinal action on medium-soft material, while on the bi-convex convergent side-scraper has been identified an impact fracture.

Among the unretouched flakes, 118 were selected for the use-wear analysis (111 on quartz and 7 on spongolite). Nine quartz unretouched flakes show use-wear traces and on just one of them have been identified two different zones of use. Regarding the nature of actions observed, the presence of one flake with use-wear traces relating to the perforation of medium-hard material is quite remarkable.

Table 2. Ciota Ciara cave. Results of the use-wear analysis performed on the artefacts of S.U. 13. The position of the traces identified is referred to the scheme made by Van Gijn (1989) and modified by Berruti (Berruti & Arzarello 2012). Action: T = Transversal; P = Perforation; L = Longitudinal; I = Impact. Worked materials: H. = Hard; M.H. = Medium hard; S. = Soft; M.S. = Medium soft. The retouched tools are highlighted.

Tool	Raw material	Zones of use	Zone of use 1: position	Zone of use 1: action	Zone of use 1: processed material	Zone of use 2: position	Zone of use 2: action	Zone of use 2: processed material
13F397	Quartz	2	19	T.	M.H.	18	T.	M.H.
15F364	Quartz	1	18	/	M.H.	-	-	-
13F4144	Quartz	1	18	T.	H.	-	-	-
13F22	Quartz	1	07	P.	M.H.	-	-	-
13E413	Quartz	1	10	T.	M.S.	-	-	-
13F3136	Quartz	1	09	L.	M.H.	-	-	-
13F430	Quartz	1	20	T.	S.	-	-	-
13F443	Quartz	1	18	L.	M.S.	-	-	-
13F427	Quartz	1	10	/	/	-	-	-
13E4121	Quartz	1	19	L.	M.H.	-	-	-
13F2389	Quartz	2	18	/	M.S.	08	-	M.S.
13E4124	Quartz	1	20	T.	M.H.	-	-	-
13F337	Quartz	1	20	I.?	/	-	-	-

Most use-wear traces identified on this kind of artefacts can be attributed to the processing of medium-hard or medium-soft materials (Figure 11), with the exception of an artefact that demonstrate a transversal action on soft material.

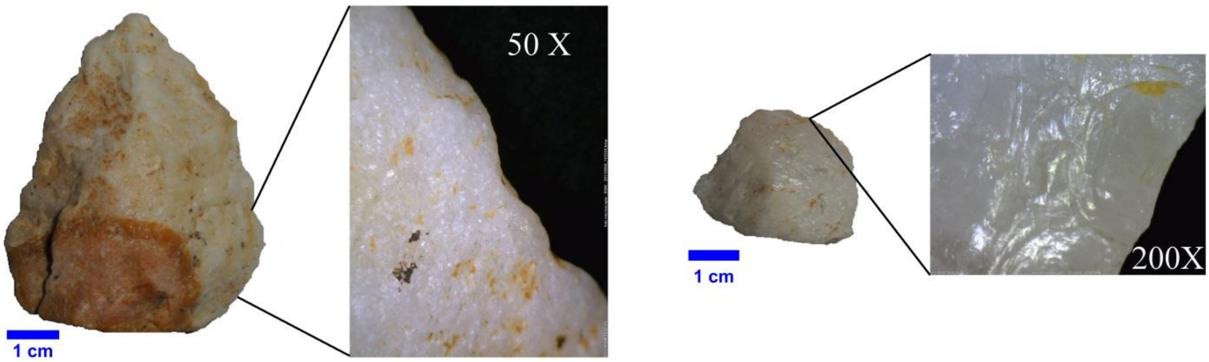

Figure 11. Mousterian point from the Ciota Ciara cave showing use-wear traces due to the processing of medium-hard materials (on the left); non-retouched flake showing use-wear traces due to the processing of medium-soft materials. The scale bars to the lower left of each macroscopic image are 1 cm wide.

Concerning the use-wear traces identified on the edges of the retouched tools, a clear prevalence of medium-hard and hard materials' processing is evident but it is not possible to set a specific connection between tool's typology, kind of action and processed material

(Arzarello et al. 2012b). These data corresponds to the analysis results carried out on coeval sites (Beyries 1987; Lemorini 2000).

About the unretouched flakes, the processing of medium-hard and hard materials is prevailing, even if two of them show use-wear traces referable to the processing of medium-soft and soft materials.

The presence of just two artefacts, within the lithic assemblage of S.U. 13, each one showing two different zones of use, all referable to the processing of the same kind of material, highlights a poor versatility of lithic tools.

The use of quartz tools for the hard and medium-hard materials processing, although the poor mechanical resistance of this raw material, is probably due to its availability in the area nearby the site.

Finally, evaluating all of artefacts showing use-wear traces, it is evident a predominance of the processing of materials with hardness varying from medium-hard to medium-soft. According to Odell (1981), this hardness is related to such materials as soft wood, seasoned wood and deer antler.

A poor activity concerning the processing of carcasses is highlighted by the presence of both an impact fracture on the bi-convex convergent side-scarper and of two flakes showing use-wear traces, related to the processing of soft and medium-soft materials.

4. Discussion

Monte Fenera represents the most important evidence of the presence of *Homo neanderthalensis* in Piedmont.

The reopening, in 2009, of the systematic excavations at the Ciota Ciara cave has allowed to obtain new and interesting data concerning the first population of the North-western of Italy.

The palaeo-environmental reconstruction shows that the human settlement of the Ciota Ciara cave (S.U. 13 and 14) took place during OIS 5, in a temperate-humid period, with an environment characterized, especially, by deciduous woodland, as demonstrated by faunal remains (Arzarello et al. 2012a; 2012b).

The lithic assemblage reveals an “opportunistic” behaviour pattern: i.e. a strong adaptation to the characteristics of the raw materials available in the area (quartz and spongolite) for the production of lithic tools. The local raw materials were exploited through all the *débitage* methods typical of the Middle Palaeolithic (Boëda et al. 1990) but the reduction sequences are short and customized for local raw materials not particularly suitable for knapping.

Based on the characteristics of the lithic assemblage and on the use-wear analysis, in addition to the significant presence of *Ursus spelaeus*, we can conclude that the Ciota Ciara cave was occupied, time after time, for short periods, probably in summertime (Arzarello et al. 2012a; 2012b).

In conclusion, the data emerging from the interdisciplinary approach has allowed us to definitively criticize the theory of the “Alpine Mousterian” (Battaglia 1957; Lo Porto 1957), characterized by a lithic industry “rough and primitive” based on the lack of the *Levallois* method and of the limited number of retouched tools. The lithic industry from the Ciota Ciara cave proves that the limited number of retouched tools, in addition to the use of short reduction sequences for the production of lithic tools, is just the result of a technological behaviour extremely conditioned to the nature and availability of lithic raw materials (Arzarello et al. 2012b).

Acknowledgments

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Producing adornment: Evidence of different levels of expertise in the production of obsidian items of adornment at two late Neolithic communities in northern Mesopotamia

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Abstract:

In the Near East obsidian is of particular interest to archaeologists because it is an exotic material and best known for is use in tool manufacture, but it is also occasionally used to make items of personal adornment. Some of these items are very highly finished, while others appear much more rudimentary though it is by no means obvious why this should be. Here we will review such artefacts at two contemporary late Neolithic communities, Domuztepe in SE Anatolia and Tell Arpachiyah in northern Iraq. Both have seemingly unusually high numbers of such objects as well as evidence for obsidian tool production on site. At Domuztepe some objects are highly finished while others appear much more ad hoc. At Arpachiyah on the other hand, the objects appear very similar to each other so as to seem standardised or at least the product of a single workshop. Our main aim in this paper is to try to unravel the evidence needed to determine whether they were produced on site, or whether they were acquired as finished objects (or both).

Keywords: obsidian; obsidian as personal adornment; Domuztepe; Arpachiyah

1. Introduction

Obsidian is an exotic raw material at most sites in the Near East and best known for its use, alongside flint, as a material from which to make tools. Some excavations have also produced items of personal adornment, mirrors and vessels made of obsidian. Some of these objects are very highly finished while others appear more rudimentary. The exotic and aesthetic nature of obsidian along with this unusual way of using it (and in a way that flint was not[1]) suggests that as a raw material, it may have had a special place in people's world views (Healey 2013). Since items of jewellery and personal adornment are also often considered to be markers of different identities and social status (see for example, Costin et al. 1998, White 2007: 287; Wright & Garrard 2003), the additional factor of the choice of obsidian as a raw material may have accorded them additional meaning. It follows from this

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that the places and processes of manufacture might provide insights into the structure and allegiances of the communities that made and possessed such objects.

Hitherto the focus of study has tended to be on obsidian as a raw material, especially its origins and distribution (Cauvin et al. 1998) and more recently on technological characteristics (Binder 2008; Pelegrin 2012). Little attention has been paid to the non-utilitarian items, let alone to their manufacture or how they were used (see Wright & Garrard 2003 for a similar situation involving other materials). Here we will attempt to contextualize such objects at two broadly contemporary sixth millennium cal. BC communities of rather different type, Domuztepe in south-east Anatolia and Tell Arpachiyah in northern Iraq (Figure 1). Both sites have unusually high numbers of ground and polished items of obsidian as well as evidence of obsidian working and tool production. Wider and in-depth studies of the obsidian and other lithics from both sites is underway elsewhere (Healey in preparation; Campbell & Healey in preparation) but the particular question we want to address here is whether the non-tool items of obsidian were made within the communities and whether specialist craftspeople were involved or whether they were acquired as finished objects (or both).

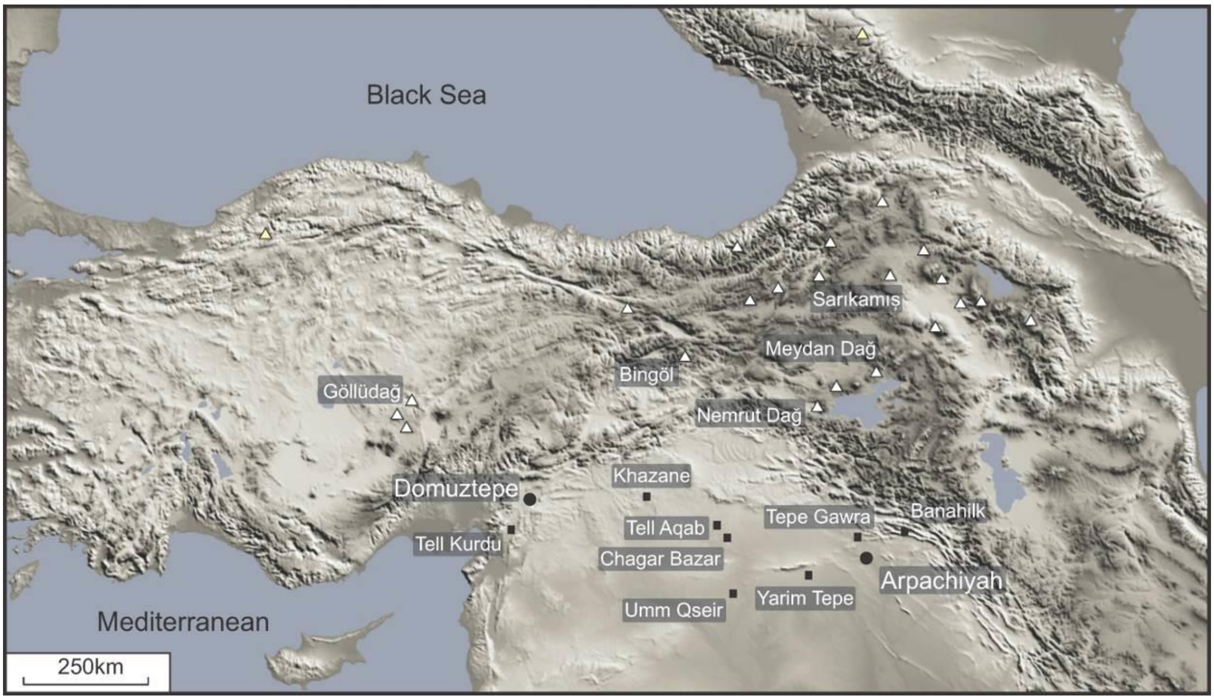


Figure 1. Map showing the location of Arpachiyah and Domuztepe (circles) and other sites (squares) mentioned in the text in relation to obsidian sources (open triangles) (Source Stuart Campbell).

2. Obsidian use at Domuztepe

Domuztepe is a large site (Figure 2) occupied from the early ceramic Neolithic through to the late Neolithic (c. 6800-5450 cal. BC) and then again in the first millennium AD.

The main focus of the excavation has been on the Halaf period (c.6100-5450 cal. BC). In this period settlement covered some 20 ha. It may have comprised a number of loosely knit communities with some evidence for the demarcation of space albeit with limited evidence of hierarchy. Identities and social roles may have been marked by or reflected in the material culture including elaborately painted ceramics, figurines, stone bowls, stamp seals, beads and other jewellery made of stone, shells and bone (Campbell & Fletcher 2013: 42-43). The main raw material used for chipped stone tool manufacture is locally obtainable flint which was regularly worked within different contexts at Domuztepe; there is also some evidence for the occasional choice and elaborate working of attractive and possibly non-local flints. Other non-local raw materials include a range of obsidians, from various geographically widely separated sources between 250 km and 900 km away. Obsidian artefacts from different sources account for about 9-20% of the tool kit depending on context. This obsidian component numbers around 8000 artefacts and comprises cores, flakes, blades and some retouched pieces as well as over 190 non-tool items including beads, links, pendants, mirrors, vessels and other items which have been finished by grinding and polishing; a selection is illustrated in Figure 3.

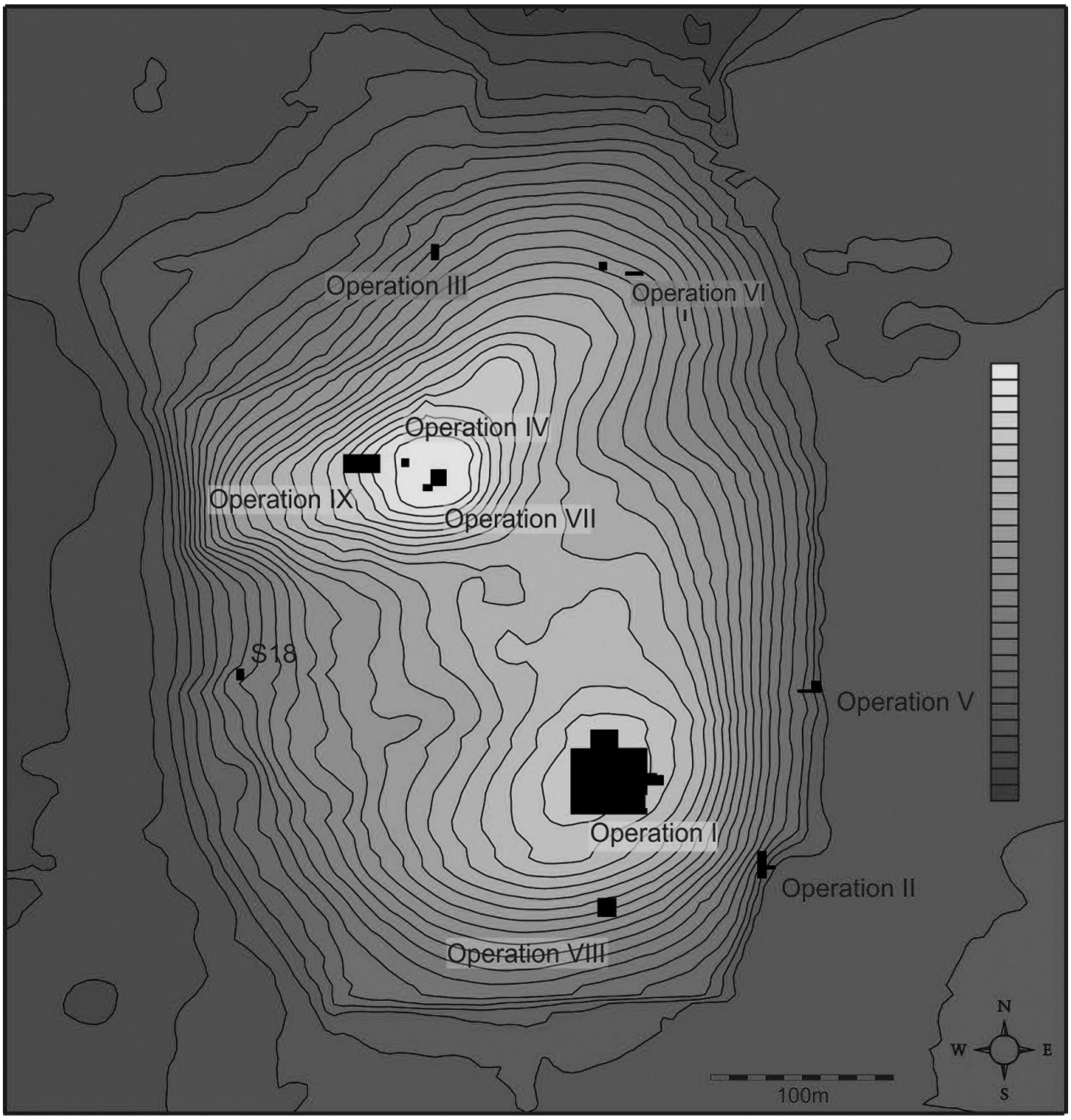


Figure 2. Contour plan of Domuztepe, showing excavated areas (source Stuart Campbell)

Most come from late Halaf contexts but earlier examples are also present (Healey 2013: Table 22.1). Some of these items are much more elaborate than others both in terms of their finish and in their concept. Less elaborate forms include pendants, no. 3, made on a flake shaped by rudimentary grinding (see also Healey 2013: Fig. 22.4, nos. 2 and 3). These are of a very different ilk from the highly polished objects such as Figure 3, nos. 1, 2, 4, 6 and 7. Some idea of the significance and perhaps value of such items is suggested by their repair after breakage. For example one small, highly finished, incised pendant, dt3859, was re-perforated and reshaped (Healey 2013: Fig. 22.4, no. 6).

Figure 3. A selection of ground and polished objects from Domuztepe: 1. Mirror with strap handle, dt3494; 2. Highly polished disc or mirror with concentric grooves around the edges, dt427; 3 Pendant, dt2141, with minimal grinding and break on perforation; 4 Crescentic link, dt1069; 5. Vessel fragment, dt2625, pecked and ground but not polished; 6. Rim fragment of highly polished vessel, dt275; 7-9. Beads, dt1107, dt2832 and dt2227; 10-12: Unfinished obsidian items, dt6973, dt354 and dt7164 (photographs by Stuart Campbell).

2.1 Unfinished items and possible bead production area

Unfinished objects include a part-drilled link, Figure 3, no. 12, from a ceramic Neolithic context, and other partly drilled pieces, e.g., no. 10 from a later context; there is also a blade segment, no. 11, chipped into a lozenge-shape but not ground, and some rectangular pieces. Two blades also show incipient grinding which appears to have been deliberate, but they are not otherwise worked. In addition a number of small discoidal and rectangular objects, mainly of obsidian but also other raw materials, have been interpreted as bead blanks (see also Belcher 2011). These were found concentrated in a small area of a partially burnt complex of structures and activity areas which preserved quantities of *in situ* artefacts including ceramics, flint and obsidian. Apart from a number of drills (yet to be fully analysed, though there are none as obviously worn as those from Mezraa Teleilat (Coşkunsu 2008)), no tools (such as abraders, grinding stones, polishers) that could be specifically related to the manufacture of the beads have been identified.

In all 27 obsidian blanks or pre-forms of three different types were found in a restricted part of this area. They include nine disc-like pieces (Figure 4, nos. 6-8) which have been shaped by chipping around the edges, presumably blanks or preforms for barrel or biconical beads prior to grinding and perforation. The blanks measure between 7 and 10.7 mm in diameter and 4 to 7.3 mm in thickness (Figure 5). The size range of many of the finished obsidian beads is compatible with blanks of this size: the more robust finished beads (Figure 3, no. 7) measure between 5.2 mm and 10 mm in diameter and 5mm and 10mm in thickness (Figure 5 top). Similar pieces in other raw materials were also recovered in this area and include a small unperforated sub-discoidal object of translucent green amorphous silica (Belcher 2011: Fig. 3).

The other two types of pre-forms (all obsidian) are thinner. One type is rectangular in shape and the other square to sub-discoidal (e.g., Figure 4, nos. 1-3, 9 and 10). The rectangular examples measure between 14 and 39 mm in length, the majority being under 20 mm. They are made on blades, some of which have incipient grinding on their surfaces. The square examples, which are ground on both surfaces, are about 4.9 to 7.5 mm square and under 3 mm in thickness (Figure 5 bottom). It is possible that they are blanks for minute disc beads like those in Figure 3, nos. 9 and 10 (see also Healey 2013, Fig. 22.3, nos. 8-11), which often measure less than 4 mm in diameter and 1.6 mm in thickness.

There is also a small, partly ground tear-drop flake of obsidian (possibly an unfinished pendant), and a tranchet object with ground sides (Figure 4, nos. 4 and 5); the tranchet object seems to have been re-made from a larger object and is made of a different obsidian from the other blanks. A flake apparently from a ground and polished object and a fragmentary 'mirror', was also found in the same area as the bead blanks.

These items were associated with a considerable amount of obsidian and flint debitage and retouched pieces, suggesting that it was a chipped stone working area. Obsidian of various colours and types was present in this assemblage but the blanks were all made of transparent grey or grey-brown obsidian and it was also noted that this type of obsidian predominated in the contexts in which the bead blanks were found. In the rest of this complex, green obsidian is dominant. We were able to determine through pXRF analysis that seven of the blanks, the mirror fragment and the tear drop were made of obsidian which originated from Göllüdağ but that one was made of obsidian from Sarıkamış (Lehner et al. in preparation; Frahm et al. in preparation); both types of obsidian were also present amongst the debitage though relative proportions have not yet been determined.

On the basis of the above, we tentatively conclude that here we have the truncated remnants of an area where the preliminary stages of bead manufacture and perhaps other items was undertaken using specific types of obsidian and other raw materials alongside and perhaps as part of tool production (compare with the situation at Çatalhöyük described by Bains et al. 2013: 343). This was on a small scale, probably at household level (for examples see Costin 1991; Belcher 2011), akin to what Hirth describes as diversified household manufacture (Hirth 2009).

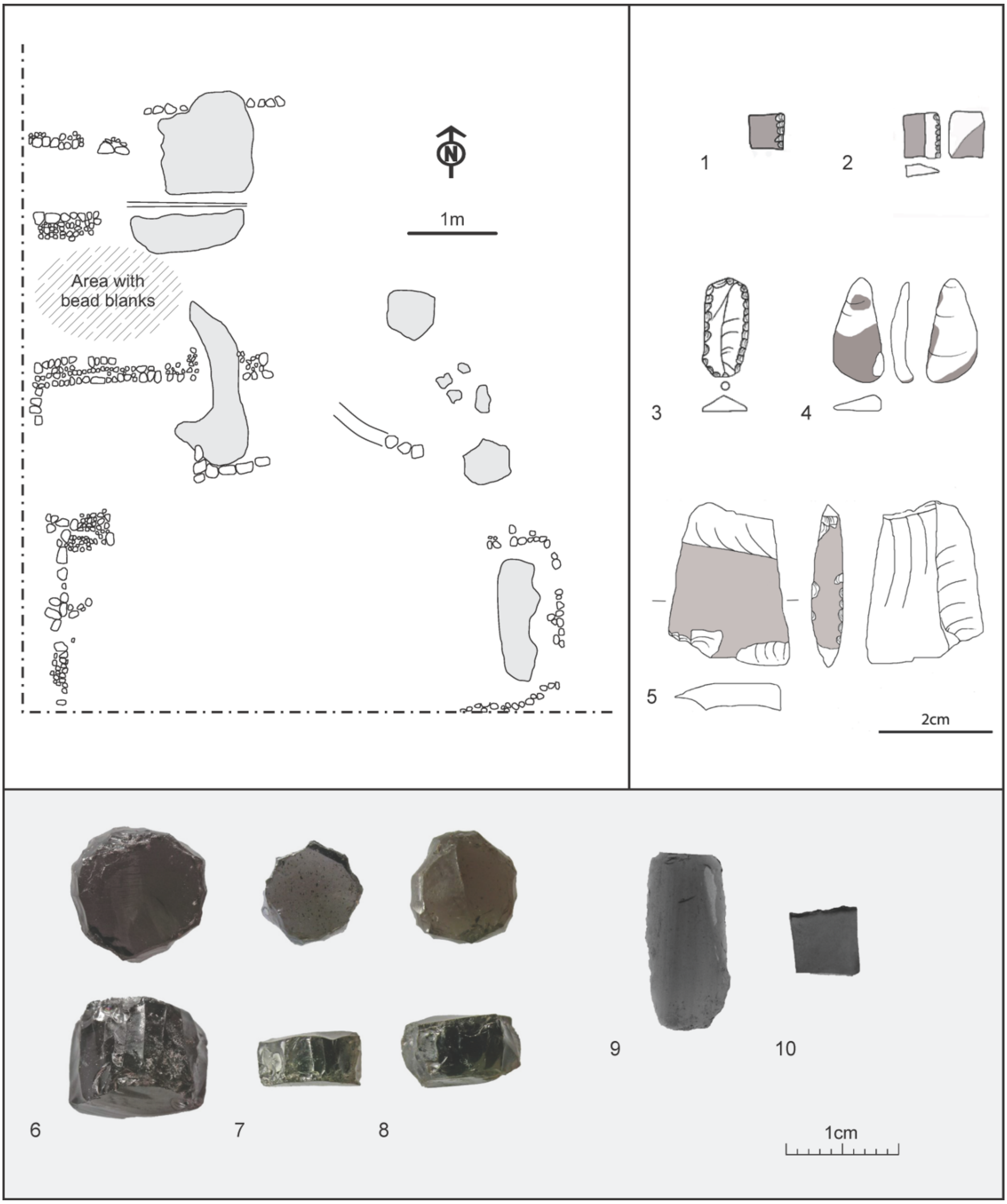
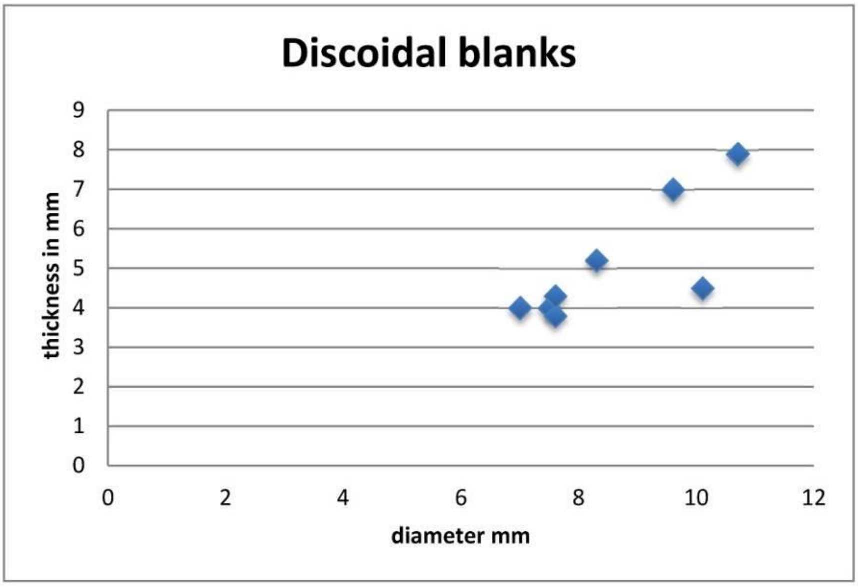


Figure 4. Upper left: Plan of activity areas around the Burnt Structure in Operation I at Domuztepe showing location of possible bead blanks. Right and lower: Square and rectangular blanks (nos. 1-3: L3919/10, L3959 and L4044). Incomplete pendant (no.4: dt4948). Incomplete tranchet (no. 5). Examples of discoidal bead blanks (nos. 6-8: dt4774, dt4595 and dt4835) and rectangular and square pieces (nos. 9 and 10: L3919-9 and L3919-10); L3919-10 is ground on its dorsal surface (Source, Stuart Campbell and Elizabeth Healey)



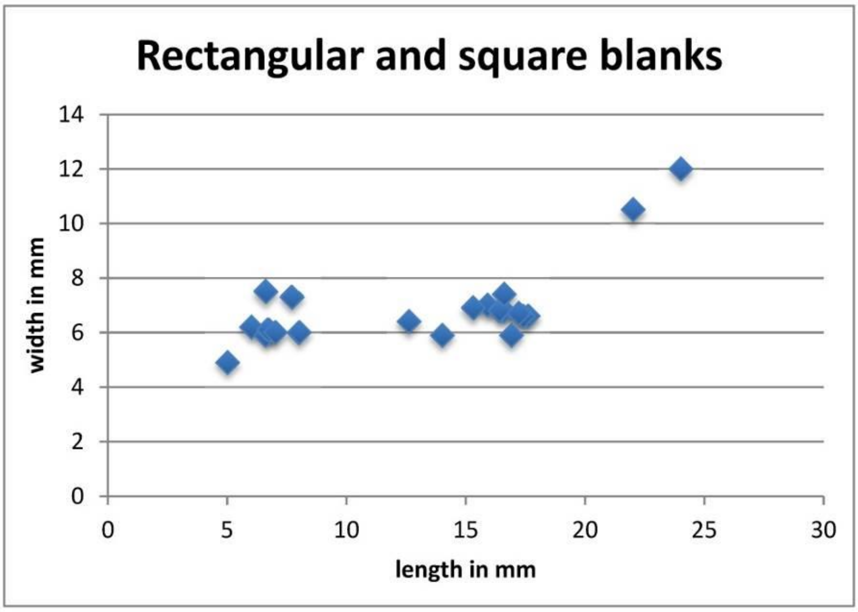


Figure 5. Chart showing dimensions of possible blanks from the Burnt Structure at Domuztepe (source Elizabeth Healey).

It is tempting to see the more rudimentarily produced pieces such as simple pendants and some of the beads, for example Figure 3, no. 3, 8-10, as products of similar production systems. The more elaborately finished obsidian objects such as some of the mirrors and most of the vessels suggest that they were deliberately designed and executed by experts either at Domuztepe or perhaps elsewhere.

3. Obsidian use in the Burnt House at Tell Arpachiyah

Arpachiyah, in contrast to Domuztepe, is a small tell with its main occupation from c.6000 to 5000 cal. BC. Most of our best quality information comes from the building known as the 'Burnt House' which is dated to the mid sixth millennium cal. BC (i.e. the late Halaf) and is broadly contemporary with the late Halaf levels at Domuztepe. The Burnt House is a rare and unusual context interpreted in various ways, including as a centralizing institution and redistribution centre (Campbell 2000; Campbell and Fletcher 2013: 43).

In it (and more precisely in the Long Room and the Full Room, Figure 6) were found some highly decorated ceramics, stamp seals, stone vessels, including one made of obsidian, figurines, a necklace made up of six obsidian lozenge-shaped links, cowrie shells and stone pendant and a clay bead, 36 rectangular links made of obsidian and a considerable amount of flint and obsidian tools and debitage (Figures 7-9) (Campbell 2000; Healey 2000). So many in fact that when excavated in 1933 the excavator, Sir Max Mallowan, described it in his notes as an obsidian workers dwelling (Mallowan nd: 245) and only later said “This house, which alike by its situation and size was clearly the property of one of the headmen of the village, proved to have been the workshop of a potter and a maker of stone vases and of flint and obsidian tools” (Mallowan & Rose 1935: 16). He describes the flint and obsidian tools as “lying in confusion in a single room” and adds “there were in addition thousands of cores and chips characteristic of the debris in a stone-carver's shop” (Mallowan & Rose 1935: 17, 103). The objects, though, were on charred wood, possibly a shelf or table, at the edge of a room suggesting deliberate placement (Mallowan & Rose 1935: 17, 97). The necklace was seemingly found in the arrangement shown by Mallowan & Rose (1935: 17, Pl. XI), however it has gone through various slightly different arrangements since then (Figure 7). The rectangular links (Figure 8), he suggested, adorned a helmet or similar object (Mallowan & Rose 1935: 97). The other flint and obsidian artefacts consist of flint sickle blades and perforators and both flint and obsidian cores and blades, preparation pieces and flakes. In addition there were two fragments of an obsidian pendant or link and some thicker pieces of obsidian, possibly core ends which have been chipped and partially ground (Figure 9).

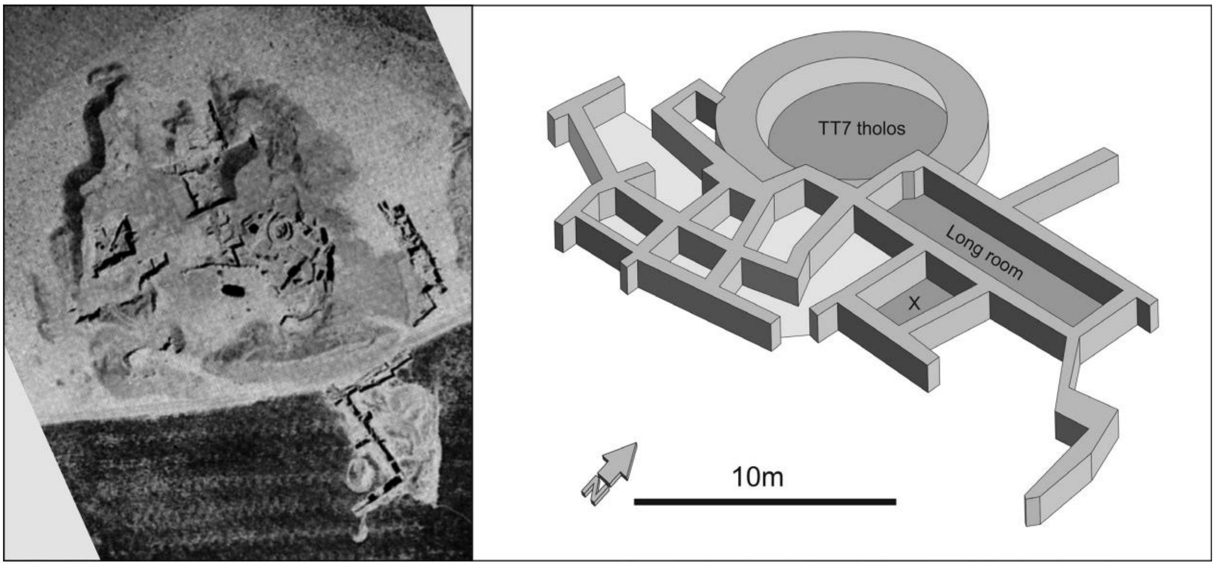


Figure 6. Left: air photograph of Arpachiyah during excavation; the TT7 tholos underlying the Burnt House is visible at the centre right (RAF photo. Original in British Museum). Right: isometric reconstruction of the TT6 Burnt House indicating the long room where most of the obsidian was found.

After the excavation the artefacts were divided between the expedition and the Iraq Museum in Baghdad. The finest pieces from the expedition share were given to the British Museum with other items distributed to various museums around the world. The necklace and seventeen of the links ended up in the British Museum and the bulk of the lithic debitage in the Institute of Archaeology, UCL, London, including two small broken perforated, ground and polished pieces and some sub-discoidal partially ground pieces (Figure 9); the remaining links and the vessel are in the Iraq Museum which were fortuitously recorded as part of another project by Campbell in the 1980s (Campbell 2000).

Figure 7. The necklace from Arpachiyah (A909): note the obsidian links interspersed with cowrie shells, stone pendant and clay bead. (1) as strung in the 1980s, (2) as currently strung and possibly found (©Trustees of the British Museum).

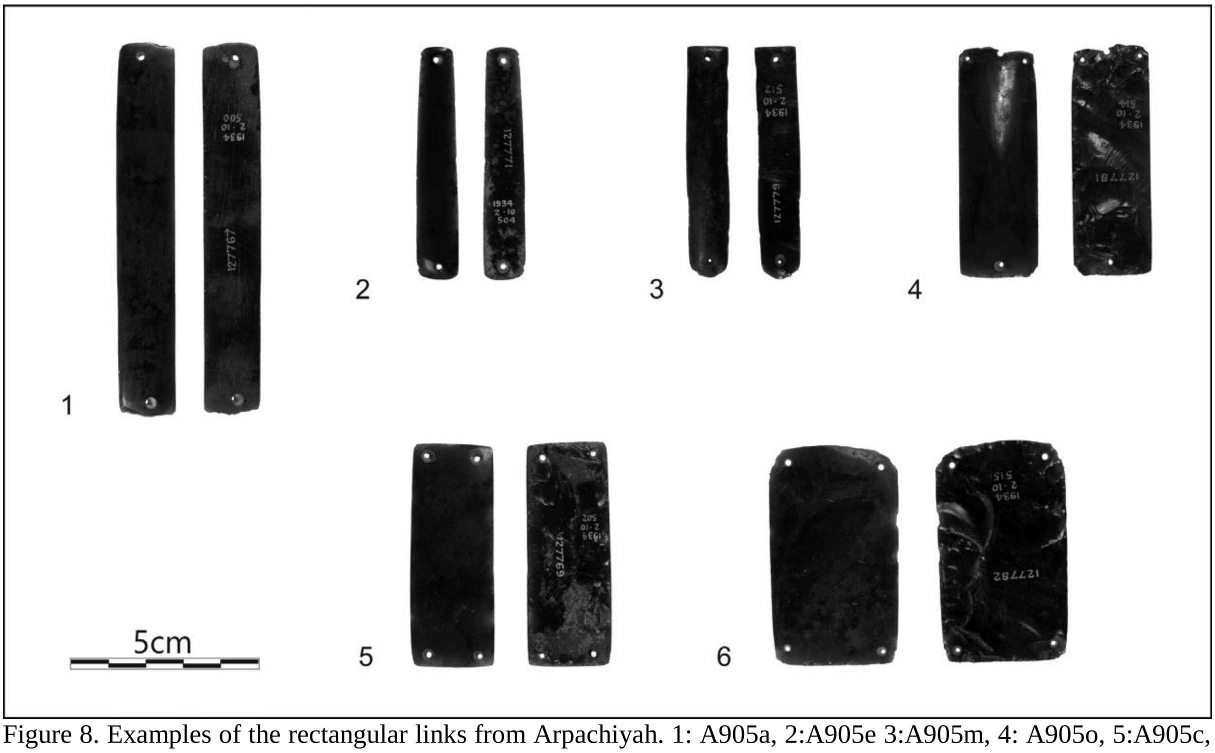


Figure 8. Examples of the rectangular links from Arpachiyah. 1: A905a, 2:A905e 3:A905m, 4: A905o, 5:A905c, 6: A905p (photographs by Stuart Campbell).

The presence of a range of highly finished, elaborate and sometimes exotic objects of various types, together with stone tools and chipped stone debitage, in such a prominent structure as the Burnt House, suggests that the location and association of the objects was of some importance and certainly very different from most other contexts in which obsidian has been found. We felt that an in-depth study of the obsidian objects, made of an unequivocally imported material, could help determine the function of the Burnt House. Our aim was to try to determine whether the links could have been made in the Burnt House or indeed were the result of a single episode of manufacture there or elsewhere, and to see whether the debitage recorded by Mallowan could be implicated in their manufacture. To achieve this we set up a project to investigate the processes that might have been involved in the manufacture of the links and the origin of the obsidians used, and to compare this with the rest of the obsidian found in the Burnt House (see also Campbell & Healey 2013).

Figure 9. Cores and partially ground chunks from Arpachiyah (photographs by Stuart Campbell).

Previous examination of the obsidian for different purposes suggested that a number of different types were present (Campbell 1992; Healey 2000) but the only provenance analysis then available was that carried out by Renfrew in 1960s on five, now unidentified, pieces of obsidian (Renfrew et al. 1966). This indicated that both obsidian from his group 4c (Bingöl A/Nemrut Dağ), Bingöl B and an unknown source was present. Since then others have geochemically analysed other artefacts in Australian and Canadian museums: five in Australia have been attributed to Meydan Dağ and Bingöl B and two in Canada are from Meydan Dağ (Forster & Grave 2012; personal communications with Tristan Carter). We were fortunate in obtaining permission from the British Museum and funding from the British Academy and CHARISMA to analyse the links and other artefacts at the AGLAE facility in the Louvre using PIXE. This enabled us to geochemically characterize 22 links (all those in the British Museum) and 51 other pieces, mostly debitage but also two fragments of a pendant or small link in the Institute of Archaeology and two of the partly ground pieces. The results of the analyses showed that all the links in the necklace were made of peralkaline obsidian from a single flow on Nemrut Dağ (probably Frahm's flow EA21/22 (Frahm 2010)) as were 13 of the rectangular links and the small partly ground pieces; a further two of the rectangular links were made of calcalkaline obsidian from the Bingöl area and another three of obsidian probably from Meydan Dağ. The flakes, blades and cores showed similar origins. This data, together with correlation of colour with source (Healey & Campbell 2009; see also Milič et al. 2013), allowed us to attribute the bulk of the debitage to different sources with a reasonable degree of confidence. The green obsidian comes from a peralkaline source, almost certainly Nemrut Dağ, although the possibility that some are from the Bingöl A group cannot be ruled out. The grey and black obsidian probably originates from the Bingöl B group, Meydan Dağ or both. In essence this means that about 75% of the debitage originated from Nemrut Dağ (with the possibility that some came from Bingöl A sources) and the bulk of the remaining 25% of the debitage came from the calcalkaline sources of Bingöl and Meydan Dağ. A few completely colourless flakes are from an unknown source (Campbell & Healey 2013; Campbell et al. in preparation). In terms of the origins of the obsidian, the debitage could be compatible with the manufacture of the links.

Our interpretation of the manufacturing processes are necessarily based on inferences from the observation of finished pieces since no. unfinished links or tools which could be associated with their manufacture are present among the debitage. However, we may note the presence of three stylised objects of pumice and another of sandstone in the Burnt House (Mallowan & Rose 1935: 100 and Pl. X, d-f; Campbell 2000: 20, Fig. 13.1), which perhaps indicates the presence of material that could have been used for grinding.

The links themselves are of standardised sizes and shapes (Figure 10), suggesting that blanks (blades and flakes) of a particular type must have been chosen. The larger of the oval and lozenge shaped links measure between 53 and 60 mm in length and 30-37 mm in width and 7-9.7 mm in thickness. They seem to have been made on large flakes which, allowing for removal of the bulb and about 2 or 3 mm from the edges to ensure even thickness, we estimate must have been in the region of 65 x 41 mm. Most of the rectangular links were made on blades, though in a few cases the width and the faint evidence of dorsal scarring patterns suggest that the blanks were more likely to have been flakes We estimate that to achieve a typical rectangular link of 60 mm x 15 mm x 5 mm, a blade measuring about 70-75 x 21 x 5 mm would have been needed; this would allow about 5 mm at each end for the removal of the bulb and regularizing the shape of the distal end, and 3 mm from the edges to ensure an even thickness (Figure 11). These are sizable blades and flakes and it is likely that they were especially produced as blanks for the links; the most regular blades almost certainly involved reduction by pressure perhaps using the lever technique (Pelegrin 2012).

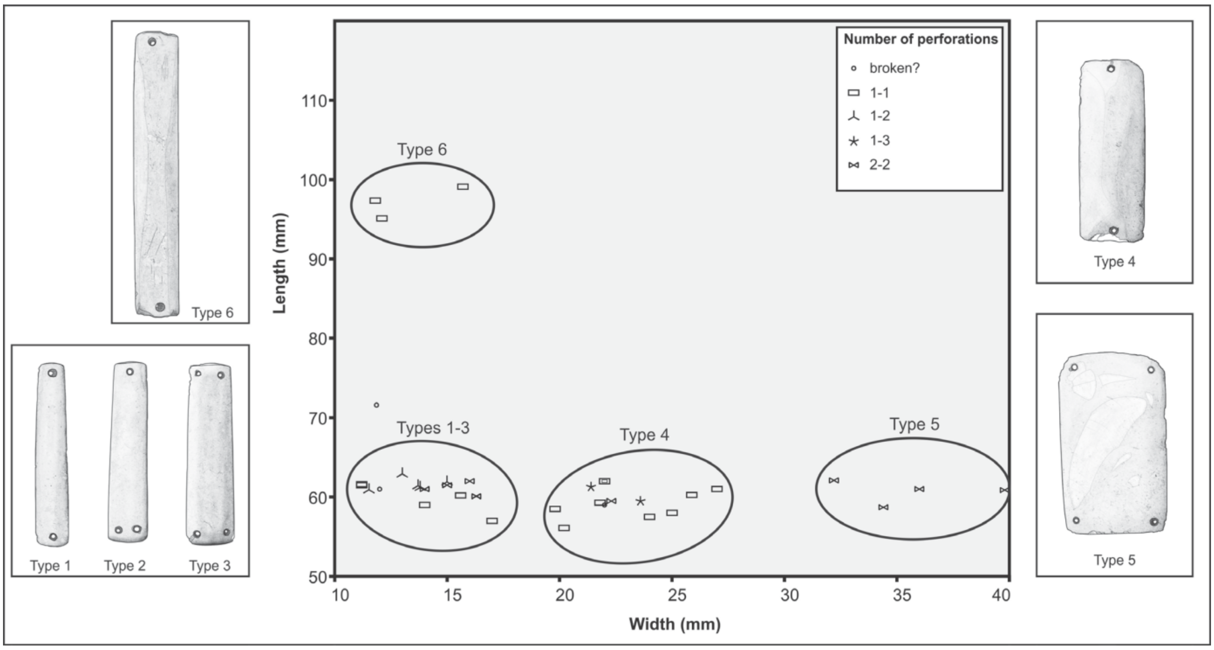


Figure 10. Typology of the rectangular links from Arpachiyah (source Stuart Campbell).

Once a suitable blank had been selected the ends and edges were worked (probably by flaking or retouch) into a symmetric, rectangular shape of relatively standard size, the ends were ground to shape (some are bevelled suggesting that they may have been closely abutted but that they would have articulated without rubbing against each other) and attention was given to the ventral surface. It is sometimes left unmodified but at other times prepared by grinding or flaking. After this the sides were regularized by grinding, which in most cases is quite coarse; it was executed in a longitudinal motion, sometimes leaving spalling along the ventral surface. In a few instances the flaking of the ventral surface is extensive and appears to have taken place after the grinding of the sides and possibly indicates reworking. The next stage seems to have been to grind down the dorsal surface of the blanks to obliterate the ridges and to form an even, regular dome-shape thus creating a plano-convex section; the link was then ready for perforating prior to the final polishing. We surmise that this was the order because most links show chipping and signs of drill slippage on the ground surface. The links were transversally perforated from each side with varying degrees of success as there are some mis-drillings. Judging by the regular striations in the holes, this was probably achieved using a bow or other sort of mechanical drill (Gwinnet & Gorelik 1981; Bains et al. 2013). Sometimes the upper and lower holes are drilled from opposing angles and this may indicate that the hole at each end was initiated from different faces (as the unfinished link at Domuztepe, Figure 3, no.12). The final stage was the polishing the dorsal surface of the links to create a highly reflective surface but few now retain this level of polish probably due to post-depositional factors. We hope that our observations on the processes and stages of manufacture will be corroborated by the experimental replication of the links currently being undertaken by Laurence Astruc, Athina Boletti and tribological analysis by Roberto Varioglu (CNRS); hopefully this will also identify the nature of the materials need to achieve the various levels of finish as well as the methods used and the sorts of skills needed and the time involved in their manufacture.

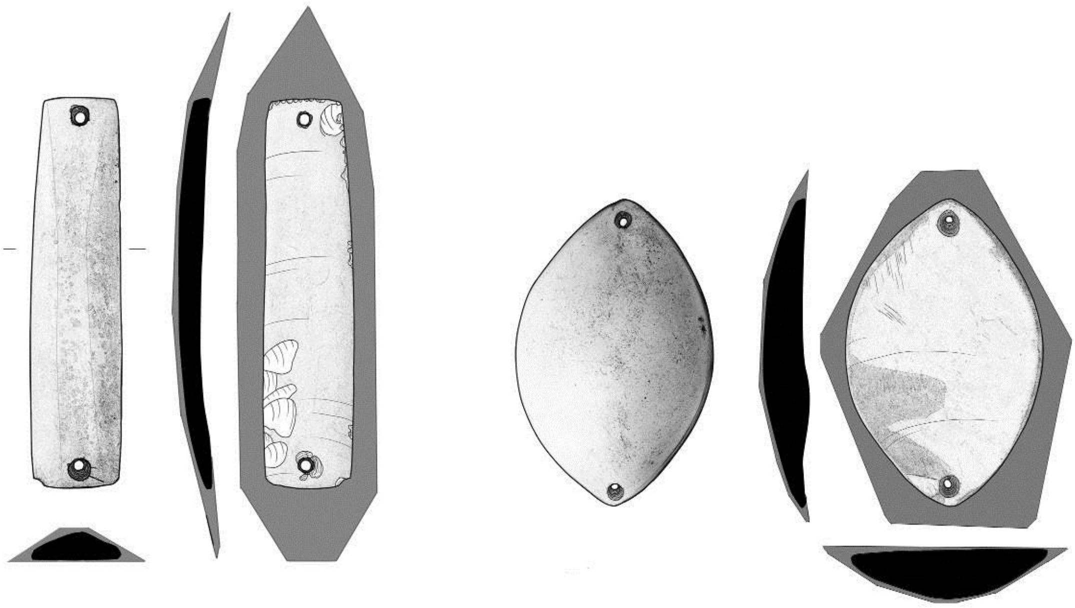


Figure 11. Schematic diagram to indicate the size of the original blade or flake that likely would have been needed to make a rectangular link, A905g 60.7 x 15.5 x 3.5 mm and an oval link A909j 51.7 x 36,1 x 7.8 mm (source Elizabeth Healey; drawing of links S. Bellshaw).

Although the links appear quite standard in their size, shape and manufacturing method, there are a number of subtle differences, such as the different methods and levels of care in making the perforations and in the degree of grinding. We also noted differences in the links made of non-peralkaline obsidian. For example A905c (Figure 8, no. 5) is made of obsidian from Bingöl B or Meydan Dağ and is unique in having its ventral surface ground and then flaked and A905m (Figure 8, no. 3) also of calcalkaline obsidian, has differently shaped terminations and the proximal end of the blade blank has not been truncated to the same extent as the others so that the perforation goes through the thickness of the bulb.

As well as these slight differences in manufacture, we noted that some of the links had different signs of wear, including some that were re-perforated when the hole broke either side of the broken hole to maintain the length of the link (Figure 8, no. 4, A905o). Some are re-flaked on the ventral surface after edge grinding (Figure 8, nos. 4 and 6, A905o and p). A different solution to the 'repair' of a broken hole is seen on the small lozenge-shaped obsidian link in the necklace where the edge of the broken perforation was ground smooth, necessitating a different way of stringing the link. It is tempting to see the clay bead of almost the same size and also broken across the perforation as an imitation of this. These and other attributes suggest to us that the links had had different and extended life-histories starting from the selection of the blank and were not freshly made for the group as found.

Despite this we felt that it was important to examine the debitage to see if it could have something to do with the manufacture of the links. Certainly the collection of so much obsidian debitage in one place is unusual and, in an assemblage that in other respects is composed of finished items, it seems that it may have been deliberately placed. Therefore, we examined the over 2000 obsidian artefacts that survive in the Institute of Archaeology, London which, as far as we can reasonably ascertain, come from the Burnt House to see if, even theoretically, it could have been connected with the manufacture of some or all of the links even if some had been brought together from different places. To this end we recorded techno-typological attributes, dimensions and other physical characteristics including colour in transmitted light. They are summarized by obsidian type in Figure 12.

It is clear from this study that there are a few blades and flakes present which would have been large enough to serve as blanks for the links, suggesting that cores potentially large enough to produce suitable blades had been available. However, the surviving cores are thoroughly reduced and the debitage much smaller. Some, too, are retouched or show evidence of use. It is of course probable that we only have a partial or mixed assemblage. On balance, though, it seems unlikely that the debitage relates immediately to their manufacture. Its inclusion in the Burnt House may, however, be significant and embody meaning of activities going on there (for related discussion see Carter 2007).

4. The wider picture

Obsidian is regularly used in contemporary sites as an exotic raw material (Healey 2000; 2007: Table 2). Amounts range from very small amounts to quantities as large as, or 'more common than' flint. The latter situation is particularly common in northern Iraq and northeast Syria, including the region in which Arpachiyah is located. In some assemblages there is evidence for core reduction and tool production; in others obsidian seems to be present only in the form of blades, with no evidence of core reduction on site. The obsidian used in the northern Mesopotamian sites is mainly from Nemrut Dağ and Bingöl B sources, but occasionally we note the presence of Meydan Dağ. Further to the west, obsidians from both south east Anatolian and Cappadocian sources are present and we may note that both Tell Kurdu and Domuztepe have obsidian from Sarıkamış. This provides only a very general picture because it is often hard to tease out exact amounts or technological information from published data and few assemblages have provenance data (Healey 2000: Appendix 5). Some (in fact an estimated 35-40% based on present evidence) of these assemblages also have ground and polished items of obsidian but of different forms and finishes (Table 1); evidence for their manufacture or even repair, however, is all but absent, repairs being noted only at Domuztepe, Arpachiyah and Kazane Höyük (see below). For this reason we focus here more on the presence and morphology and finish of the ground and polished obsidian artefacts and on any potential evidence for their manufacture.

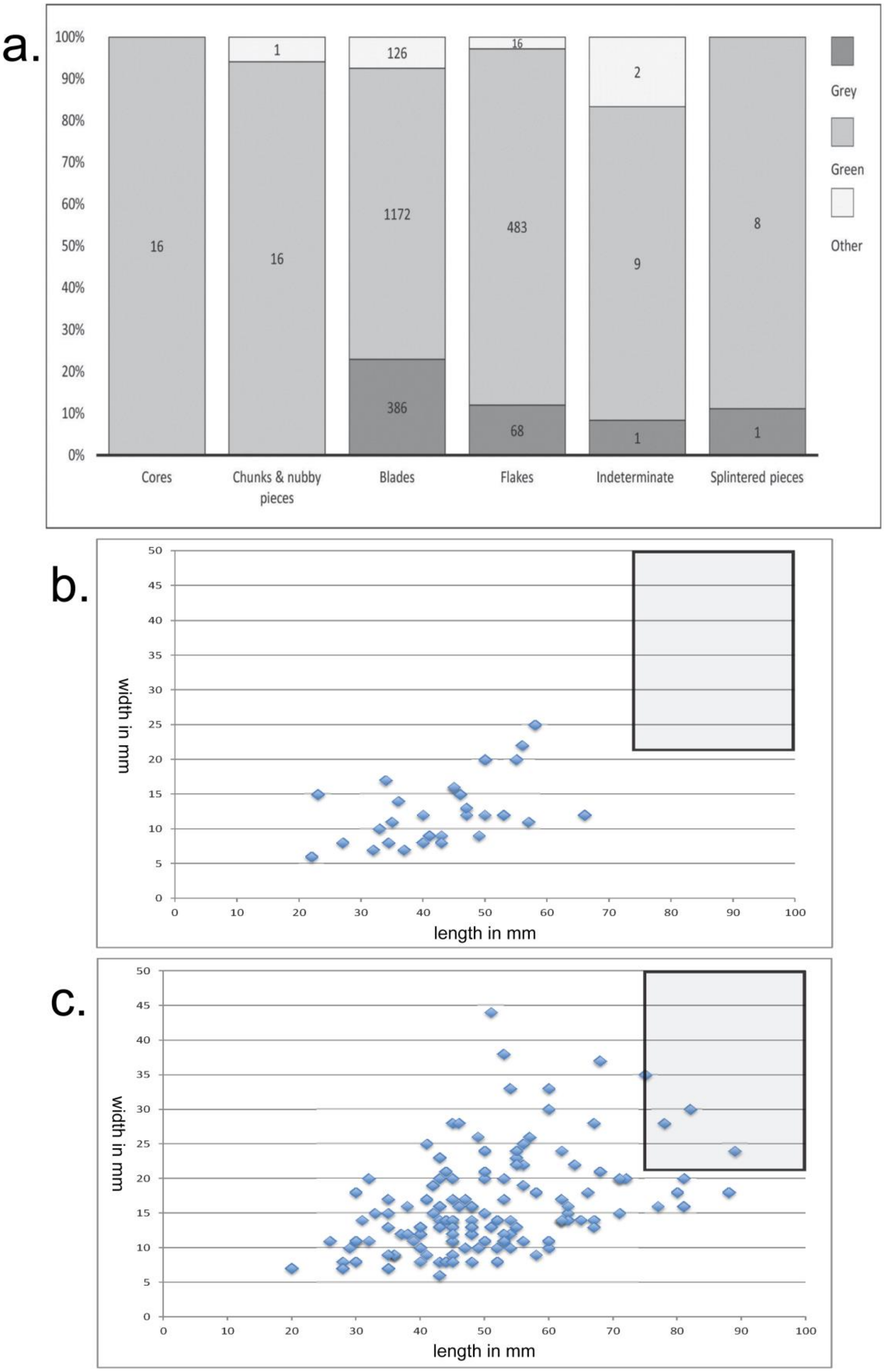


Figure 12. Charts summarizing the obsidian debitage from Arpachiyah currently in the Institute of Archaeology in London: a. by type and colour. b. & c. scattergram showing the length and width of complete grey and green blades; inset rectangles show estimated size of blank required to make rectangular links (b. obsidian, c. green obsidian) (source Stuart Campbell and Elizabeth Healey).

Table 1. The occurrence of ground and polished obsidian at selected sites within the Halaf area of influence broadly contemporary with Late Halaf levels at Domuztepe and Arpachiyah (note there is considerable variation in the amount of information available). For further details see Healey 2007, Table 2.

		Origin of obsidian				**Ground and polished objects**		
Geographic region	**Site**	**Central Anatolian obsidian**	**Eastern Anatolian obsidian**	**Percent obsidian**	**On site obsidian working**	**Highly finished objects**	**Less well finished objects**	**Ten or more objects**
Levant	Domuztepe	*	*	9-20%	y	*	*	y
	Kurdu	*	*		y		*	
	Ras Shamra Vc-IVa	*		10-15%		*		
	Kabri		*	not recorded	very large core	*		
	Hagoshrim	*	*	ratio of 1:47	y; also large core	*	*	y
Syrian Euphrates	Kazane Hoyuk	?	?	3%		*		
	Sabi Abyad Halaf		*	22%		*		
	Aqab		?	80%	y	*		y
	Chagar Bazar		*		y	*		
	Umm Qseir		*	36%	n	*		
	Tell Halaf		*	* (great quantity)	y; also very large core		*	
N. Mesopotamia	Tell Arpachiyah		*	50% plus	y	*		y
	Tepe Gawra		?			*		
	Yarim Tepe II		*	20-25%		*		
	Yarim Tepe III		*	numerous		*		
	Banahilk		*	29%	y	*		
	Nineveh		?	much	?	*		

Ground and polished items are also found outside of the region which is normally understood as the traditional sphere of Halaf influence in southern Mesopotamia and the Gulf at about this time.

Distinctive rectangular links like those from Arpachiyah have been reported from only two other sites, both in northern Mesopotamia, namely Tepe Gawra XVI where a link 60 mm long and 20 mm wide was recorded (Tobler 1950; Pl. CLXXV, no. 71) and a fragmentary one from Banahilk (15 mm wide and 35 mm plus in length (Watson 1983: 573, Fig. 210.4)). Another possible example measuring 15 mm in width was found in late Halaf levels at Kazane in SE Anatolia described as a "very thin elongated oblong made of ground and polished obsidian with bevelled edges and two holes at one end" (Bernbeck et al. 1999: 124, Fig. 17c). It appears to have broken across one of the holes and been re-pierced beneath the hole unlike the Arpachiyah ones which are re-pierced beside the broken hole. There are also several related examples in the British Museum from Chagar Bazar but inspection suggests that they are not quite the same as those from Arpachiyah in that one edge is thicker than the other; they are made of calcalkaline obsidian of Bingöl B type (Campbell et al. in preparation). It appears that we are dealing with several different types of objects, the most similar being found at settlements which lie within as short distance (c. 40-50 km) of each other, suggesting localised traditions.

Oval and lozenge-shaped links of the type in the Arpachiyah necklace have been recorded from at least seven sites, notably Tell Aqab (where they are found in considerable numbers and described as being “exactly like those from the necklace at Arpachiyah” although they are not illustrated and no dimensions are given (Davidson & Watkins 1981: 10)), Tepe Gawra where they are a little smaller and one is perforated at four points (Tobler 1950: Pl. XCII, c3), Yarim Tepe III (53 x 34 mm and a smaller oval one 40 x 22 mm (Merpert & Munchaev 1993a: 178, Fig. 9.23)), Banahilk (although seemingly a little smaller it is possibly of green obsidian (Watson 1963: 576-77 & Fig. 264)), Ras Shamra (50 x 35 mm (de Contenson 1992: 108, Pl. XCVIII, 5)), Choga Mami (Mortensen 1973: 37-55) and possibly Chagar Bazar though again this is a little small and not certainly pierced at both ends (Mallowan 1936: 24, Fig 7, 30).

Other elaborate types include incised pendants which have been recovered from Domuztepe, Chagar Bazar and possibly Umm Qseir (Cruells 2006: 44, Pl. 4.1b) and Tepe Gawra XVI (Tobler 1950: Pl. CLXXII, 22 & 29).

Beads of obsidian occur at most sites, sometimes highly finished like the barrel-shaped beads from Ras Shamra IVA (de Contenson 1992: 115, Pl. CIII, 4), Tepe Gawra (Tobler 1950: Pl. XC, a) and Yarim Tepe II (Merpert & Munchaev 1993b: 216, Fig. 10.7.1 & 2). Small irregular disc beads also occur at Tepe Gawra (Tobler 1950: Pl. XCb) and Yarim Tepe II (Merpert & Munchaev 1993b: Fig. 10.7.2). Unground beads have been found at the contemporary site of Hagoshrim in the southern Levant (Schechter et al. 2013: 522, Fig. 11a) suggesting *ad hoc* production. No workshops dedicated to bead manufacture are known at this time, although they do occur earlier for production in other materials, for example in Azraq-Jilat basin (Wright & Garrard 2003) and Kumartepe (Grace & Calley 1988)).

Other items of personal adornment such as small links and pendants also show different degrees of finish. For example an oval link found in an Amuq C context at Tell Kurdu shows only rudimentary shaping and no grinding (Healey 2004: 13.9), as do those from Tell Halaf (von Oppenheim & Schmidt 1943: 114, Pl. XXXVII, 3 & 4, Pl. CXIII, 3 & 4) where there are also two possible preforms, described as scrapers (von Oppenheim & Schmidt 1943: 108 & Pl. XXXIV, 19 & 20). Others have some grinding as at Hagoshrim which Schechter et al. (2013: 522, Fig. 11 b) consider to be products of a different *chaîne opératoire* from the beads but they are not as highly finished as some from Domuztepe. Triangular links seem to be a north-eastern Mesopotamian type, recorded from Banahilk (Watson 1983: Fig. 2, 10.5), Tepe Gawra (Tobler 1950: Pl. CLXXV & Fig. 69) and Yarim Tepe III (Merpert & Munchaev 1993a: 240, Fig. 11.10.12).

Although neither vessels nor mirrors have been discussed in this paper, it is worth noting that that they are part of the repertoire of ground and polished items of obsidian in 6th millennium cal. BC northern Mesopotamia and that the non-utilitarian use of obsidian is not confined to personal adornment. Again we can note two different types of finish. Most vessels are thinned walled and highly polished (as those from Domuztepe Figure 3, no. 6, and Banahilk (Watson 1983: 574)); thicker but highly polished and incised are also known from Hagoshrim in the southern Levant (Schechter et al. 2013: Fig. 11d & e). Unpolished examples, shaped by pecking and sometimes grinding, are present at both Domuztepe (Figure 3, no. 5) and Arpachiyah. Similarly ‘mirrors’ are of different types and finish from elaborate to simple forms

5. Conclusions

The array of different types and degrees of finish of ground and polished artefacts from basic to highly finished suggests that they belonged to different contexts and perhaps involved different concepts of manufacture (although the operational sequences may have been similar). Special targeted blanks may have been produced for the highly polished links like those from Arpachiyah, whereas elsewhere there may have been more opportunistic use of general debitage.

At Domuztepe we see some localized and small-scale production of certain objects which in the initial stages at least seem to part of the continuum or even a spin-off from tool production. It may well be that the less elaborate pieces from other sites were also locally made, perhaps in similar circumstances. In all cases there is evidence of obsidian working on site so the opportunity for parallel but linked production existed. The more elaborate and standardized objects such as the vessels, mirrors with strap-handles as well as links like those from Arpachiyah seem to be products which require a different mindset and higher levels of expertise to produce them (compare different levels of bead making expertise in Khambhat (Bril et al. 2005: 67ff; Roux & David 2005)). The accumulation of such objects in the Burnt House at Arpachiyah, even if they were not made there, may be indicative of some sort of common product and a centralized system of acquisition and dispersal and perhaps expertise at least in north-eastern Mesopotamia. The challenge now is to understand the organisation and social context of such a system, as well as the mechanisms through which techniques were developed, learnt and practiced, whether in one or in several locations.

Footnote

[1.] Whether this is because flint was a local, everyday material and therefore not considered appropriate for jewellery or whether it simply too difficult to work in this way is beyond the scope of this paper. Conversely we may note that at Çatalhöyük where obsidian is the predominant raw material used to make tools, it is not listed amongst the raw materials used to make items of personal adornment although chert is (Bains et al. 2013: Tables 19.1-3; although see Mellart 1964: 95 & Pl. XXVc). It is of course also use to make mirrors at Çatalhöyük (see, for example, Vedder 2005).

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Armorican arrowhead biographies: Production and function of an Early Bronze Age prestige good from Brittany (France)

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Abstract:

Brittany can pride itself on the Armorican arrowheads found in Early Bronze Age graves (2150-1700 BC). In the present state of knowledge, these are the only specialized craft products in knapped flint produced in this region at the western edge of continental Europe. Admired since the 19th century, these flint arrowheads have never really been studied. Due to the wealth of graves and grave-goods, a relatively precise study can be undertaken of the development of these craft products, despite the low number of reliable radiocarbon dates.

These arrowheads are characterized by a well-defined type (pointed tang and oblique barbs) most often combined with ogival form. Raw materials show the selection of a high quality yellow translucent flint, of which the origin has to be sought at more than 400 kilometers (Lower Turonian flint from Cher Valley). From a technical point of view, Armorican arrowheads reveal a great mastery of retouch by pressure-flaking. This skill is written in stone by the perfection of forms, the extreme thinness (until 2,5 mm thick) and very long barbs (until 25 mm long). Such work could not have been done without the use of copper, even bronze, awls. Moreover, some marks may testify to the implication of these tools. On 549 arrowheads that have reached to us, none of them presents diagnostical impact features. However, use-wear analysis indicates that most of them were hafted (adhesive traces, bright spots, blunt edges). These facts suggest that they are less functional arrowheads than objects for the show. In the graves, Armorican arrowheads are frequently set down carefully in wooden boxes taking the shaft off.

The Armorican arrowheads with their exotic raw materials, their high-degree of technicality, and their absence of use, have all features of a prestige good. They have been discovered by dozens in few graves under barrows with very rich funeral items (bronze daggers decorated with golden pins, precious bracers, silver beakers, etc.). According to these obvious facts, they symbolize the power of the elites. The genesis of Armorican arrowheads are in all likelihood explained by a climate of increasing social competition, which express itself in Brittany by an individualization of burial rites, a development of metalworking and a reorganization of territories.

In this article, we will stress on raw materials selection, technology and know-how, as well as use-wear analyses. All these approaches will help us to trace the biographies of the Armorican arrowheads.

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Keywords: Armorican arrowhead; flint; Britanny; France; Early Bronze Age; technology; use-wear analysis

1. Introduction

Brittany can pride itself on productions of outstanding projectile points, the Armorican arrowheads, recovered from Early Bronze Age tombs (2150-1600 BC). More than one thousand tumuli are known from this period in Brittany but only 32 yielded Armorican arrowheads (Figure 1). From the neighbouring regions, three further graves have contained Armorican arrowheads but they are located quite far from the core area in western Brittany: around ten arrowheads in Fosse-Yvon barrow (Beaumont-Hague, Manche, Normandy), six in Loucé barrow (Orne, Normandy) and one in the passage tomb of Tumulus de la Motte (Pornic, Loire-Atlantique, Pays-de-la-Loire). The arrowheads from these three graves are not examined in this article (some could have been imported from Brittany, others could be local imitations).

In most cases, the Breton graves with Armorican arrowheads were covered by cairns or huge tumuli that may measure 6 m in height and 60 m in diameter. The grave architecture greatly varies: megalithic slabs used for the covering or the walls, straight or vaulted dry-stone walls, wooden features, coffins or floors occurring in multiple combinations. Generally, the acid soil conditions dissolved all the skeletal remains except for a few cases which confirm that the graves of the Early Bronze Age were individual burials although rare double or triple burials are known.

In all, 762 arrowheads were discovered in these tombs from Brittany; frequently tens and up to 60 specimens were present in the same grave. Nonetheless, only 549 pieces have been preserved, the others have been lost, stolen or modified for other purposes (assembled on a jewel or used as a lighter stone during the 19th century; Lukis, 1886; Bertrand, 1891).

In the burials, very abundant grave goods, seemingly placed in wooden boxes, accompanied the Armorican arrowheads (Prigent, 1880, 1881; Martin & Berthelot du Chesnay; Martin & Prigent, 1907; Briard, 1970). The most striking example is certainly the deposit of numerous daggers made of copper alloy (up to ten in a single grave). Fair preservation conditions permitted the survival of organic remains such as the scabbards of the daggers thanks to the presence of metal oxides. Personal ornaments of distant origin were also discovered in these burials: pendants and wrist guards made from Baltic amber (Gardin, 1996), wrist guard made from Whitby jet (Yorkshire, Northern England; Needham, 2009), gold or silver spiral chains, probably of Iberian origin, and pendants made from jadeite originating from the Monte Viso area (Italy; Nicolas *et al.*, 2013). In summary, tombs including Early Bronze Age arrowheads are rare, monumental and richly equipped. For these reasons, they were identified as being burials of Early Bronze Age chiefs in Brittany (Briard, 1984).

The Armorican arrowheads are present in exceptionally high numbers in the burials of these elites. This raises a question about the status of these projectile points: were they ordinary arrowheads or specific productions? What makes them particular? Their shape, their material or the way they were manufactured? Were these arrowheads strictly funerary offerings or were they everyday implements? Were they used, and, if this is the case, for what purposes? In sum, were these prestige items? In order to answer all these questions, we developed multiple approaches based on typology, the study of raw materials, technology and use wear analyses, with the aim of tracing their biographies, from their manufacture to their use and finally their deposit in the graves. In addition, the important number of burials and accompanying grave goods makes it possible to develop a rather detailed picture of the evolution of this craft despite the small number of reliable radiocarbon dates.

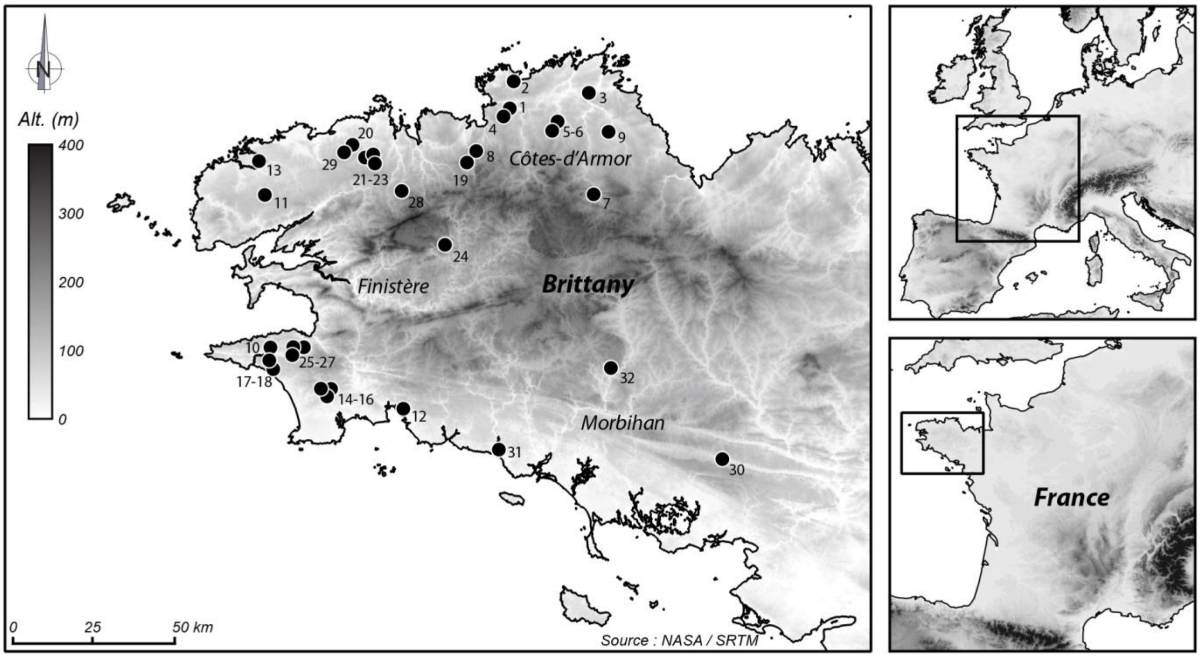

Figure 1. Distribution map of the Early Bronze Age graves including Armorican arrowheads in Brittany (mapping C. Nicolas). Côtes-d'Armor: 1. La Motta, Lannion; 2. Crec'h-Perros, Perros-Guirec; 3. Mouden-Bras, Pleudaniel; 4. Rumédon, Ploumiliau; 5. Tossen-Kergourognon, Prat; 6. Tossen-Rugouec, Prat; 7. Brun-Bras, Saint-Adrien; 8. Porz-ar-Saoz, Trémel; 9. Tossen-Maharit, Trévérec; Finistère: 10. Kerodou, Beuzec-Cap-Sizun; 11. Coatanéa, Bourg-Blanc; 12. Le Rhun, Concarneau; 13. Prat-ar-Simon-Pella, Lannilis; 14. Cosmaner, Plonéour-Lanvern; 15. Fao-Youen, Plonéour-Lanvern; 16. Kerhué-Bras, Plonéour-Lanvern; 17. Kersandy, Plouhinec; 18. Lescongar, Plouhinec; 19. Cazin, Plouigneau; 20. Goarillac'h, Plounévez-Lochrist; 21. Kernonen, Plouvorn; 22. Keruzoret, Plouvorn; 23. Lambader (?), Plouvorn; 24. Kerguévarec, Plouyé; 25. Kerlivit 2, Pouldergat; 26. Kervini Nord, Poullan-sur-Mer; 27. Kervini Sud, Poullan-sur-Mer; 28. Limbabu, Saint-Thégonnec; 29. Graeoc 2, Saint-Vougay; Morbihan: 30. Coët-er-Garf, Elven; 31. Cruguel, Guidel; 32. Saint-Fiacre, Melrand.

2. Typology of the Armorican arrowheads

The Armorican arrowheads are characterised by oblique barbs associated with a pointed tang, except for some cases in which the tang is rounded or substituted by a concave base (Briard & Giot, 1956; Nicolas, 2013). Only a few arrowheads were found out of grave context: at present, six specimens have been recorded. They are rather small and match the smallest ones discovered in the burials (Figure 2).

We distinguished nine different types based on the shape of the tang or of the concave base, to the overall shape of the arrowhead (concave triangular, triangular, sub-triangular, ogive-shaped, pointed horseshoe arch shape), the length/width ratio and the length of the barbs (Nicolas, 2011, 2013; Figure 3 & Table 1).

The short and medium shapes (Rumédon, Cazin, Kerguévarec, and Kernonen types) are by far the most numerous (Figure 4, a). The elongated ogive-shaped arrowheads (Kervini, Limbabu, Graeoc types) show a clearly differentiated distribution in that the arrowheads with long barbs (Limbabu and Graeoc types) are clustered in the north-western part of Finistère (Figure 4, b). This picture suggests the existence of several production places in Brittany. Finally, the triangular arrowheads (Cruguel and Keruzoret types) occur in small numbers (18) and do not show a particular distribution pattern (Figure 4, c).

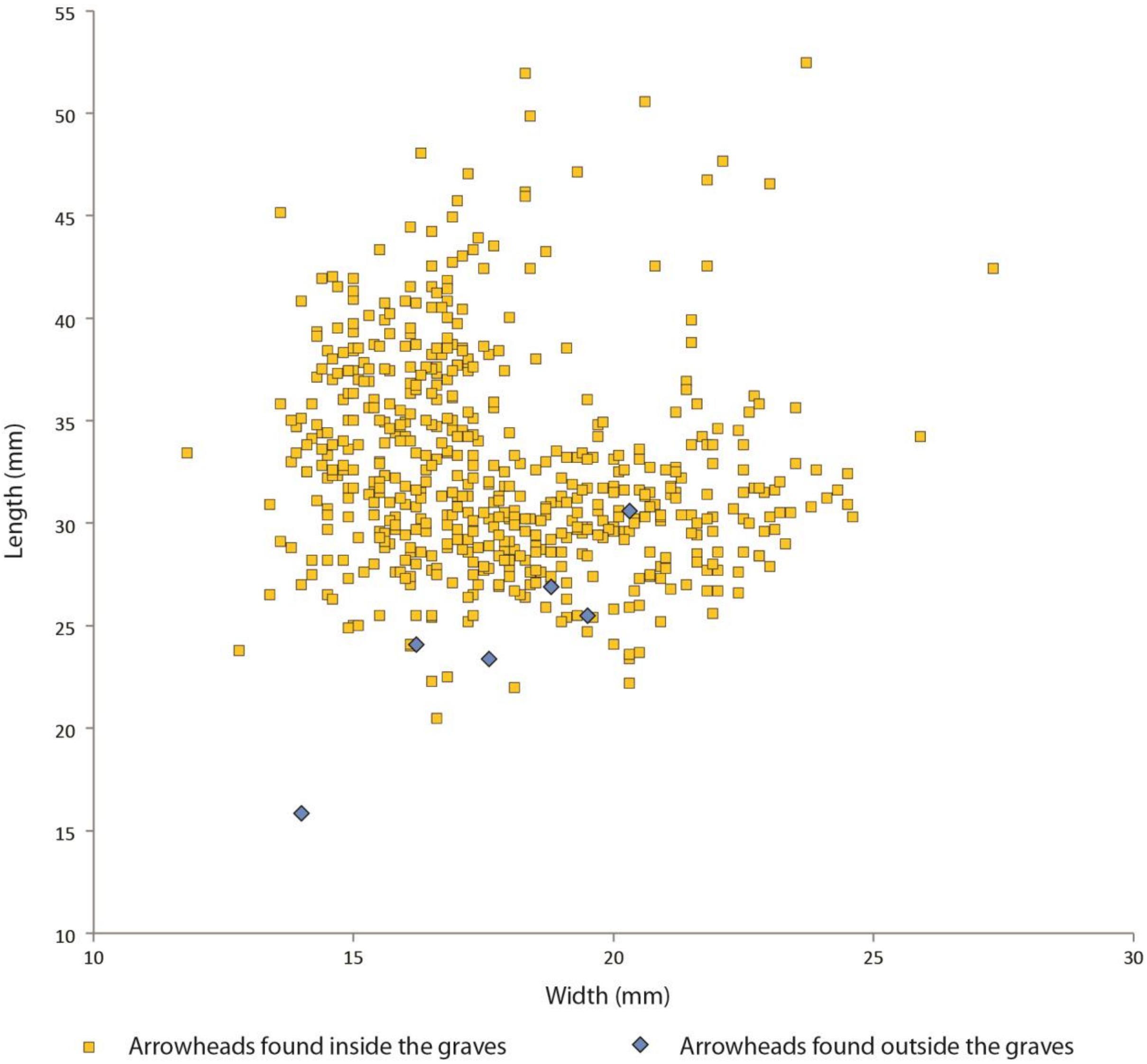

Figure 2. Comparison between arrowheads found inside and outside the graves.

3. Typo-chronology

The Armorican arrowheads derived quite clearly from the main type of Bell Beaker arrowheads (ca. 2500-2000 BC) with squared tang and squared barbs, that are found in most part of the Western Europe (Nicolas, 2013; Bailly, 2014). We know some intermediary arrowheads with pointed tang and squared barbs or with squared tang and slanted barbs, found both in late Bell Beaker burials and graves of the beginnings of the Early Bronze Age, illustrating a short sequence of elaboration of the Armorican type from the Bell Beaker arrowheads (Nicolas, 2011a, 2013).

The abundant material recovered from the burials including arrowheads enabled Stuart Needham (2000) to propose an initial seriation of these graves. Based on our arrowhead typology and taking into account distinct regional variability, it was possible to further refine this typo-chronology (Nicolas, 2013). It was possible to recognise three stages illustrating the continuous evolution of the Armorican arrowheads (Figure 5). During stage 1, the short and almost triangular pieces (Cazin type) tend to develop towards short (Kerguévarec and Rumédon types) or medium ogive-shaped arrowheads (Kernonen type). During stage 2, the ogive-shaped arrowheads are elongated and distinct types show long barbs (Limbabu and Graeoc types). During stage 3, the arrowheads are triangular in shape with a tang (Cruguel type) or alternatively a concave base (Keruzoret type). Two specimens made from copper alloy may be interpreted as being imitations of flint arrowheads (Figure 5).

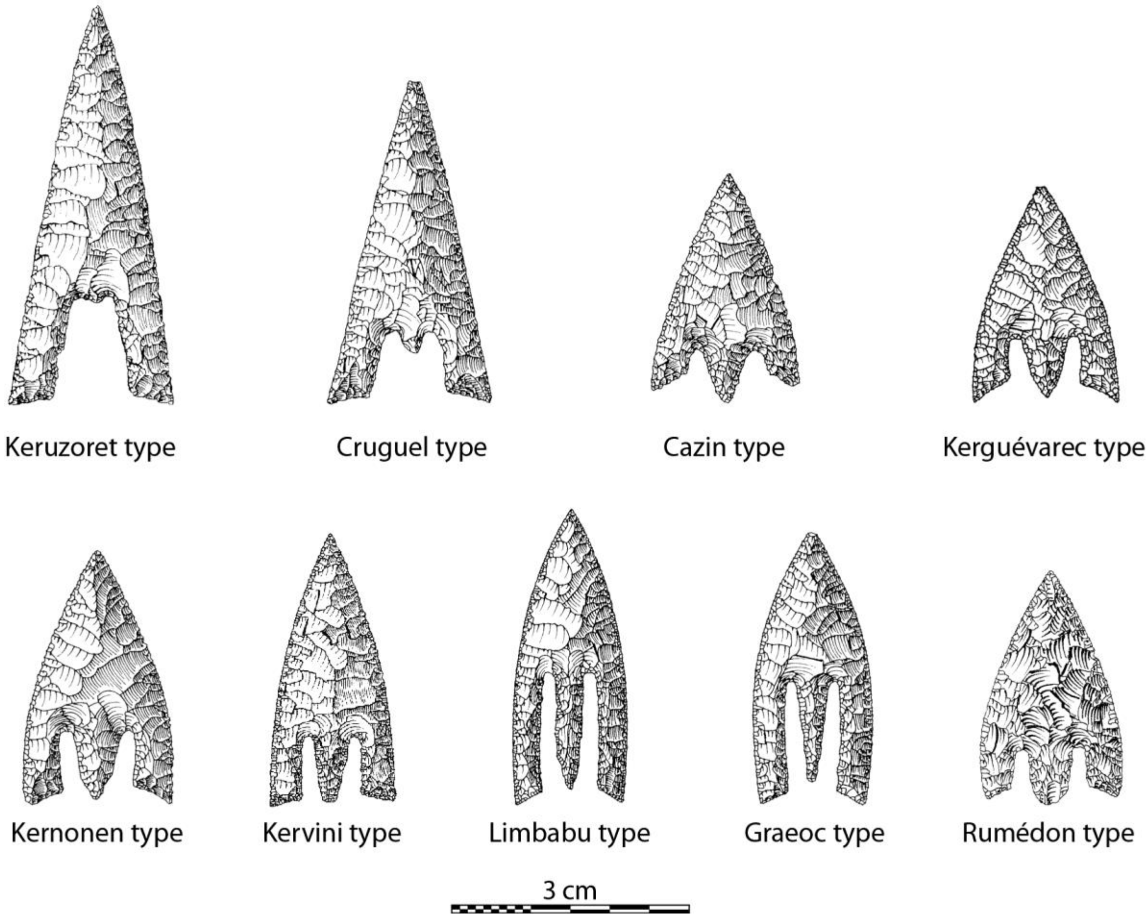

Figure 3. Types of Armorican arrowheads (drawings C. Nicolas).

Table 1. Typology and inventory of the arrowheads found in the Early Bronze Age grave from Brittany.

Type	Tang	Form	Ratio length/width	Length of the barbs	Total number
Keruzoret	None	triangular	2 - 3	-	8
Cruguel	Pointed	concave triangular to triangular	1,5 – 3	-	9
Cazin	Pointed	sub-triangular	1 - 2	< 12 mm	20
Kerguévarec	Pointed	ogive-shaped	1 - 1,49	< 12 mm	93
Kernonen	Pointed	ogive-shaped	1,5 – 1,99	< 12 mm	192
Kervini	Pointed	ogive-shaped	2 – 3	< 12 mm	82
Limbabu	Pointed	ogive-shaped	2 – 3,5	≥ 12 mm	82
Graeoc	Pointed	pointed horseshoe arch shape	2 – 3	≥ 12 mm	3
Rumédon	Rounded	Subtriangular to ogive-shaped	1 - 2	< 12 mm	10
				Other type	8
				Undefined	111
				Unknown	144
				Total number	762

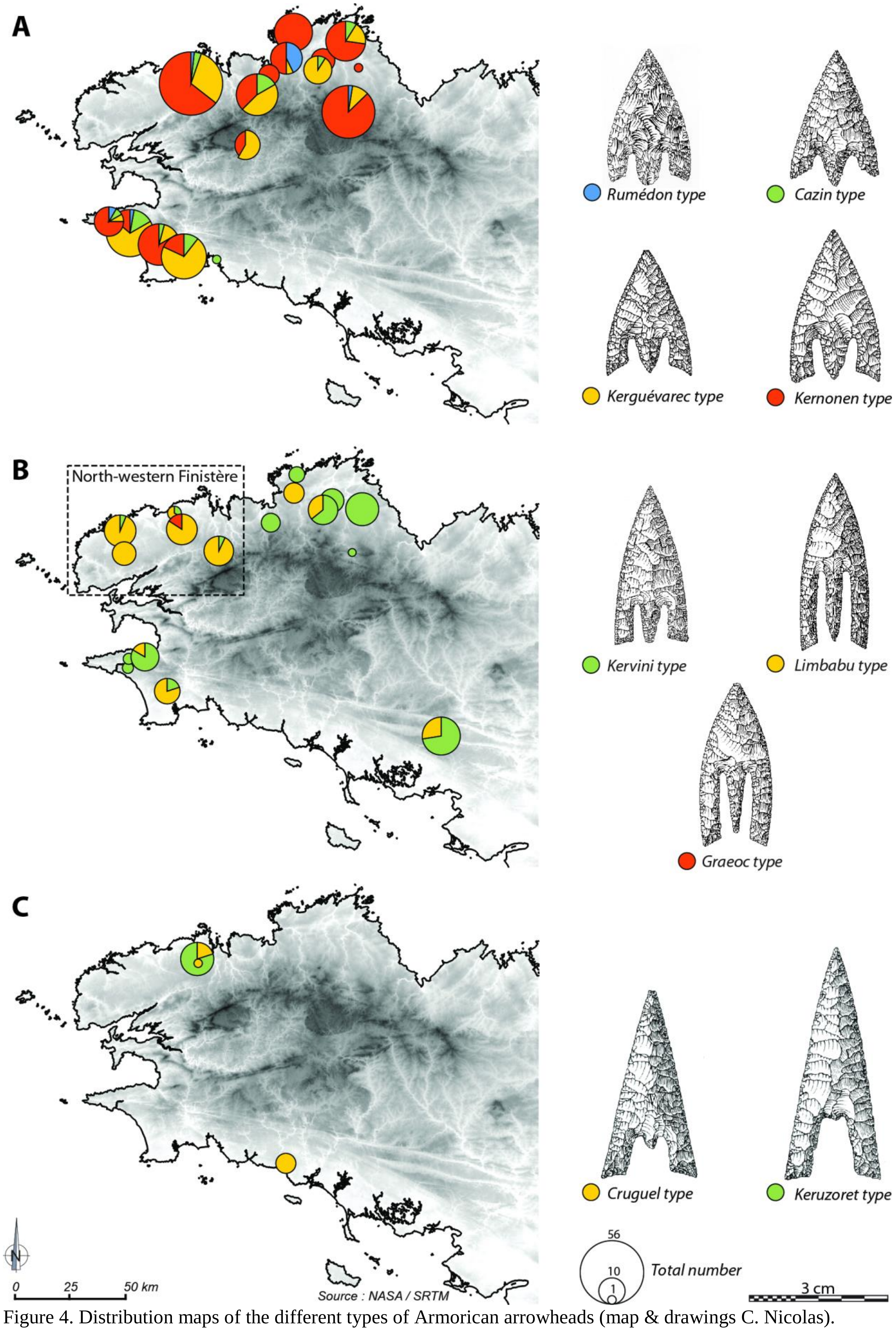

Figure 4. Distribution maps of the different types of Armorican arrowheads (map & drawings C. Nicolas).

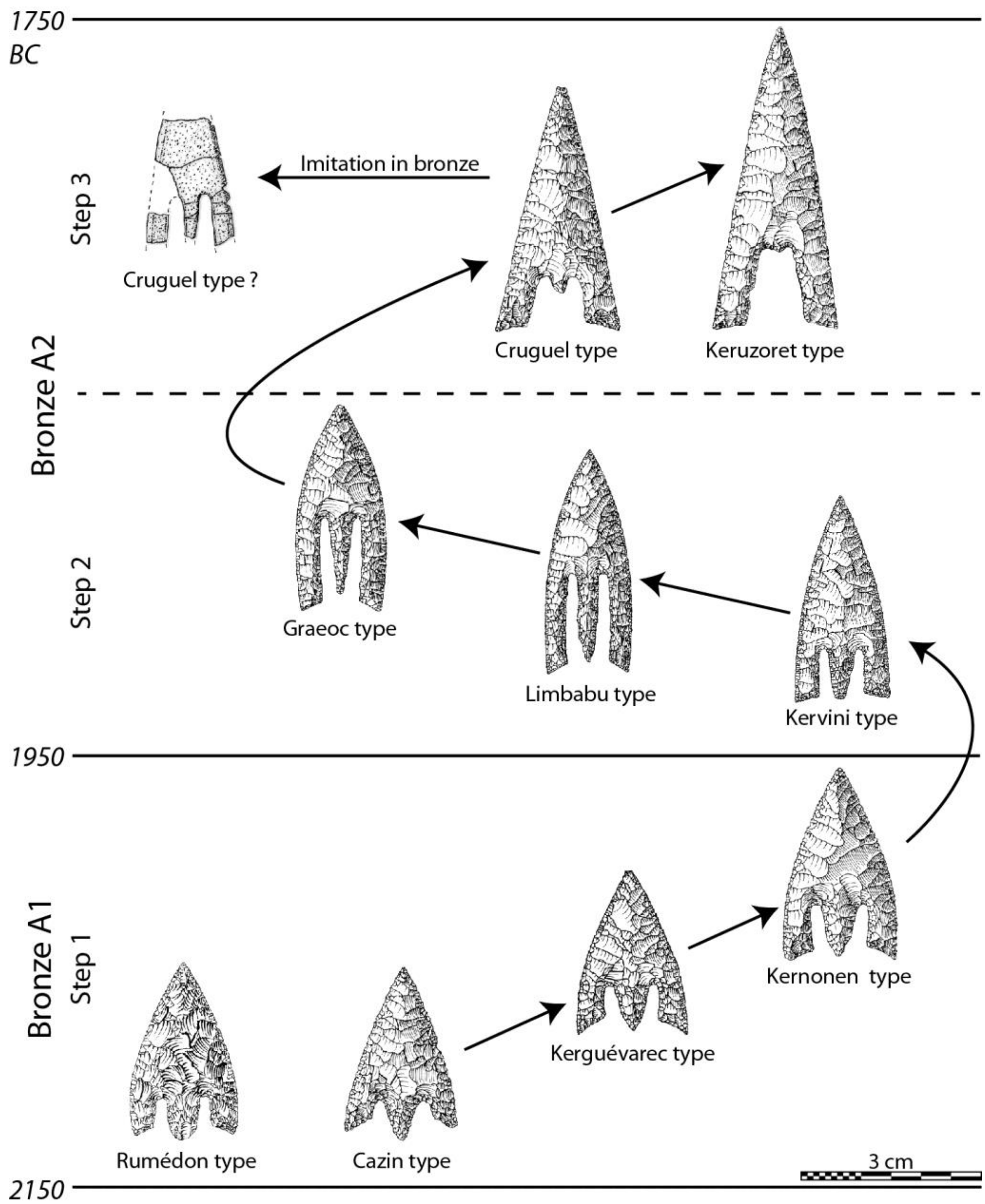

Figure 5. Evolution of the Armorican arrowheads (drawings C. Nicolas).

Three reliable and precise radiocarbon dates are available which do not challenge the general pattern of this seriation. Stage 1 is dated by the burial of Brun-Bras (Saint-Adrien, Côtes-d'Armor; Briard, 1978) to 3650 ± 35 BP (GRN-7176), i.e. between 2137 and 1929 cal. BC (95.4 %). Stages 2 and 3 cannot be subdivided and seem to be contemporaneous. These dates range between 2016 and 1771 cal BC (95.4 %) and they stem from the barrow of Crec'h-Perros (Perros-Guirec, Côtes-d'Armor; 3542 ± 22 BP, UBA-11989; personal communication with Henri Gandois), attributed to stage 2, and from the grave of Saint-Fiacre (Melrand, Morbihan; 3555 ± 35 BP, SUERC-30676; communication with Alison Sheridan), attributed to stage 3. Stages 1 and 2/3 overlap by almost one century because of the inaccuracy of radiocarbon dating. To put it simply, stage 1 can be dated between 2150 and 1950 BC and stages 2 and 3 between 1950 and 1750 BC. This subdivision fits the chronology established for Southern Germany and Switzerland distinguishing Bronze A1 and A2 (Voruz, 1996; Hafner and Suter, 2003), as well as the chronology established for the British Isles (Needham *et al.*, 2010).

4. The raw materials

The Armorican arrowheads show the use of a large variety of raw materials. It was possible to record 25 different facies ranging from translucent or semi-translucent colours (colourless, grey, honey-coloured, orange, red, brown) to more opaque colours (grey or honey-coloured).

During stage 1, almost all of these facies were employed but the use of translucent honey-coloured or dark honey-coloured flints and honey-coloured, red or grey semi-translucent flints was predominant. The best example of this diversity is the barrow of Kernonen (Plouvorn, Finistère; Briard, 1970) which yielded 60 arrowheads deposited at three spots within the burial. 30 arrowheads were made from opaque and translucent flint covering a wide range of colours from honey-coloured to orange, red, and pinkish and to grey and black (Figure 6). These arrowheads seem to have been placed in a wooden box.

Figure 6. Arrowheads stemming from one of the wooden boxes found in the Kernonen barrow at Plouvorn, Finistère (photo C. Nicolas).

During stage 2, this diversity of raw materials was severely restricted. The arrowhead series were much more homogeneous and were mainly manufactured from honey-coloured translucent flint (64.4 %). This proportion strongly increases when considering the only projectile points with long barbs of the Limbabu and Graeoc types stemming from the north-western part of the Finistère: 82.3 % of them were made of honey-coloured translucent flint, whereas 10.6 % were manufactured from dark honey-coloured translucent flint, honey-coloured semi-translucent flint, grey- honey-coloured translucent flint or orange translucent flint. Simultaneously, in the remainder of Brittany, several assemblages are entirely or partially comprised of arrowheads made of grey flint, most often opaque but sometimes also translucent flints (Figure 7).

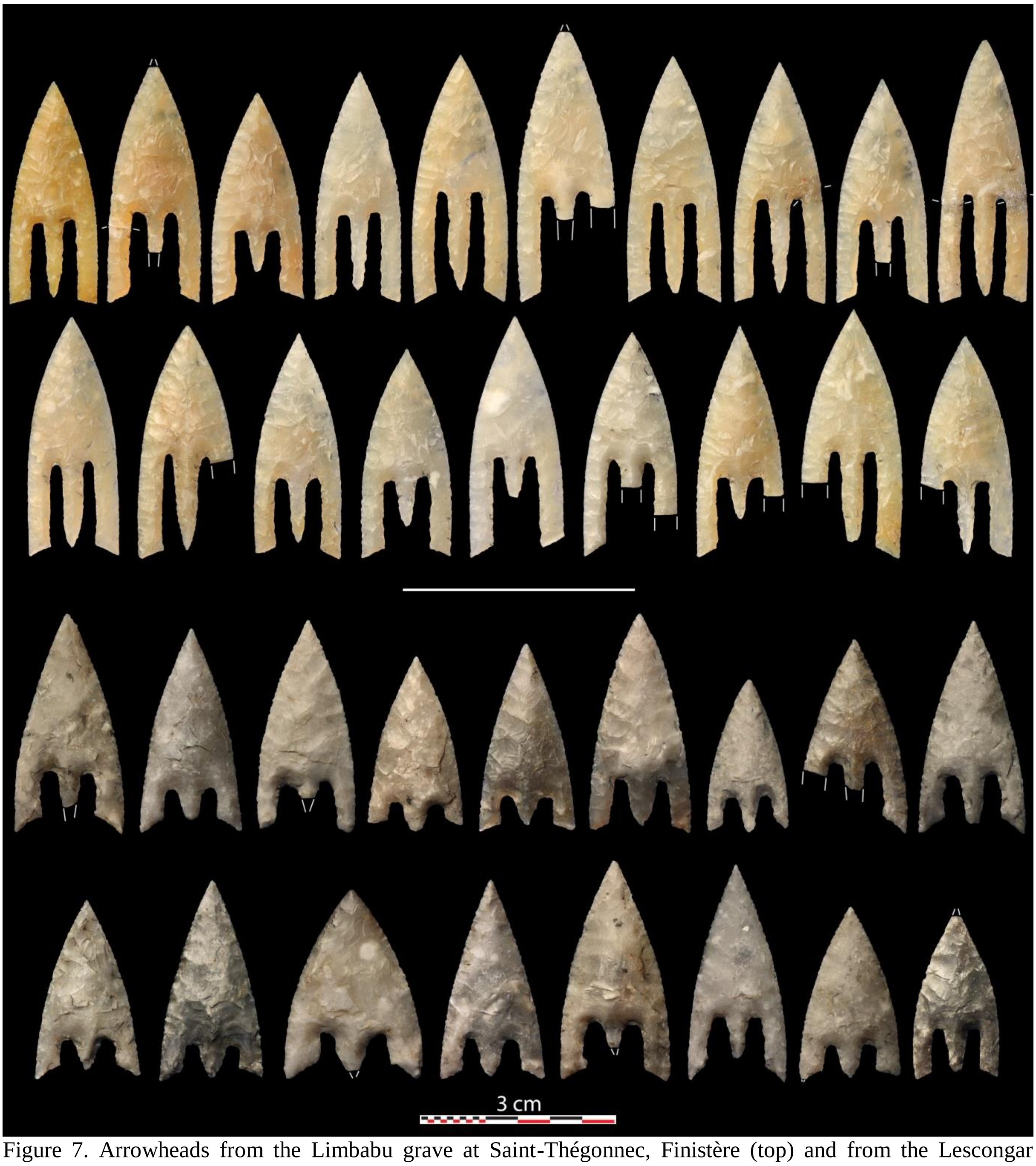

Figure 7. Arrowheads from the Limbabu grave at Saint-Thégonnec, Finistère (top) and from the Lescongar barrow at Plouhinec, Finistère (bottom) (photo C. Nicolas).

During stage 3, the honey-coloured translucent flint remains predominant but it is invariably accompanied by a range of other types which are apparently only variations.

The large number of arrowheads made of honey-coloured translucent flint allows us to depict a wide-ranging picture of its characteristics. We are dealing here with fine-grained flint including various intraclasts. Calcareous inclusions are amongst the most numerous and they are smaller than 1 mm, about 1 mm or even as large as 10 mm. They occur in varying scatters and are sometimes completely absent from the matrix. Pinkish, red or violet zonation and more rarely colourless, black or orange ones can be recognised.

At first sight, it seems impossible that this fine-grained translucent honey-coloured flint stems from the Armorican massif that hosts not a single primary flint source (Marchand, 2012; Figure 7, top). Flint pebbles originating from the coastal belt exhibit similar colours but their texture is often coarser. Moreover, no cortex or subcortical zones were ever observed on the arrowheads which may support the hypothesis of local origin of the honey-coloured flint. We therefore have to turn towards flint sources located outside the Armorican massif. The eastern margins of this massif are at about 200 km from the main distributions of Armorican arrowheads: several types of honey-coloured translucent flint are found in the Paris Basin but its western part is imperfectly documented. The best element of comparison is the honey-coloured flint of Meusnes procured from the Lower Turonian levels in the Cher valley. This latter type occurs in various colours: honey-coloured, light brown, grey, greenish, black. An opaque zoned variety exhibiting bright colours, ranging from yellow to red, is also attested (Aubry, 1991, p. 106). It also contains the same types of intraclasts as the honey-coloured flint of the Armorican arrowheads (bryozoans, quartz microgeodes, manganese dendrites). The red-coloured variety is probably a patina due to a ferruginous impregnation in a context of terraces or detrital spreadings where a large amount of iron is flowing in the waters and the soils (Masson, 1981). Equally, the large number of raw material facies can probably be explained by the wide colour range of the Meusnes flint (Nicolas, 2012).

The honey flint from Meusnes and its possible variants are clearly the most common in the assemblages of Armorican arrowheads. Nonetheless, distinct translucent, semi-translucent or opaque flint types encountered do not match the description of the Meusnes flint. Most often this is high quality flint of probable Cretaceous origin the provenience of which could not be identified. The grey opaque flint types as well as distinct semi-translucent flint types of poor quality may have been recovered from gravel barrier on the coast (Figure 7, bottom). However, the absence of cortical zones makes it impossible to confirm this assumption. It was possible to identify several flint types that occur in anecdotic quantities: one arrowhead was knapped on rock crystal, three on Upper Turonian flint originating from the Grand Pressigny region and six specimens were probably manufactured from Bajocian or Bathonian flint stemming from the Anglin valley in the Vienne region (Fouéré, 1994; Primault, 2003).

Raw material was possibly procured in close proximity to the local sources: two arrowheads of honey-coloured flint present a small zone of beige-coloured fine and grained cortex, rather indicating procurement near the primary sources. However, the raw material could also have been procured further downstream. Lower Turonian flint blocks occur in the alluvium of the Cher River, and they were then transported by the Loire River up to the estuary at Saint-Nazaire (Loire-Atlantique). From there, the sea currents deposited small nodules along the Atlantic coasts. Pebbles with a maximum size of 10-15 cm can be observed in the gravel barriers of the Morbihan and the Pays-de-la-Loire. In the Loire estuary, the blocks still measure up to 40 or 50 cm (personal communication with Philippe Forré). These different possibilities of flint procurement do not necessarily exclude each other. The hypothesis of procurement in the Loire estuary seems attractive. This is the most important source containing high-quality material which is located the closest to Brittany. In addition, the Loire River drained the whole amount of flint pebbles encountered on its course and one of its tributaries, which may explain the variety of flint types used for the manufacturing of the Armorican arrowheads.

5. Technology

Reconstructing the operational sequence of the Armorican arrowheads is a difficult task because only finished, highly retouched products are known. For 25 arrowheads only it was possible to recognise the nature of their blanks: these are flakes originating from full debitage (18), cortical flakes (3), Kombewa flakes (3) and patinated flakes (1). The use of these supports varies just as much: the arrowheads are generally shaped in the direction of debitage (29) but also in the opposite direction (10) or used laterally (14). The production and the use of the blanks were apparently not determined by a strict operational scheme. The adaptation of the volume of the blank to the planned arrowhead seems to be important. No traces of heat treatment have been recorded, despite its frequent use in Prehistory for pressure-flaking. Some arrowheads are indeed red-coloured but this is most probably due to a coloured patina. Especially, no differences of brightness between blank and retouch have been recorded, which should be expected in case of heat treatment (Masson, 1981; Inizan & Tixier, 2000).

The shaping of the Armorican arrowheads apparently starts with a preform made by soft organic percussion as is suggested by the small and scaled removals observed on several pieces. The shaping is then continued by pressure flaking, as is attested to by clearly concave first negatives of removal, fine and regular removals and sharp micro-overhangs left on either side of the pressure point (Pelegrin, 2004). The use of an awl made from copper alloy is demonstrated through the presence of small pressure points (< 1 mm) and of slight greyish green traces left by unsuccessful retouch (Nicolas, 2013; Figure 8). The retouch types are generally covering (91 %) and more rarely invasive (7.9 %) or short (1.1 %). The most frequent combinations are parallel (51.6 %), transverse (32.8 %), multidirectional (14.7 %) or more rarely rippled (0.9 %). These different retouch combinations are generally present on the same assemblages of arrowheads (Figure 9). Most of the pieces manufactured in this way are perfectly biconvex. The edges were systematically regularised by particularly fine microretouch (< 2 mm long).

The most critical moment in the manufacture of an Armorican arrowhead is the knapping of the tang and the barbs. Each removal requires controlled pressure that is sufficient to remove the flake and to avoid overshot. The more the knapping progresses, the greater the risk of breaking the tang or the barbs: all efforts may be ruined by an unfortunate counter-blow by the compressor. Plunging marks, which occurred during notching or retouching, attest to the difficulty of this operation.

The shaping of the tang and the long barbs requires the use of high-quality material (honey-coloured flint of Meusnes) as well as sophisticated knapping in shaping an arrowhead that is both slender and thin; this is very well demonstrated by the Armorican arrowheads in the northern part of Finistère (Figure 10). We could state that the arrowheads in this sector had an elongated ogive-shaped form and long barbs during stage 2 of the Early Bronze age. They are extremely slender and thin, measuring generally between 2.6 and 4.1 mm in thickness. Only a few arrowheads of the Limbabu type measure between 4.2 and 5.3 mm in thickness. The long ogive-shaped arrowheads are clearly distinguishable from the shorter and thicker specimens of the preceding stage. It clearly appears that greater thickness was required in order to shape the tang and the long barbs by striking off longer blanks. During stage 3, the triangular, still elongated arrowheads become thicker but they are also characterised by the abandonment of the tang (Keruzoret type): as the preform was not thin enough, it was not possible to shape long barbs and tang.

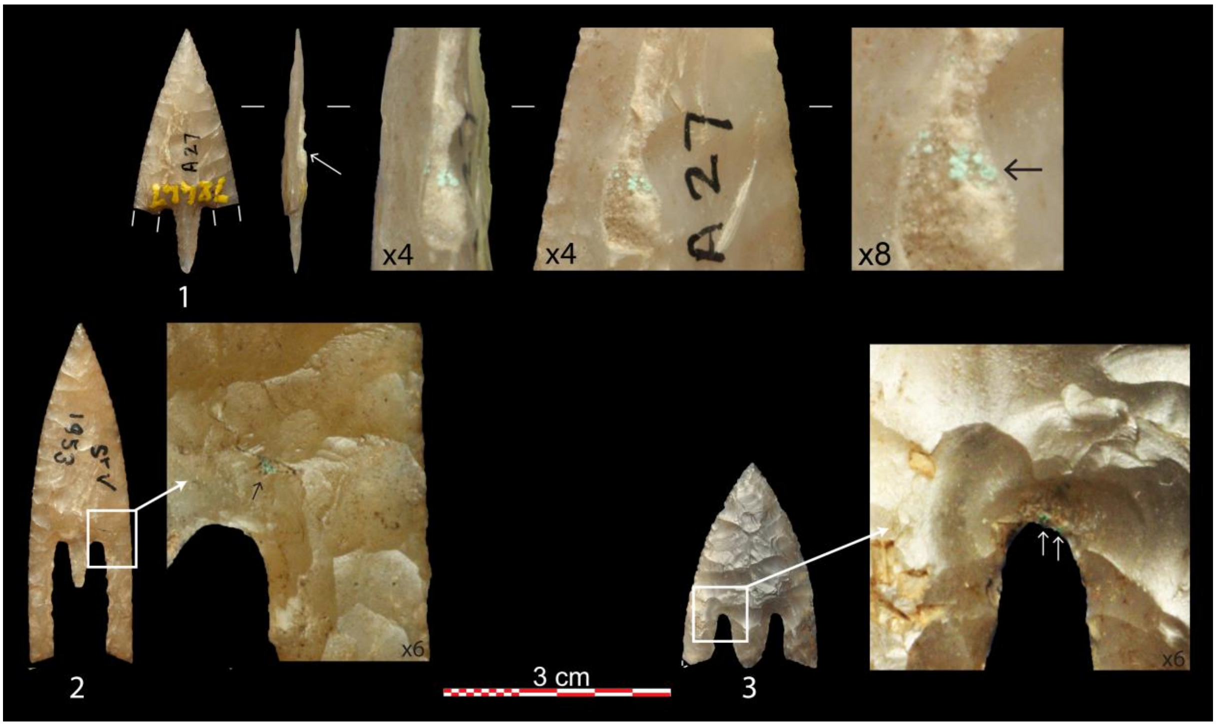

Figure 8. Greyish green traces on Armorican arrowheads indicating the use of copper (or copper alloy) awl for pressure-flaking (photo C. Nicolas). These greyish green traces are located in key spots of the *chaîne-opératoire*. The first one (1) is located on a crystalline inclusion of the flint, which has hampered the pressure flaking. The knapper succeeded in removing the left part of the inclusion but removals stopped against the left part, leaving a step 1,4 mm thick visible on the profile. The knapper tried to remove it by pressure. By this way, he managed to do three removals, clearly visible by two concave beginnings. Below the second concavity, we could see two greyish green traces, indicating a last attempt to do a fourth removal. In the two other cases, the knapper should have tried to eliminate a hinged removal (2) or to correct a slight asymmetry of the spaces between barbs and tang (3). 1. Tossen-Rugouec, Prat, Côtes-d'Armor; 2. Graeoc 2, Saint-Vougay, Finistère; 3. Rumédon, Ploumiliau, Côtes-d'Armor.

6. Craft specialization and organization of the production

The Armorican arrowheads doubtlessly required a high level of skills in order to master all the stages of the operational sequence and to control pressure flaking with maximum accuracy. Experiments were carried out by Frédéric Leconte according to an operational sequence similar to the one observed on the archaeological pieces (Nicolas, 2013). These experiments revealed that a self-taught knapper after two years of daily practice will master the knapping of arrowheads with barbs of 12 mm length (Limbabu type) and of arrowheads with barbs of 16 mm length after several additional months of training. Yet, Frédéric Leconte was not a complete novice in flint knapping and he practised for about ten years (knapping mostly handaxe). Two to three years could be therefore the minimum time span to master the manufacturing of Armorican arrowheads. This apprenticeship period is certainly different from that of prehistoric times. The teaching provided by the knapping masters probably encouraged the progress of the apprentice. In Western Europe, few communities carry on high-skilled production of flint artefacts during the Bronze Age. The most famous example is the Danish flint daggers. We are dealing in both cases with bifacial technology of flint working but the size of products and the know-how required are different. Nonetheless, these flint daggers offer a good benchmark about craft specialization. The most striking pieces of Danish daggers require a high degree of know-how: preforms could be knapped by a skilled apprentice but the final pressure-flaking takes years of practice for a self-taught knapper

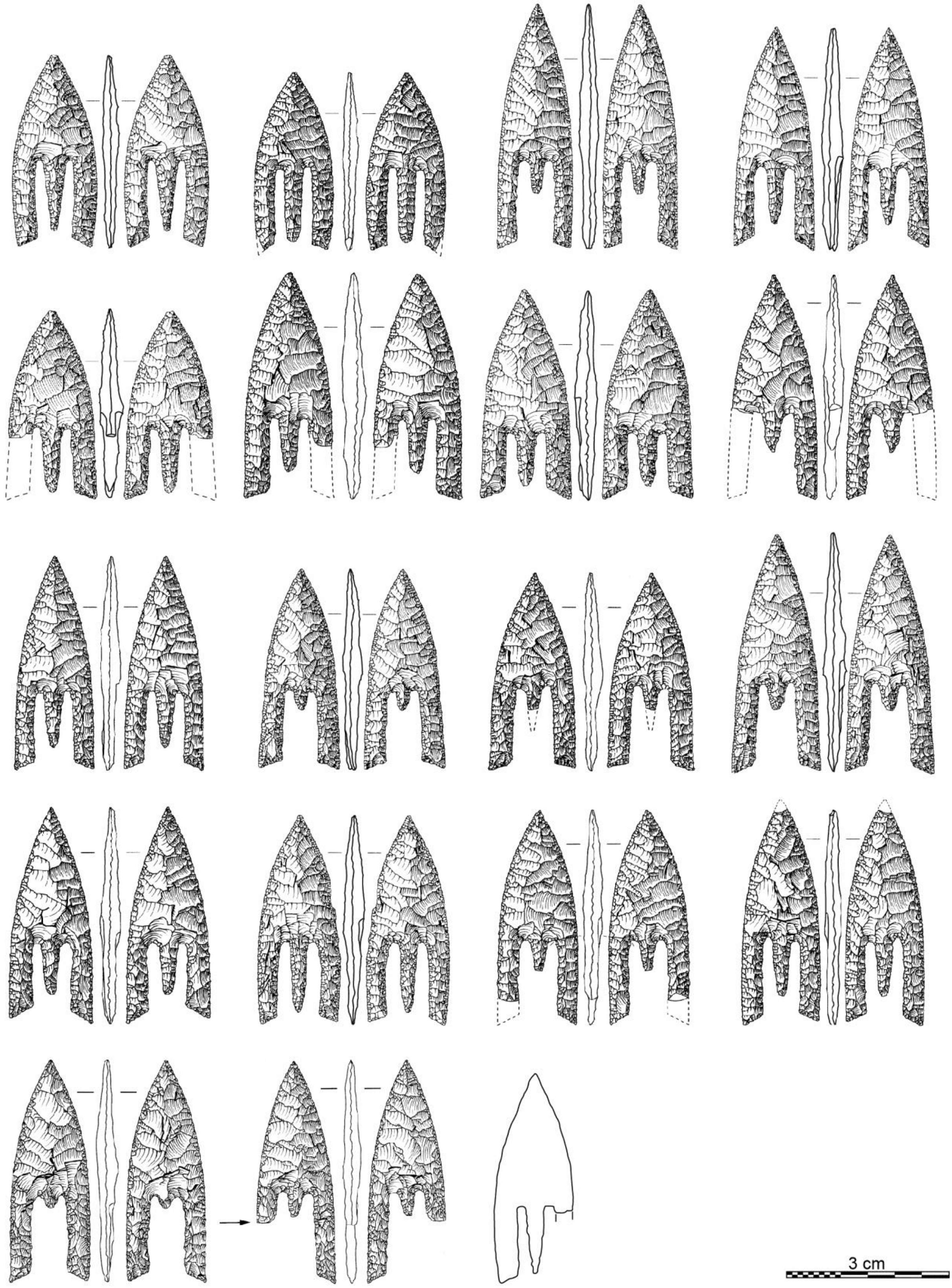

Figure 9. The arrowheads from Graeoc 2 barrow, Saint-Vougay, Finistère: an example of the variety of retouch with transverse, parallel or multidirectional retouch combination (drawings C. Nicolas).

(Apel, 2001, 2008; Stafford, 2003). For imparting this technical tradition, Jan Apel (2001) proposed that the daggers production was based on an apprenticeship system and was the privilege of specific lineage or clan, as well as access to sources of flint of good quality and sufficiently large. This kind of organization could be effective for the production of Armorican arrowheads. Regarding to the raw materials, the acquisition of the translucent honey-coloured flint could have been done directly by the craftsmen of Armorican arrowheads venturing in areas not necessary friendly or by exchange involving a control on the quality and the volumetry of the flakes used as blanks.

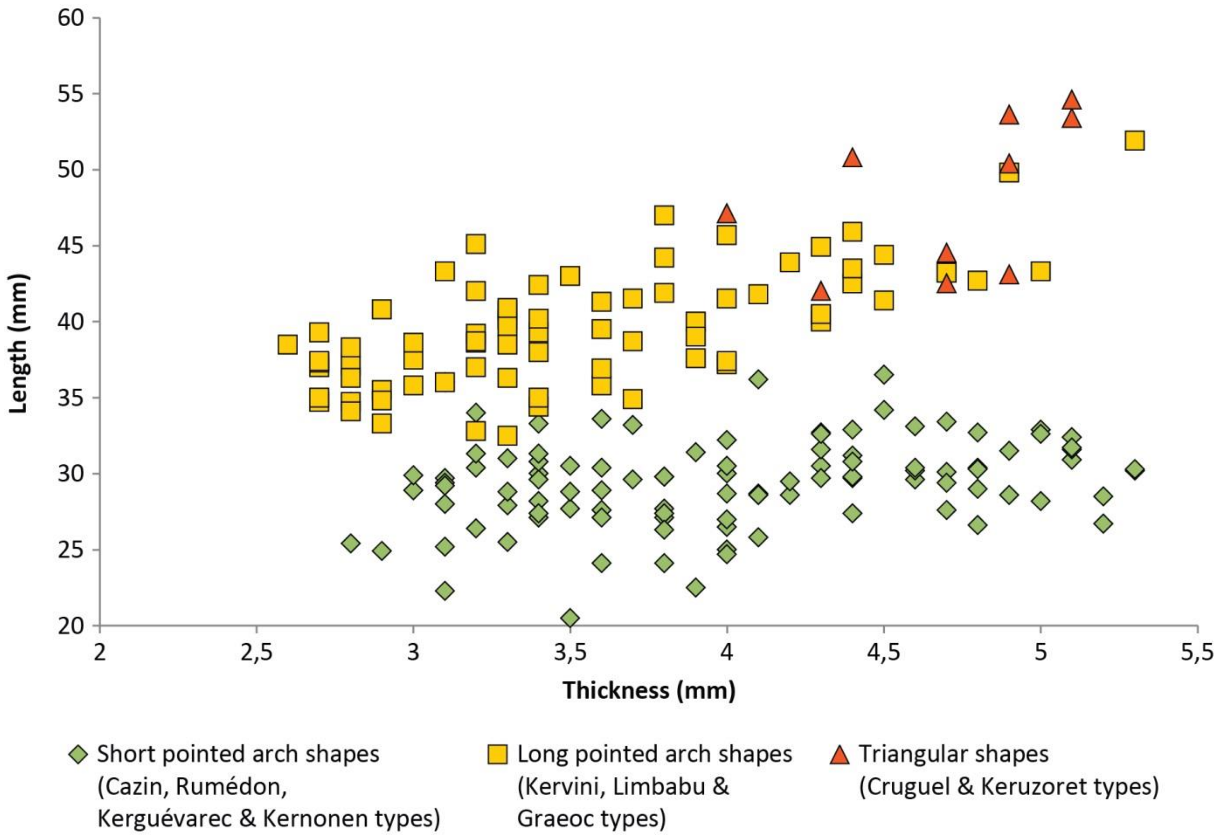

Figure 10. Diagram of the length/thickness ratio of the Armorican arrowheads from the northern part of Finistère.

As we know only the finished products in burials, it is impossible to reconstruct the whole *chaîne opératoire* of the Armorican arrowheads and the ways of the organization of their production. The scarcity of Armorican arrowheads out of Brittany (except few exceptional finds in the neighbouring areas or coarse copies) indicates most probably a manufacture in this region not so far from the barrows of chiefs. Nevertheless, we know only few Early Bronze Age settlements and most of them have yielded a scarce lithic industry, excepted the dry-stone house of Beg ar Loued in Molène Archipelago (Finistère) where numerous flint pebbles from the coast have been knapped mainly by split percussion (Pailler *et al.*, 2011). By the way, we have supervised several field surveys in northern Finistère in order to find Early Bronze Age domestic sites or workshops with elements of the *chaîne-opératoire* of the Armorican arrowheads. In the neighbouring (around 3 km) of barrows with Armorican arrowheads (Figure 1, no. 13 and 29), two surface sites very similar (Langristin, Plounévez-Lochrist and Kerfricho, Lannilis) have yielded stone artefacts which could match with a Late Neolithic or an Early Bronze Age date: the lithic industry is characterized by direct or split percussion, a predominance of scrapers and a sandstone sharpener (supposedly for metal). The main feature in both cases is the presence of a yellow translucent flint, similar of the one used for the Armorican arrowheads, representing around 25 % of the flints (other flints are mainly sea pebbles). This yellow translucent flint has been taken from deposits close to the primary sources (beige-coloured fine and grained cortex) or from rivers (smooth neo-cortex). Unfortunately, no pieces of this yellow translucent flint could match with the bifacial knapping of the Armorican arrowheads, even if tiny flakes (around 0,5 cm) have been collected. Furthermore, this yellow translucent flint has been knapped like the flint pebbles, by direct percussion with hard hammer or split percussion until little exhausted cores (around 2-3 cm). Only excavations could help in dating the import of this yellow translucent flint and its relationship or not with Armorican arrowheads production (Le Goffic, 1995; Nicolas, 2010, 2011b).

7. Use wear analyses

Use wear analysis with a stereo microscope and a metallographic microscope was carried out according to the conventional protocols used in this field (Keeley, 1980). Only three series of Armorican arrowheads stemming from Brun-Bras (Saint-Adrien, Côtes-d'Armor; Briard, 1978), Crec'h-Perros (Perros-Guirec, Côtes-d'Armor; Blanchet, 2005) and Prat-ar-Simon-Pella (Lannilis, Finistère; Le Goffic & Nallier, 2008), in total 72 projectile points, corresponding to 14.3 % of the entire corpus were investigated. However, this analysis was completed by macroscopic observations made on all the Armorican arrowheads that were preserved.

7.1. Use wear analysis of the blanks testifying to the circulation of flake blanks?

In three cases in which the original surface of the blank was preserved, this latter could be slightly distinguished from the negatives of removal. At Crec'h-Perros, the blank is characterised by a weak polish with loose to medium density and mat to bright polish more strongly marked on the higher points of the microtopography (Figure 11, no. 2). At Prat-ar-Simon-Pella, the extent of the polish is more intense and brighter (Figure 11, no. 1). It seems that these alterations affected the surface of the pieces prior to retouching. It is perfectly possible that they were produced during transport through the friction between the flint flakes or through contact with the container. Similar traces were obtained after a couple of days when the flint pieces were transported in a leather bag. These traces became even more marked after several weeks of transport (Rots, 2002, p. 67-68). It seems quite logical to assume transport if we admit that the exogenous flint materials used for the Armorican arrowheads were transported and stored in the form of flake blanks.

7.2. Hafting traces

On the occasion of ancient or more recent excavations, several archaeologists observed the survival of shafts, glue and binding threads (Chatellier, 1880; Le Pontois, 1890; Martin, 1904; Briard *et al.*, 1982; Briard, 1984). The remnants of shaft bindings have disappeared since the excavation but the traces of glue were better preserved. These are visible to the naked eye in the form of brown-black deposits, sometimes associated with a brown film and can be identified as remnants of glue (Figure 12, no. 1 to 5). The aspect of these brown-black deposits is generally mat, sometimes greasy (Figure 12, no. 4). In most cases, this brown-black matter can be observed only occasionally on the surface of the arrowheads. Often, it is well-preserved in small cavities such as those left by hinge fractures (Figure 12, no 4). Preliminary analyses (infrared spectroscopy) carried out by Maxime Rageot (doctoral student, University of Nizza Sophia Antipolis) made it possible to confirm that the brown-black matter attached to the three arrowheads found in the burial of Prat-ar-Simon-Pella (Lannilis, Finistère) is indeed remnants of glue. The obtained signal matches that of plant tar or resin, perhaps of birch tar (personal communications with Martine Regert).

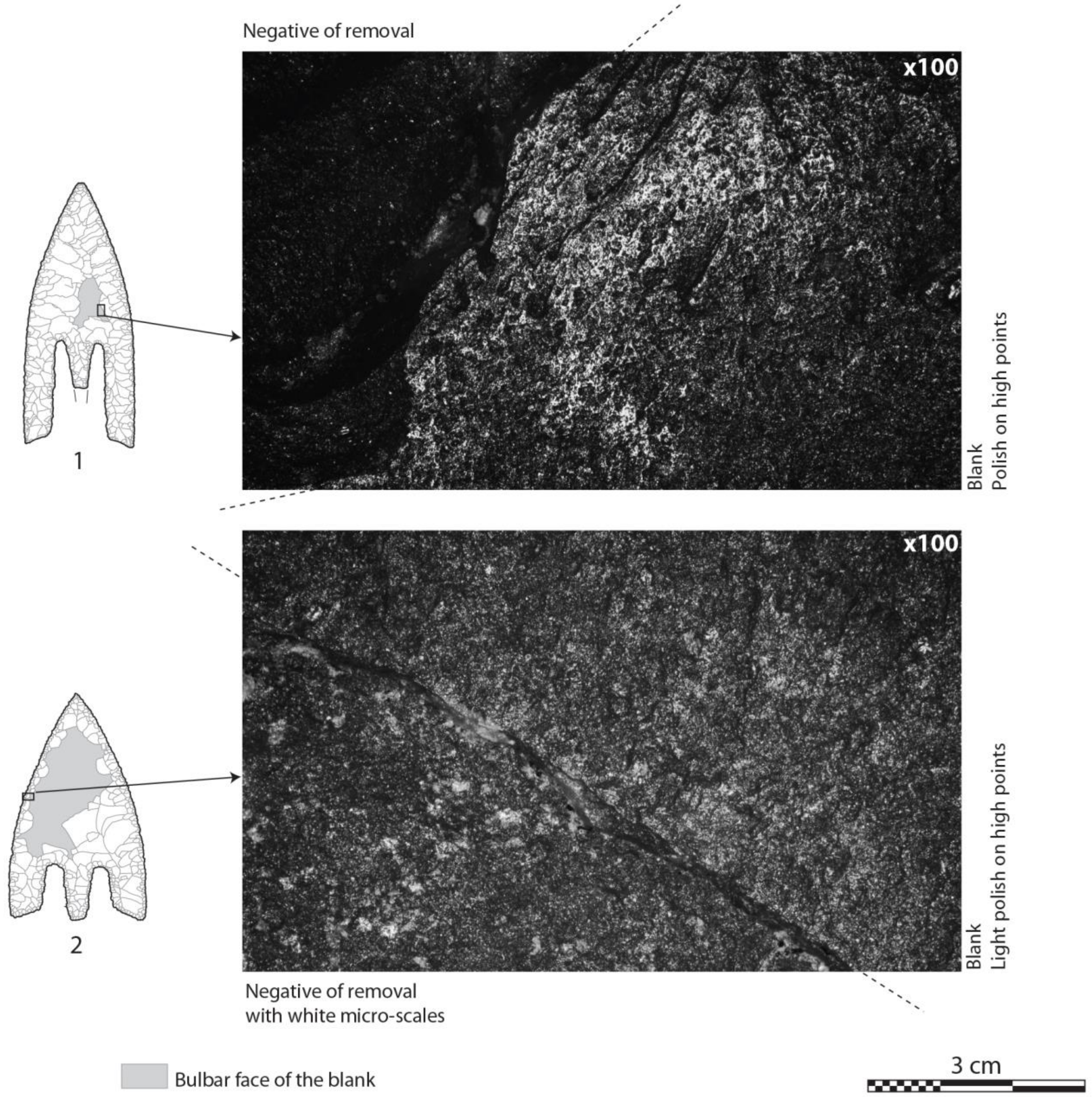

Figure 11. Use wear analysis of two Armorican arrowheads (photo C. Guéret; drawing C. Nicolas). 1. arrowhead from Prat-ar-Simon-Pella grave, Lannilis, Finistère; 2. arrowhead from Crec'h-Perros barrow, Perros-Guirec, Côtes-d'Armor.

Arrowheads exhibiting well-preserved remnants of glue are rare. In these cases, it can be stated that the brown-black matter covers not only the barbs (Figure 12, no. 2 and 5) but also the entire arrowhead: the remnants of glue are present close to or on the edges of the arrowheads (Figure 12, no. 1 and 2) and sometimes near to the tip (Figure 12, no. 3). Traces of glue are occasionally located in the centre of the piece (Figure 12, no. 3) or on a break (Figure 12, no. 4). This suggests that the break existed prior to the hafting of the arrowhead. Several examples of arrowheads with concave base dated to the Early/Middle Bronze Age in Denmark, Germany or the Netherlands seem to confirm this diagnosis: the glue covers the entire piece except for a strip 2 to 3 mm wide at the cutting edge (Piesker, 1937; Schünemann, 1975; Butler, 1990; Vang Petersern, 2008). Under the microscope remnants of glue can be recognised as thin crackled deposits or small pellets at the surface of the flint piece (Figure 13). On one glue deposit it was possible to observe linear and parallel marks possibly left by a non-braided binding thread (Figure 13, no. 3).

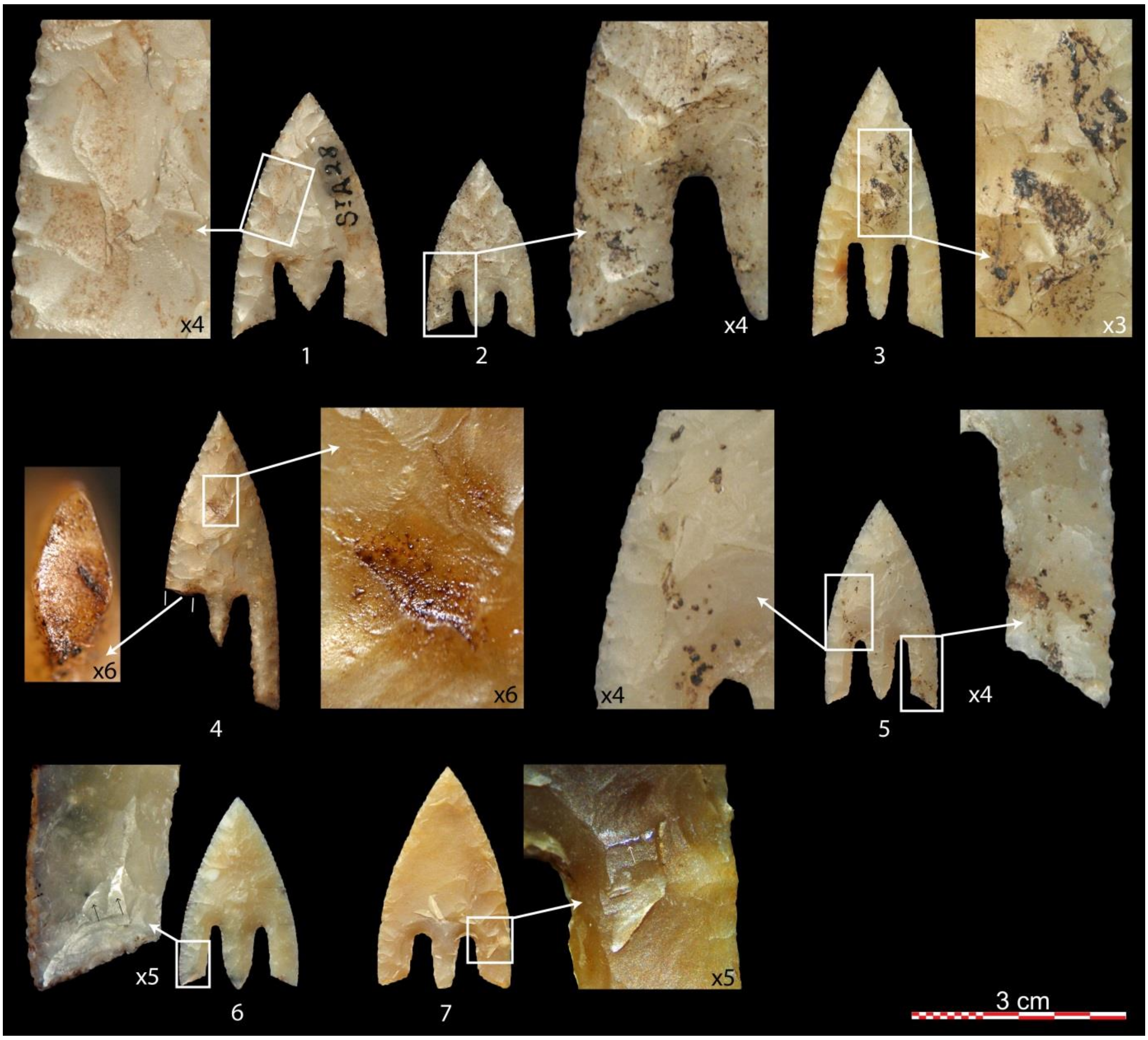

Figure 12. Macroscopic remains of glue (1 to 5) and bright spots (6 & 7) on Armorican arrowheads (photo C. Nicolas). 1. arrowhead from Brun-Bras barrow, Saint-Adrien, Côtes-d'Armor; 2. arrowhead from Rumédon barrow, Ploumiliau, Côtes-d'Armor; 3. arrowhead from Tossen-Rugouec barrow, Prat, Côtes-d'Armor; 4. arrowhead from Graeoc 2 barrow, Saint-Vougay, Finistère; 5 & 6. arrowheads from Kernonen barrow, Plouvorn, Finistère; 7. arrowhead from Crec'h-Perros barrow, Perros-Guirec, Côtes-d'Armor.

Almost all the arrowheads observed under the microscope bore very bright spots visible to the naked eye (Figure 12, no. 6 and 7). These are located on the high points, mainly on the arris of the negatives (Figure 14). Where they are particularly large, they may slightly recover the cavities (Figure 14, no. 1 and 3). They are located in the lower zone of the arrowhead, on the barbs and above, rarely exceeding half of the piece (Figure 14). Where they are well developed, the bright deposits are marked by short and large striations without polished ground. The striations are triangular with one end larger than the other. They are parallel but transversal with regard to the orientation of the arrowheads. These stigmata are often associated with blunted pieces. On a microscopic scale, these latter are systematically marked along the barbs and more particularly their denticulations (Figure 14, no. 2 and 4). They overflow only very little, except for the end of the barbs where they tend to cover the sides, associated with bright spots on the ridges of the removals (Figure 14, no. 2). They are very mat, coarse and often without polished component. In both cases, they cover the breaks, attesting that they were ancient (Figure 14, no. 4).

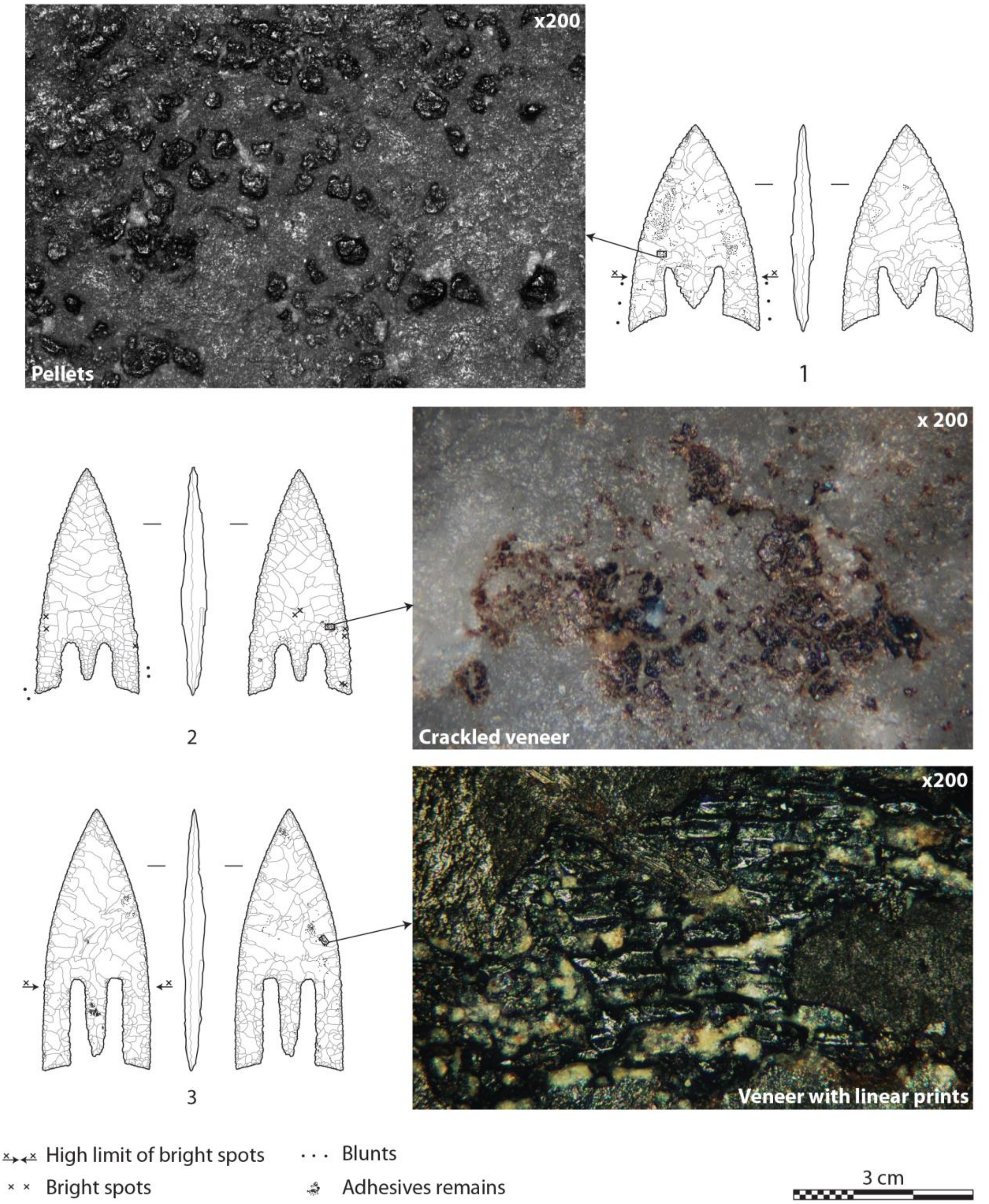

Figure 13. Different aspects of glue remnants on Armorican arrowheads observed under the microscope (photo C. Guéret, C. Nicolas; drawings C. Nicolas). 1. arrowhead from Brun-Bras barrow, Saint-Adrien, Côtes-d'Armor; 2. arrowhead from Crec'h-Perros-Guirec, Côtes-d'Armor; 3. arrowhead from Prat-ar-Simon-Pella grave, Lannilis, Finistère.

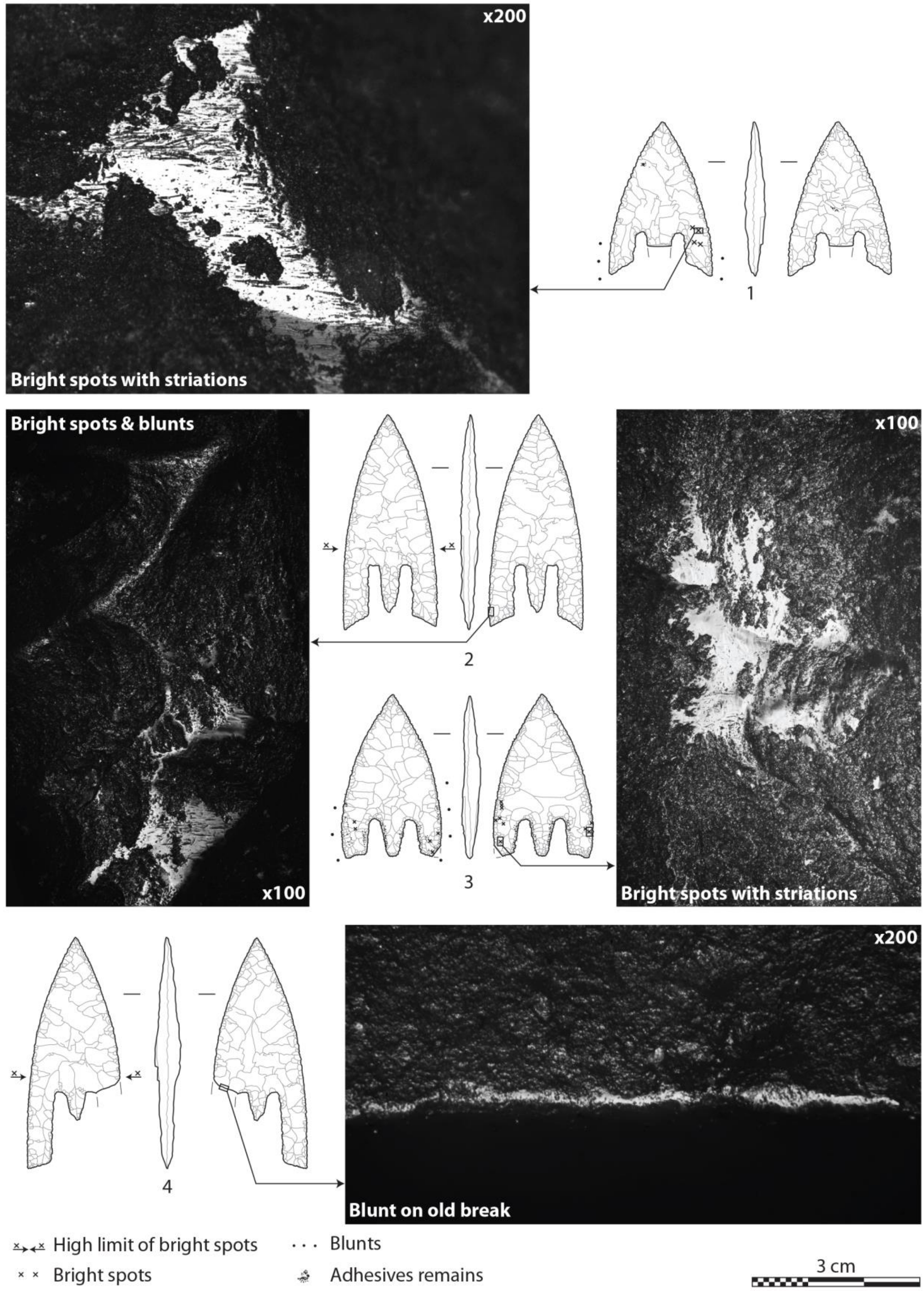

Figure 14. Bright spots and blunts on Armorican arrowheads (photo C. Guéret, C. Nicolas; drawings C. Nicolas). 1. arrowhead from Brun-Bras barrow, Saint-Adrien, Côtes-d'Armor; 2 and 4. arrowhead from Prat-ar-Simon-Pella grave, Lannilis, Finistère; 3. arrowhead from Crec'h-Perros-Guirec, Côtes-d'Armor.

The bright spots are very similar to taphonomic alterations, often visible on archaeological material. Their distribution and the pattern of the striations, however, leave no doubt about their functional origin. These stigmata are closely related to blunted pieces and seem to occur during the same period of time (Figure 14, no. 2). Most probably they result from transversal and repeated movements of the implement in the hafting. Equally, the absence of a clear directional sign, the « smoothness » and the location of the blunting are rather indicative of progressive development, certainly linked to the binding threads. This assumption would imply quite a loose hafting which enabled the piece to move in a transversal manner according to the direction of the striations. It should therefore be admitted that the hafting of these arrowheads was of poor quality and not destined for efficient shots. This statement is supported by the fact that no diagnostic break indicative of an impact could be observed on the Armorican arrowheads. The hafting of the Armorican arrowheads thus seems to be symbolic rather than functional and lasted long enough to cause bright spots and blunts. This result is no less problematic as it is difficult to demonstrate by experimentation. Indeed, how can these traces be reproduced when it took several years, even tens of years, to form them?

According to the distribution of the bright spots and the blunt zones, the arrowheads were hafted with a thread passing around the barbs. In one case, this binding thread was applied on the glue (Figure 13, no 3). Glue was placed on the internal edges of the barbs and the tang but also on the external edges of the barbs. It is thought to totally cover the binding threads, the lower part of the arrowheads and sometimes their tip. With such a type of hafting, the long barbs of the Armorican arrowheads became perfectly invisible.

7.3. Plant cutting, a practice both exceptional and anecdotic

Plant gloss, unexpected on arrowheads, was recognised on four projectile points stemming from Crec'h-Perros (Perros-Guirec, Côtes-d'Armor). The polish is visible to the naked eye and on a microscopic scale it presents all the characteristics linked with the cutting of non-woody plants (Figure 15). It starts from the ridges of the negatives and stretches longitudinally into the removal cavities. It expands by 2 to 3 mm from the edges without clear limits. The polish is very bright with a uniform pattern, bulged, smooth and without striations. Its surface is pierced by many small holes. The nature of the traces and their distribution indicates that they were used to cut soft siliceous plant materials. The polish is large and cannot possibly stem from just occasional usage. Yet, it does not result from intensive use (several hours) as generally observed on the sickle implements.

The four arrowheads were used without hafting – or at least without binding – for the cutting of plants. As a matter of fact, the hafting traces overlay the sickle gloss (Figure 14). The polish, distributed from the barbs to the tip without reaching the ends could not have developed with the hafting that covered the barbs as we could reconstruct this for the Armorican arrowheads in general.

Several alternative hypotheses as to the origin of the sickle gloss were advanced but none of them is really convincing when set against the facts:

- technical polish for the brightening of the arrowheads: however, the gloss is only visible to the naked eye if it is closely examined and it does not seem important enough to be intentional; moreover, admitting such a hypothesis, one would expect polish on most or on all the arrowheads and not only on four specimens;

- shooting into haystacks (Menez and Hingant, 2010): this hypothesis, although attractive and highly suggestive, has to be excluded. The sickle gloss is cut by the hafting traces which indicates that the four arrowheads were used for the cutting of plants prior to their hafting in a shaft;

- an arrow quiver made of plant materials: this hypothesis seems unlikely; indeed, if a quiver made of plant material had been in contact with an arrowhead, the polish should be present on the high points of the entire arrowhead (or at least on the parts that were not covered by the hafting) and not only on the edges.

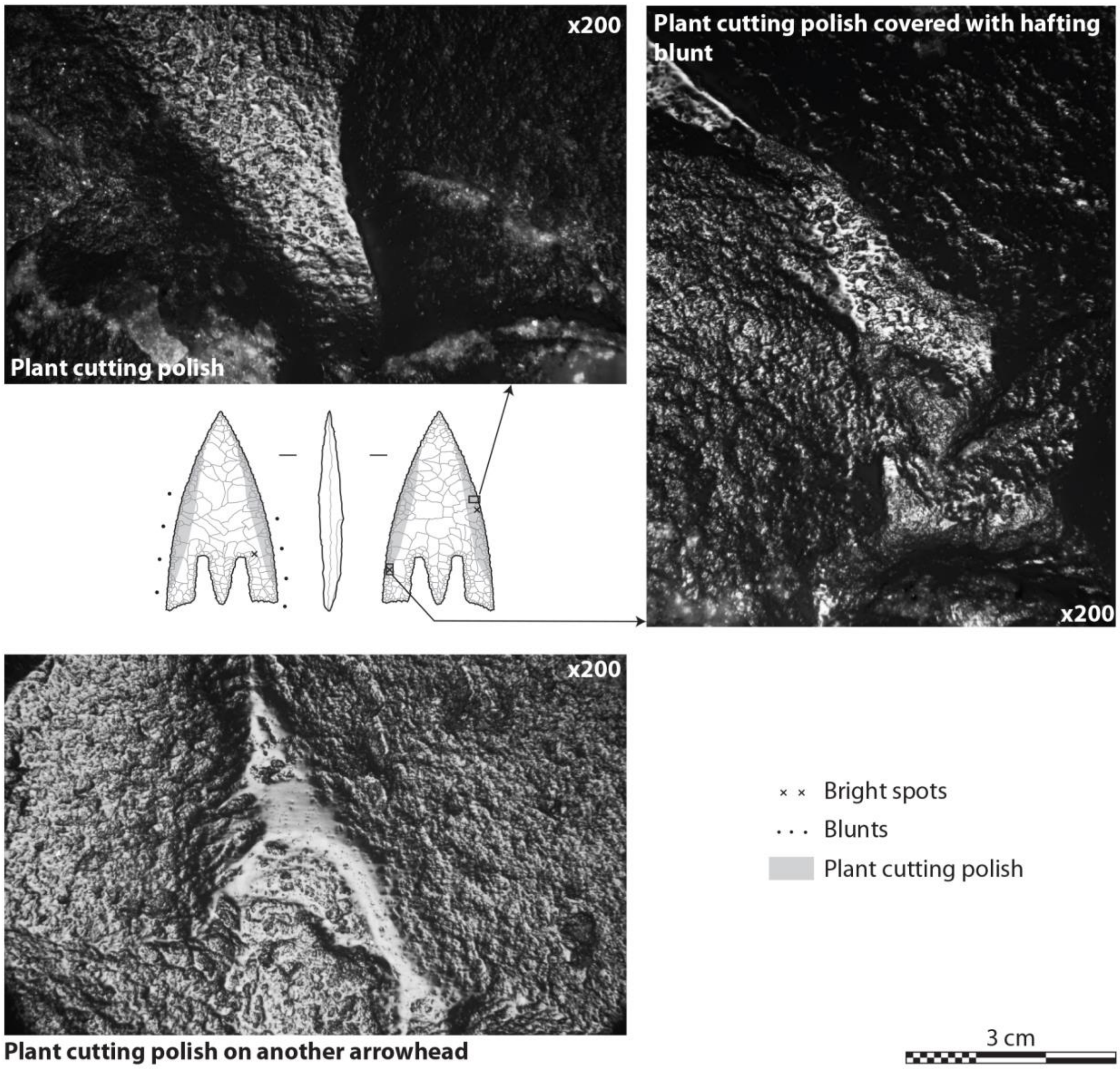

Figure 15. Plant cutting polish on arrowheads from Crec'h-Perros barrow, Perros-Guirec, Côtes-d'Armor (photo C. Guéret; drawing C. Nicolas).

Albeit surprising, plant cutting seems to be the most probable function. The occasional use of a cutting tool for the cutting of plants, however, should be excluded: the polish is well-developed and repeated on four arrowheads. The intensive use of arrowheads as sickles for cereal harvest cannot be taken into account either. The main, but currently unresolvable question is what kind of material was cut with these pieces. It is possible that these four arrowheads were used during manufacture for cutting the threads that served to fix the arrowheads on the shafts. Nonetheless, such an alienation of a highly symbolic object from its primary use is a significant action and it can be supposed that it took place within a ceremonial rite. In this regard, the gathering of plants with supposedly magic, psychotropic or medicinal virtues can be imagined. In any case, this practice remains anecdotal as it was observed on four arrowheads discovered at Crec'h-Perros only and not at all on those recovered from Brun-Bras or Prat-ar-Simon-Pella.

8. Discussion

The hypothesis that the Armorican arrowheads were strictly funerary objects (Giot *et al.*, 1995, p. 67), knapped to be deposited in the grave is not valid. On the contrary, the analysis of the traces reveals that these artefacts were widely used before they became grave goods. The observations made under the microscope can be easily generalised on a macroscopic scale to the whole body of Armorican arrowheads. Hafting glue and bright spots are visible to the naked eye if they are closely examined (Figure 11), whilst blunted zones are evidenced by touch. These three aspects (glue, bright spots and blunts) are almost systematically encountered on the different series of Armorican arrowheads. There is evidence to suggest that all or at least a very large number of the arrowheads were loosely and poorly hafted; in such a way that use wear appeared (bright spots and blunts). Such an inoperative hafting together with the absence of impact marks makes these Armorican arrowheads non-functional objects, mounted on shafts for their exhibition only. This display is in itself contradictory because the long barbs of the arrowheads become invisible when the arrowhead is hafted. If our observations are right, what mattered was not that their owner displayed them but rather that it was known that he owned them.

In many respects, the Armorican arrowheads are prestige points alienated from their primary function. They were manufactured on exogenous flint, probably transported in the form of flake-blanks. Some of the pieces had served for the cutting of plants. More particularly, most of them were loosely hafted and never shot with a bow. Lastly, they were apparently dismantled and subsequently deposited in wooden boxes as grave goods. The description of the remains of the wooden box indeed indicates that they measured about thirty centimetres in length (Briard, 1970); which cannot possibly match the length of the arrows (43 to 210 cm) documented in archaeological or ethnographic contexts (Cattelain, 2006).

The Armorican arrowheads, manufactured from exogenous flint by highly skilled knappers, certainly craftsmen, were apparently intended for display only. There is no doubt that these objects were reserved for the Early Bronze Age elite. These are in addition the most numerous and the most distinctive objects in the tombs of these chiefs. The Armorican arrowheads therefore can be considered as being insignia of power. These Early Bronze Age chiefs probably controlled the manufacturing of the arrowheads through the procurement of the raw material, by supporting the craftsmen and/or by controlling the circulation of the arrowheads. Such specialists attached to the elite also evoke an organisation close to the palatial workshops in the Eastern Mediterranean (Procopiou, 2006). Nonetheless, Cathy Lynne Costin (1991) stresses that the social context of the production (independent craftsmen or attached to the elite) has to be distinguished from its spatial organisation (dispersed or centralised). In this regard, the case of the Mycenaean arrowheads (1650-1050 before the Current Era) reveals the existence of craftsmen working for the elite without being under their physical control. In most cases, these arrowheads were discovered in the richest graves and in high numbers in the palaces of Mycenae and Pylos (Parkinson, 2007; Druart, 2010). However, none of the administrative texts (Linear B) ever mentions the work of the stone knappers in the palaces whilst these documents yield abundant details on craftsmen manufacturing bronze, weapons, chariots, textiles or scented oils (Kardulias, 2007). The control of the elite over the craft does not therefore require physical control of the craftsmen but was carried out by other means (economic power, moral authority?). Ultimately, it is possible that the knappers of Armorican arrowheads lived close to the Early Bronze Age elite or in a more dispersed manner.

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Neolithic flint mines of Treviño (Basque-Cantabrian Basin, Western Pyrenees, Spain)

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Abstract:

The prehistoric Treviño flint mine complex is located in the Sierra de Araico-Cucho (Berantevilla, Alava - Condado de Treviño, Burgos), inside the lacustrine-palustrine Cenozoic (Aquitanian, Miocene) materials of the South-Pyrenean syncline of the Basque-Cantabrian Basin. It is a landscape unit constituted by a set of carbonated layers with abundant nodular and stratiform silicifications. The extraction mining works (often referred to as 'tailing') are usually identified as dumps or trenches, subtly visible and associated with archaeological materials.

An archaeological excavation was carried out in one potential mining structure (dump or pit) that was detected by LiDAR (Light Detection and Ranging) in the mountain pass of "Pozarrate" near the villages of Grandival and Araico (Treviño, Burgos). In this work we present the results of the excavation of the last two years. The existence of a Neolithic mining dump (the tailings) with a chronology ca. 5000 cal. BC was confirmed. The base rock level with nodular flint was reached and the impressions of the exploited nodules have been identified. As well, the extraction front which reaches about 4.0-5.0 metres in height was delimited. Thousands of lithic remains associated with the extraction and the initial processing (shaping) of flint were collected, as along with mining tools. We have found and described three types of mining structures: trenches, linear dumps and crescent-shaped (or "half-moon-shaped") dumps.

This site is one of the few prehistoric flint mines dated in the Iberian Peninsula. Recent investigations in the Cantabrian Mountains and Western Pyrenees indicate that the circulation and use of Treviño flint during Prehistory reached many Holocene and Pleistocene archaeological sites, located hundreds of kilometres away from the outcrops.

Keywords: Neolithic; mines; raw materials; flint; mineral resources; prehistory; Treviño; Western Pyrenees

Resumen:

El complejo prehistórico minero de sílex de Treviño se sitúa en la Sierra de Araico-Cucho (Berantevilla, Alava - Condado de Treviño, Burgos), en materiales lacustres-palustres del Cenozoico (Aquitaniense, Mioceno) en el Sinclinal Surpirenaico de la Cuenca Vasco-Cantábrica. Se trata de una

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unidad constituida por un conjunto de niveles carbonatados con presencia de abundantes silicificaciones nodulares y estratiformes. Habitualmente se identifican labores mineras de extracción como escombreras o zanjas sutilmente visibles y asociadas a materiales arqueológicos.

Se ha llevado a cabo una excavación arqueológica en una estructura minera potencial (escombrera o pozo) que fue detectada por LiDAR (Light Detection and Ranging) en el collado de Pozarrate cerca de los pueblos de Grandival y Araico (Treviño, Burgos). En este trabajo presentamos los resultados de los dos últimos años de excavación. Se ha confirmado la existencia de una escombrera neolítica de unos 5000 AC años de antigüedad. Se ha alcanzado el nivel de base con sílex nodular y las impresiones de los nódulos explotados han sido identificados. También se ha delimitado el frente de explotación que alcanzará los 4,0 – 5,0 metros de altura. Se han recogido miles de restos líticos asociados a los trabajos de extracción y conformación inicial, así como herramientas mineras. Hemos detectado y descrito tres tipos de estructuras mineras: zanjas, escombreras lineales y escombreras de media luna.

Este yacimiento es una de las pocas minas prehistóricas datadas en la Península ibérica. Investigaciones recientes indican que en la Cordillera Cantábrica y Pirineo occidental la circulación y uso del sílex de Treviño llega a numerosos yacimientos arqueológicos del Holoceno y del Pleistoceno, situados incluso a centenares de kilómetros de los afloramientos.

Palabras clave: Neolítico; minas; materias primas; sílex; recursos minerales; prehistoria; Treviño; Pirineo occidental

1. Introduction

The archaeological area of the Treviño flint mines is located in the Sierra de Araico – Cucho in the Western Pyrenees (Burgos, Spain). This mountain range is a homoclinal structure that reaches 901 metres (at El Cerro peak), separating the basins of the rivers Ayuda and Rojo situated about 450-550 metres above sea level (Figure 1). The outcrops comprise a large area of about 2,000 hectares, where there is a wide variety of lacustrine-palustrine flint outcrops. It is a great site complex with countless vestiges associated with mining exploitation. These flints have been employed throughout prehistoric times as the study of Cantabrian-Pyrenean sites confirms (Tarriño et al. 2011b).

The results of the last excavation works carried out in 2012 and 2013 are presented in this paper. These works allowed for the defining of the structures and the flint exploitation methods. The excavation zone is specifically located in the mountain pass named "Pozarrate" near the villages of Grandival and Araico, with the following coordinates: X = 517.975; Y = 4.727.854; altitude = 814 m ASL (projection UTM ETRS89 Time Zone 30 N). This place was selected because of the presumable existence of exploitation structures. The surface revealed many flint remains and tools that might have been employed for the mining activity at Araico.

The first archaeological intervention at the site dates back to the field surveys carried out by D. Estavillo during the 1930's. Estavillo collected more than 50 ophite quarry-hammers; most of them were complete, with different sizes and weights from 0.5 to 6.5 kg, and with a central depression to make handling possible. He also collected flint cores which exhibited reuse marks, e.g., knapping hammerstones (Estavillo 1955). In the Archaeological Museum of Alava collection, there are currently more than a hundred boxes full of the lithic materials (Estavillo collection). As a consequence of this important legacy, in the beginning of the 1980's a field survey project along the Rojo River valley was promoted. Thanks to this project many archaeological sites were found in the area around the flint outcrops. In the high part of the mountains, explorations were made in the area of "Alto de San Miguel" (Ortiz et al. 1990), where the excavation is currently located.

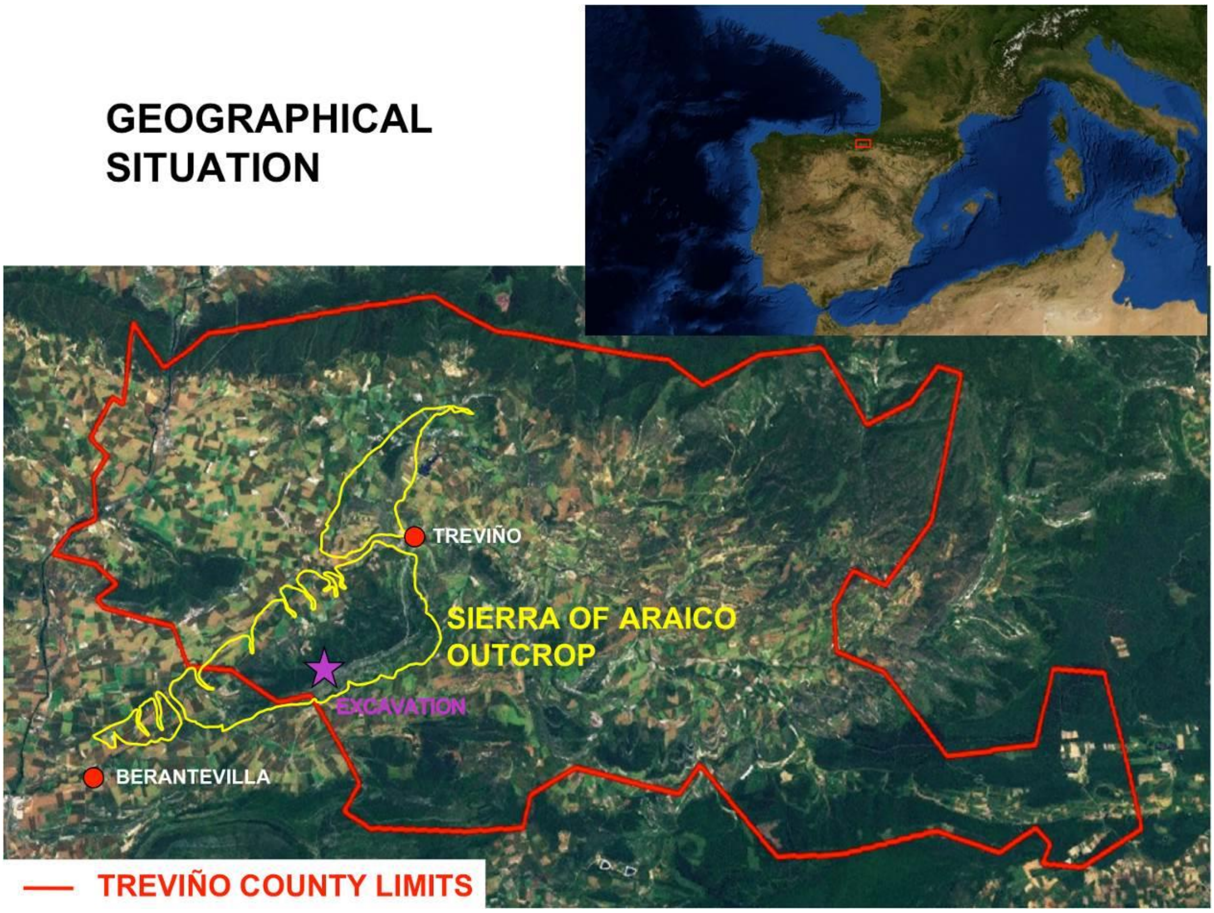

Figure 1. Localization of the outcrops of the carbonated unit that contain the flint and the spot where the excavation was performed.

In the year 2001, the PhD thesis of A. Tarriño (2001), produced from a geoarchaeological perspective, highlighted the presence in Araico and Cucho of relevant evidence of a large prehistoric mining complex with many trenches and dumps, as well as a vast quantity of flint lithic remains and ophite tools.

Eight years later, in 2009, at the “2nd International Conference of the UISPP Commission on Flint Mining in Pre-and Protohistoric Times” (Tarriño et al. 2011a), the results of the first research related to the mines were presented. Consequently, in 2010, the geomorphologic map of the site was published. On this map the erosive morphologies of the mining activity were represented based on the LiDAR data (Benito-Calvo et al. 2010). And two years later new field survey works were carried out, applying the data from the SPOT-5 satellite, as a method for the identification of structures. Due to this, the tailings that jointed the trenches described by LiDAR were recognized (Orue 2013).

2. Hypothesis and methods

The whole archaeological area presents a high density of archaeological surface material, together with the existence of abundant geological flint of excellent quality; both are evidence of mining activity. For this reason, it was necessary to locate and define the exploitation areas of this large outcrop which supplied the Cantabrian-Pyrenean Region.

The dense vegetation is one of the factors that obstructs the location and understanding of strip mining in the mountains; therefore a survey plan was designed using LiDAR data. The information was classified to generate a DTM (Digital Terrain Model) of the entire surface where flint crops out. Aerial photographs were also used, comparing them with the DTM results. The acquired data was provided by the Basque Government web site (www.geoeuskadi.net) and processed with ArcGIS 9.8 software.

The results of this data revealed erosive lines as trenches and mound formations which followed the layers of the terrain. A general interpretation would have been impossible without these methods, due to the dense vegetation and the integration with the landscape caused by the passing of time. Finally the survey confirmed that the trenches and dumps are associated with the presence of abundant flint remains (Figure 2).

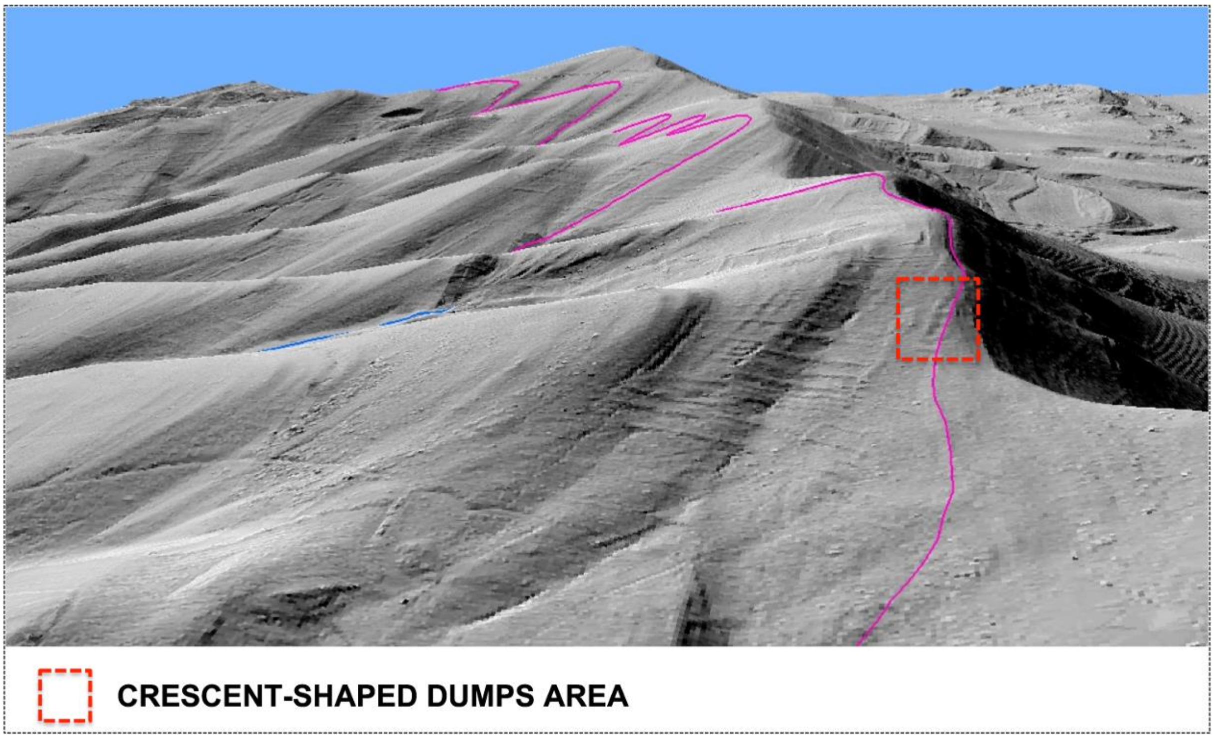

Figure 2. 3D Model of "Sierra de Araico" with the line of the nodular flint layer. The red square marks the location of the excavation with the crescent-shaped dumps.

3. Exploited flint

The silicifications are located in the unit defined by the geological map 1:50,000 (IGME, 1978) as "Marlstone and lacustrine limestones" of the Early-Middle Miocene (Aquitanian). The slopes of the A-126 road that connects Treviño (Burgos) to La Puebla de Arganzón (Burgos) allow a good observation of these materials.

These silicifications are well represented in the geological record but have remained unnoticed in geological studies. Ramírez del Pozo (1973:39) in his "Geological synthesis of Alava Province" mentioned the existence of this flint for the first time. These silicifications are situated inside a thick carbonate unit which outcrops in the South-Pyrenean syncline of Miranda-Treviño. Its thickness exceeds 1,000 metres fundamentally composed of lacustrine carbonates (IGME 1978). In this unit, compact limestone and dolomite, dolomitic limestone and calcareous dolomite with diverse cementation degrees are found (Figure 3). Some of these levels present little quantities of clay minerals and are rich in organic matter and they are often associated with silicifications (Tarriño 2001).

On the terrain we found many dark coloured flint nodules with a large content of organic material. Even when they are fractured, they give off a fetid odour because of the hydrocarbon volatilization. There are two types of nodules whose main characteristic is the cortex. The most common ones present cortex of between 2 and 5 mm thickness. Their colours are slightly darker (brown, dark grey) and, inside, they have small areas of unfinished silicification with hollow spaces and carbonate impurities. For this reason, these flints have little value for knapping. Also because of this, they appear in the site as rocky blocks that have been thrown out.

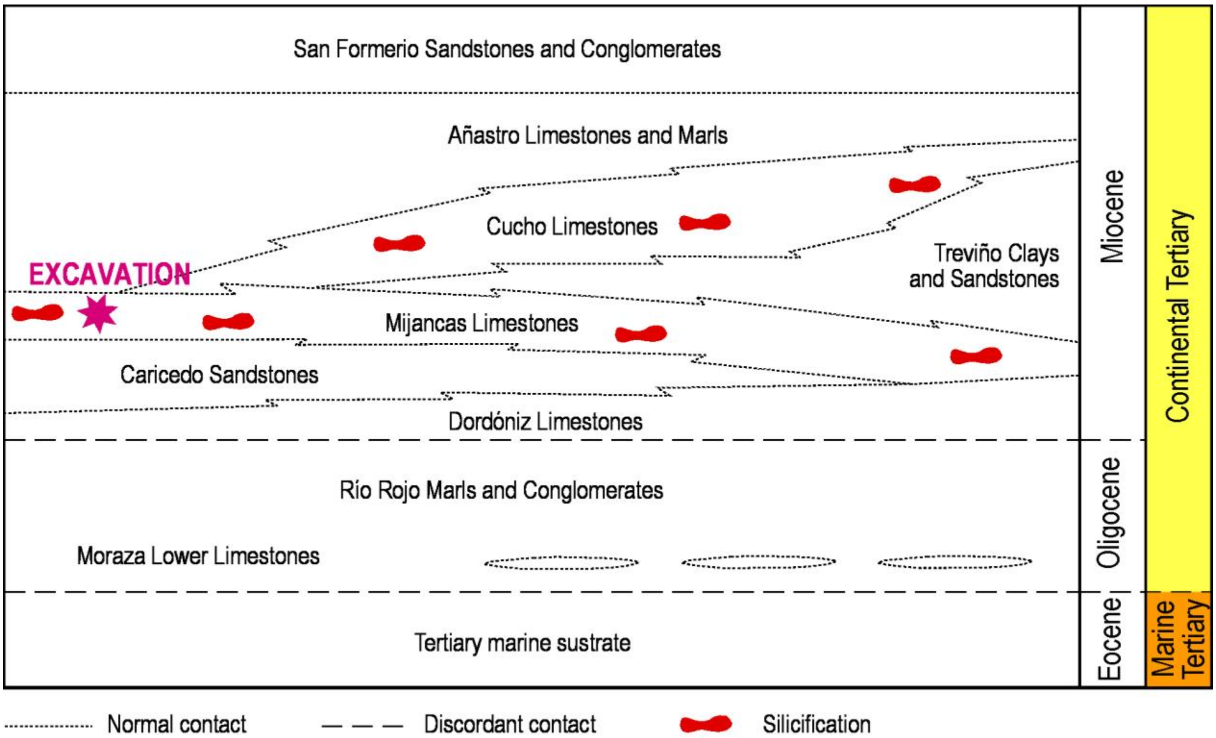

Figure 3. Lithostratigraphic scheme of the units with flint.


Figure 4. Outcrop of the nodular flints exploited at the mines, without cortex, included in the poorly consolidated lacustrine-palustrine limestones.

The other variety, with best quality, presents a very thin cortex that appears bluish grey in colour when recently extracted (Figure 4). It is homogeneous with a very fine grain (microcrystalline - grains ranging from 2 to 50 µm in diameter, and cryptocrystalline - grains being less than 1 or 2 µm in diameter (Luedtke, 1992: 11)) and only minor carbonate impurities (Figures 5 & 6). (Crystalline nature is only vaguely revealed, even microscopically in thin section by transmitted polarized light.) The host rock is whitish lacustrine limestone with some dolomite, little cementation and plenty of ostracods. They are poorly consolidated carbonates which, combined with the presence of a very thin cortex, make the nodules easy to free. Thus, this contributes to the establishment of the mining extraction works on these silicifications during Prehistory.

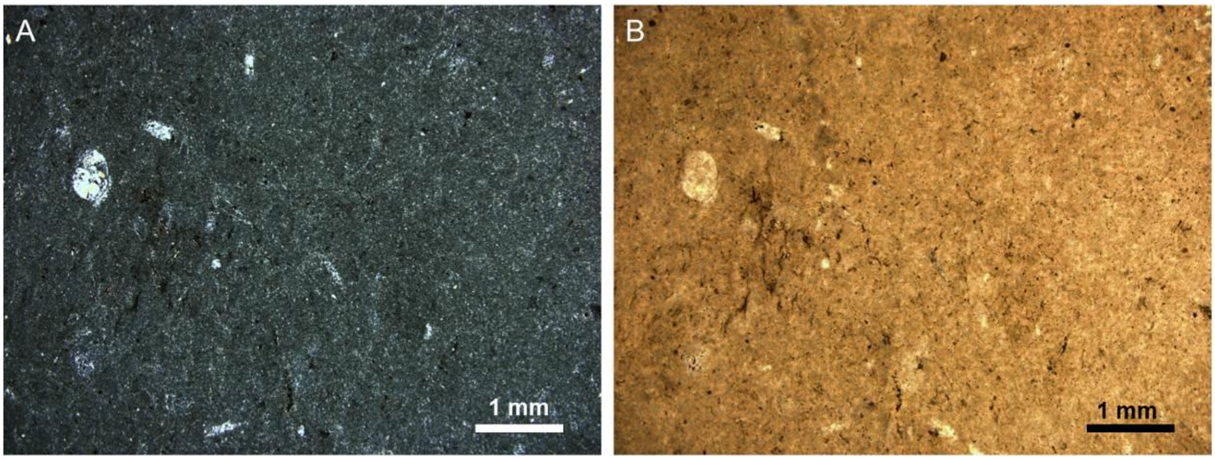

Figure 5. Microscopic appearance of the nodular flint (ARK-01SX). It presents a fine grained texture, micro-cryptocrystalline quartz with ostracods and low concentrations of organic matter. A. Crossed polarisers (xP); and B. the same view with one polariser (1P) (25x).

4. Results

As they are fundamentally silicifications with poorly consolidated host rocks, it can be deduced that the extraction of the blocks would not have been difficult. In this way extraction fronts (also referred to as the 'extraction faces') were created following the layers which penetrate the substratum. This preliminary hypothesis was fundamental for the surveys and the interpretation of the extraction methods in the mountains which have been developed in recent years.

4.1. Geomorphological interpretation

After studying the data, interpretation was made. In the excavation sector, three types of mining structures were observed: 1) trenches, 2) linear dumps and 3) crescent-shaped dumps (Figure 7). When the vegetation allows it, these mining works can be detected on the surface. Generally, surface features are associated with the mine dumps. Sometimes only the dumps can be identified but at other times only the trenches are discernible.

4.1.1. Trenches

When the layer crops out on the southern hillside, the most appropriate method of extracting the flint is the trench excavation. The trenches are observed as small linear depressions showing an erosive appearance that follow the direction of the layers (Figure 8).

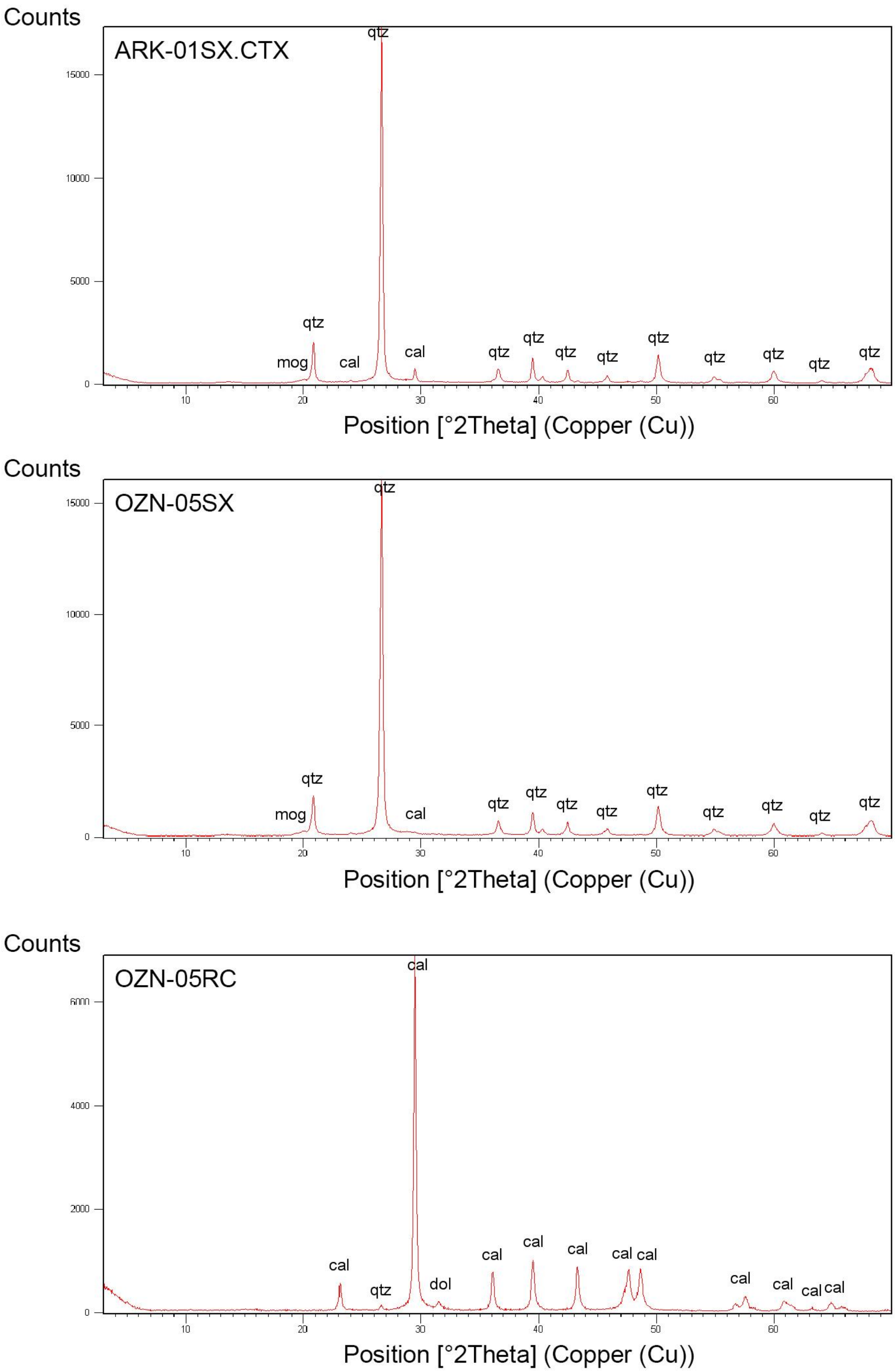

Figure 6. Diffractograms where the mineralogical composition of the nodular flint with cortex is observed (ARK-01SX.CTX). It contains carbonate impurities (calcite - cal) and moganite (mog) traces; flint without cortex (OZN-05SX) with few impurities and moganite (mog) traces; and, carbonate host rock (OZN-05RC) which is limestone (cal) with a small amount of dolomite (dol).

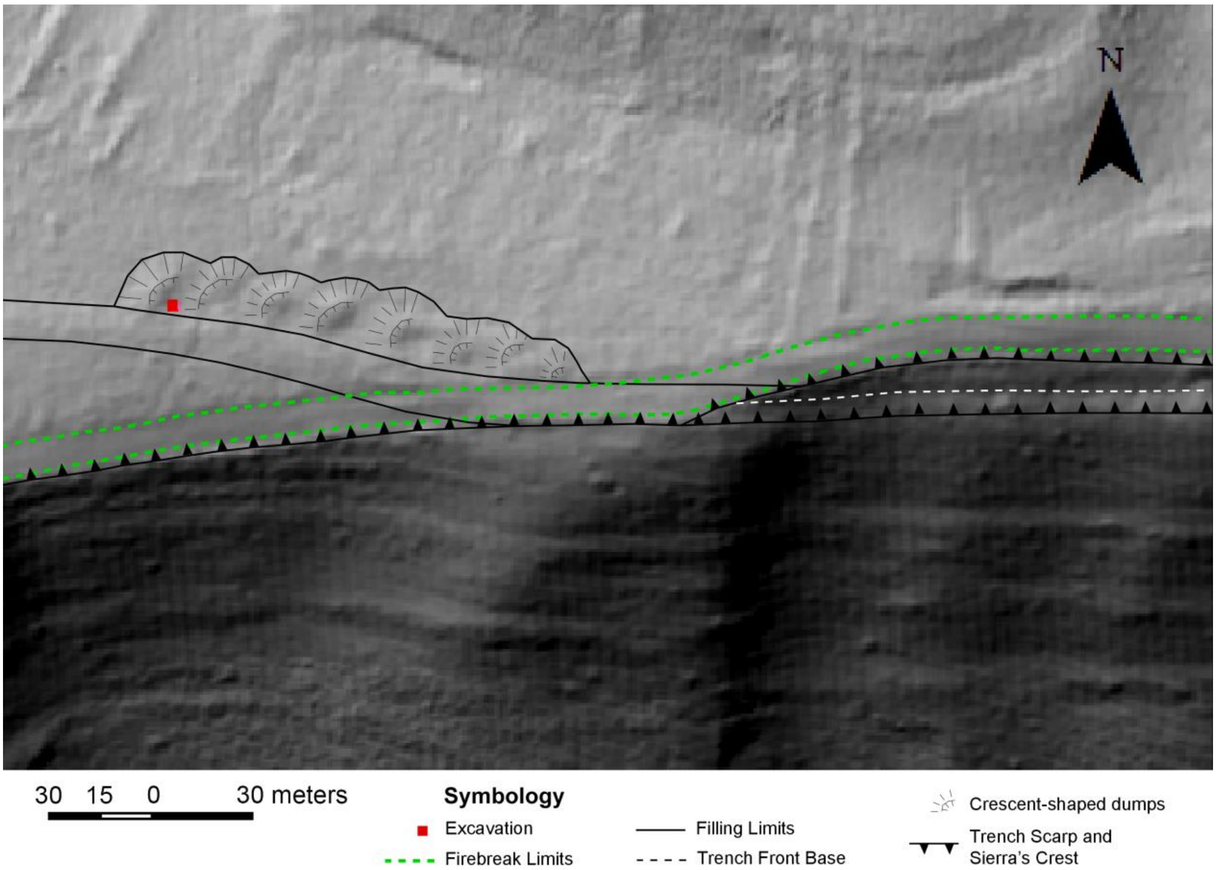

Figure 7. Geomorphological interpretation of mining structures in the excavation area.

Figure 8. A view of the mining trench.

4.1.2. Linear dumps

When the flint layers cross toward the northern side of the hill, the method of exploiting the flint has to change because the stratum crops out in the same direction of the slope. This fact is geomorphologically represented as linear dumps of about 12-15 metres wide and many thousands of metres long. It is estimated that the extraction front was about 2.0-2.5 metres height. They are part of the terrain, so they are practically impossible to be detected by photo-interpretation (Figure 9).

Figure 9. A view of a linear dump on the northern mountainside of “Sierra de Araico”.

4.1.3. Cresecent-shaped dumps

At the highest part of the northern side of the mountain, where the excavation is located, the dump can be interpreted by means of the height and the dip of the flint stratum at its base. Due to its morphology, which is described below, we called this type of dump a ‘crescent-shaped dump’. The dump is double the width of the linear dump mentioned above, up to 25-30 metres wide. In this area the existence of 8 dumps or depressions which continue to the crest until they turn into a trench has been confirmed. In these depressions the extraction fronts, due to their form, might reach 4.0-5.0 metres in height (Figure 10).

4.2. Crescent-shaped dump excavation

The intensive excavation of the crescent-shaped dump started in the year 2011. From the beginning, the aim was to delimit its extent, as well as to continue with its excavation to understand how this type of structure was managed. In this period of time, 10 square metres were excavated, four of them excavated in depth (Tarriño et al. 2011b). By 2012 the bedrock was reached and the excavation was broadened in order to delimit the dump through the digging of two trenches. In the same way, in 2013 the delimitation of this dump was continued by completing an extension in the form of an additional 14 square metres (Figure 11).

The mine dump excavated in 2011 and 2012 is 2.8 metres deep. Its stratigraphic section is generally formed by two levels. The first one presents a high number of clasts smaller than 10 cm and a few blocks between 20 and 30 cm while the second one is characterised by large blocks which may be over 0.5 metres, most of them presenting marks derived from mining activity (Figure 12). Under the blocks the rock base of the dump was identified. It coincided with the nodular flint level that the Neolithic miners were extracting, and the hollow depressions where the nodules were, as well as a piece of flint still on the rock can be observed (Figure 13).

Figure 10. View of a crescent-shaped dump, showing the central depression before the excavation.

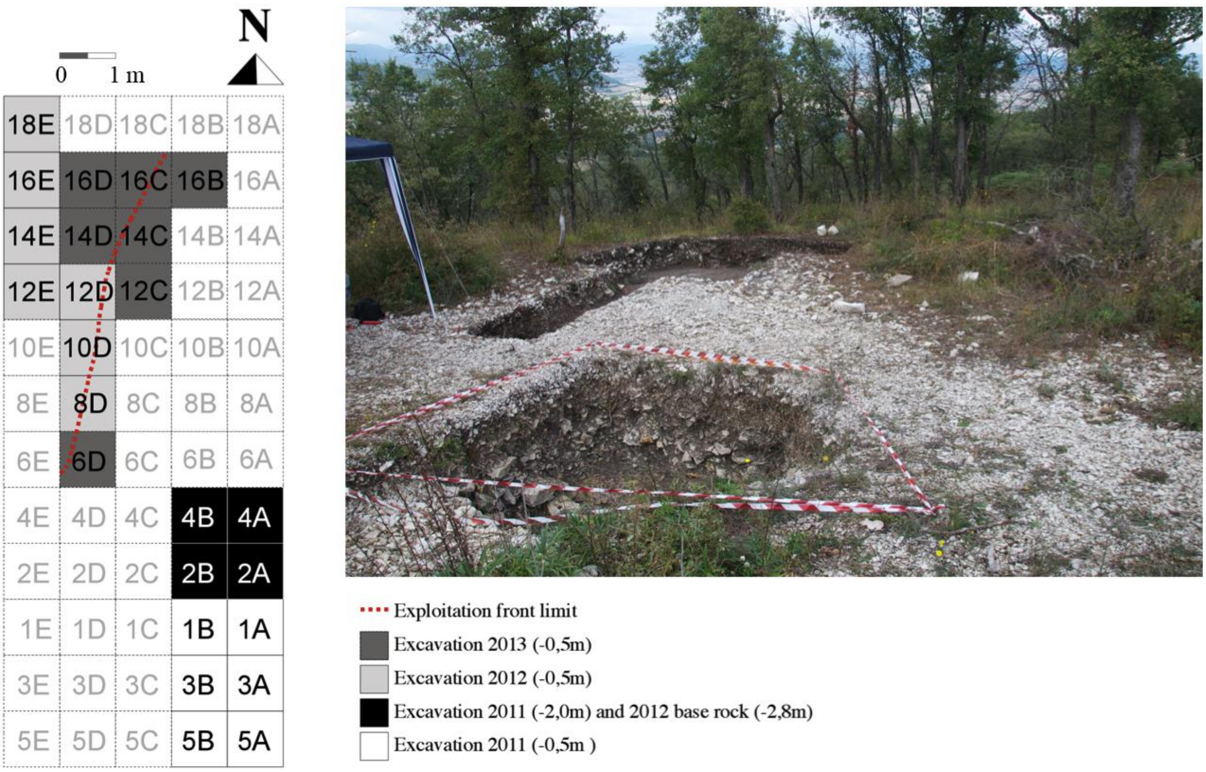

Figure 11. A plan view of the excavation and a photographic view of the site.

Once mining activity was confirmed and the layer of flint exploited by Neolithic miners identified, in 2012 we continued locating the quarry front. Two trenches were excavated, which are in the upper part of the same filling deposit of clasts and blocks mentioned above, whereas under this layer the original Neolithic slope appeared next to the edge of the crescent-shaped dump. Throughout 2013, the excavation work focused on the delimitation of the dump, and the effort in the end revealed the limit clearly (Figure 14).

Figure 12. Photograph displaying the stratigraphy and the base rock of the crescent-shaped dump.

Figure 13. Left: Hollow depressions of the flint nodules after their extraction from the bedrock. Right: A piece of nodular flint still within the host rock.

Figure 14. A photo showing the limit of the crescent-shaped dump after the 2013 excavation.

4.3. Archaeological materials recovered

The lithic assemblage recovered is composed of the remains of flint knapping, retouched artefacts, knapping hammerstones and general hammers (Tarriño et al. 2011b). The knapping remains are characterised by the presence of *débitage* products, cores, and tested flint nodules.

Within the first group there are flakes and blades with dimensions of about ten centimetres, some being even longer. Generally they are thick and a high percentage have cortex on the dorsal surface. The striking platforms of these products are mainly double-faceted and single-faceted of large size and they sweep away part of the percussion platform. In the same way, the bulbs of force are very marked. In terms of technical evidence that can be observed on the dorsal surfaces of these products, few negatives of previous extractions are detected, and those frequently have cortex surfaces. Together with the flaking products there are also core sharpenings which are characterised by one percussion platform and one flaking platform (Figure 15.1). The entire ensemble has deep negatives of large size from previous flake removals.

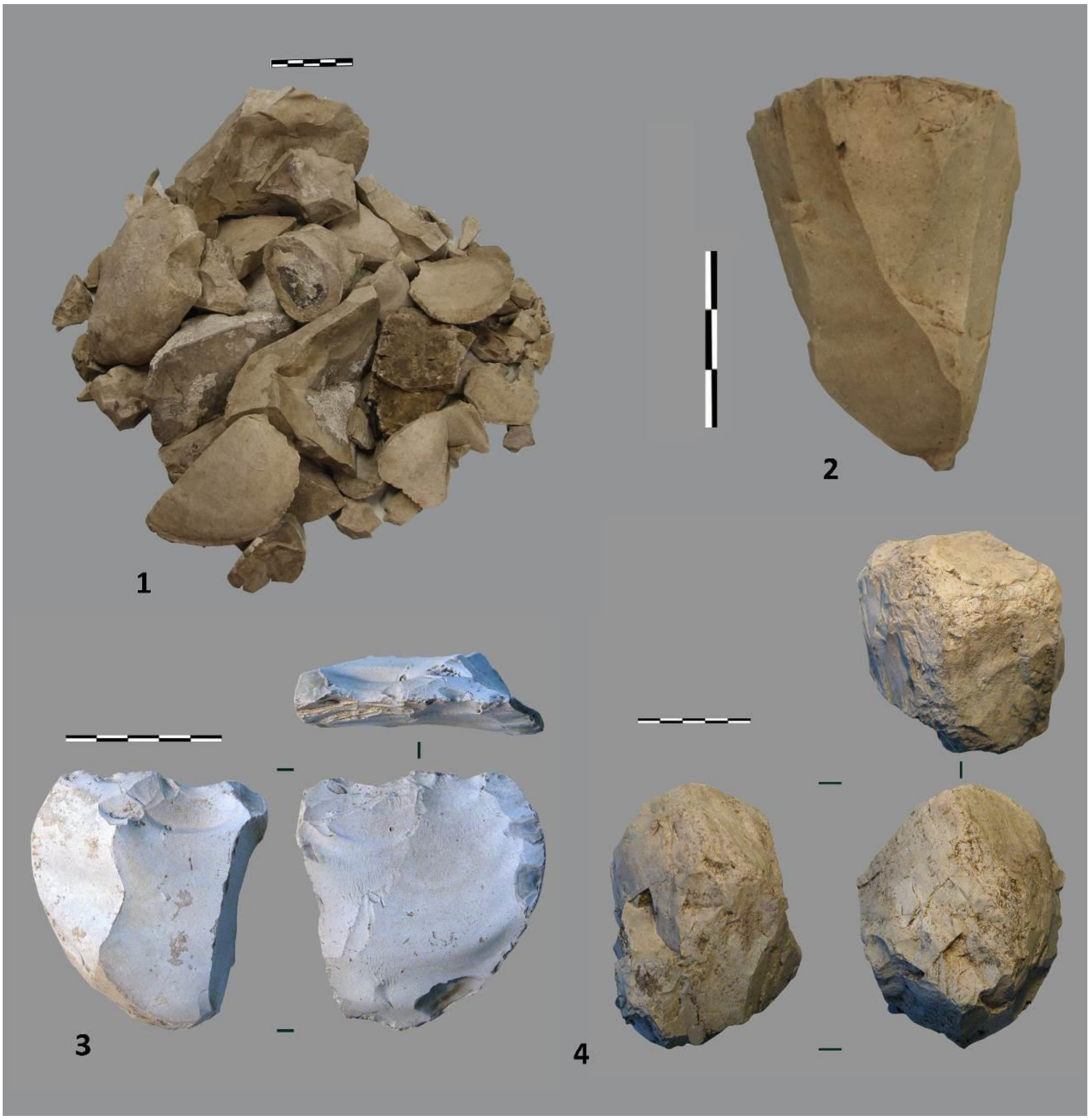

Figure 15. Photograph showing 1) the diversity of lithic material and products of large size and with cortex. 2) Pyramidal core. 3) A wedge - a retouched product that is related with the mining activity of nodules extraction. 4) A core turned into a hammer.

The cores present varied morphologies and formats - well shaped blade technology cores with percussion and flaking platforms, or cores with platforms randomly arranged and with different shapes. There are also natural cores with one or two flake removals, for testing the flint quality (Figure 15.2).

The retouched material is made up of notched and denticulated flakes and blades with the same characteristics as the *débitage* products mentioned above. Projectile points, end scrapers and side scrapers in standard forms were also collected. They are smaller than the other lithic remains and they resemble the typical lithic industries of other archaeological sites of the same age (Figure 15.3). The cores of knappable material with profuse percussion marks are identified as a consequence of their reutilisation as hammers (Figure 15.4).

Finally, apart from the flint artefacts, there are quarrying tools and remains of ophite (dolerite). For example, there are flakes and a block employed as a hammerstone with a roundness to its edges because of the impacts (Figure 16.1). The artefact most representative of the mining industry is a bevelled antler, similar to those discovered at other mining sites and described as a pick (Boguszewski & Lozny 2011) (Figure 16.2).

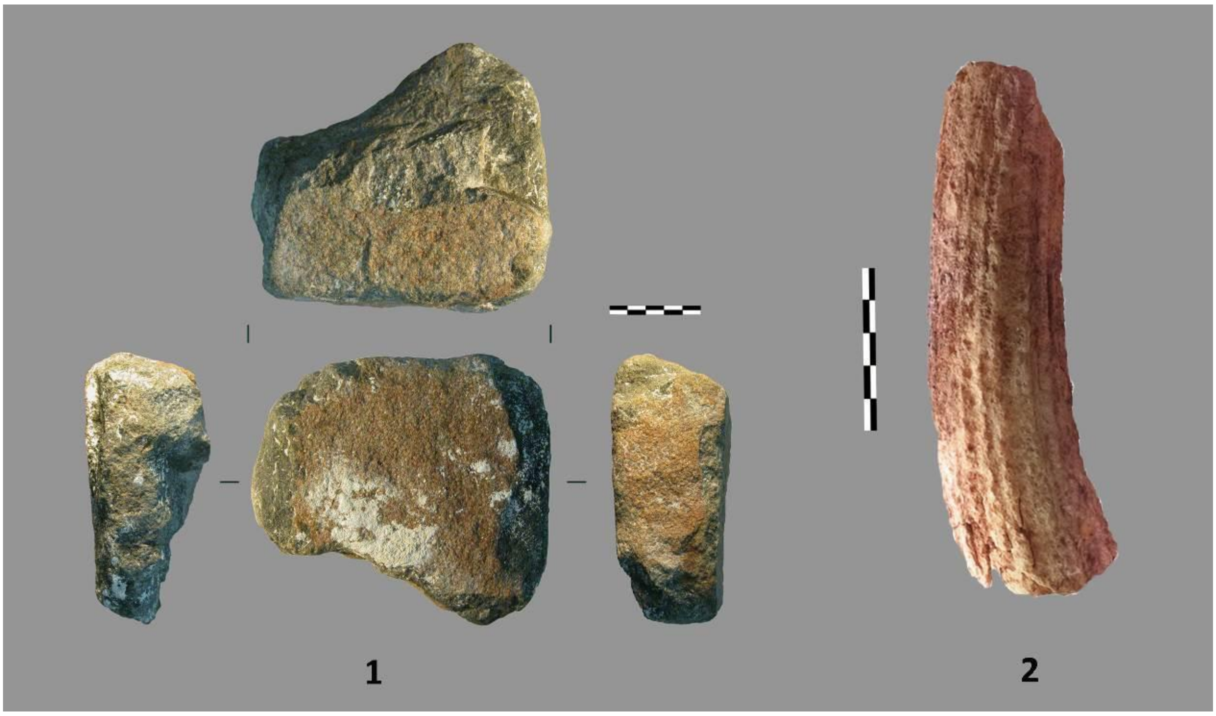

Figure 16. 1. Ophite (dolerite) block employed as a hammerstone. 2. Beveled antler.

5. The flint of Araico and its archaeological context during the Neolithic

During the last decade, in the Basque Country, multiple raw material analyses of the lithic industries have been developed. They evidence the relevance of the utilisation of Treviño flint throughout the Prehistory and define it as one of the main four “Lithological Tracers” that exist in the Cantabrian-Pyrenean area (together with ‘Urbasa flint’, ‘Chalosse flint’ and ‘Flysch flint’).

Many of the studies relating to flint sources focus on the Upper Palaeolithic period. These works confirm that Treviño flint is a “long-distance Tracer”, since it is distributed all along the Cantabrian coast from Las Caldas site (Asturias, Spain) to Brassempouy (Landes, France); covering a distance of more than 500 kilometres (Corchón et al. 2009). In the same way, this type of flint was used during the Mesolithic in the region (Tarriño 2001; Cava et al. 2007-2008).

The excavation of the crescent-shaped dump, presented in this work, permitted the dating of organic materials using C14-AMS. All the dates, including the ones from the bibliography, have been calibrated BC 2 sigma using the OxCal 4.2 program (Bronk Ramsey 2009). Concretely, a deer antler was dated: 4542-4371 cal. BC 2 sigma and a piece of charcoal (*Quercus Robur sp*.): 5056-4830 cal. BC 2 sigma. The two dates match the Middle Neolithic (base of the Middle Neolithic period in the Basque-Country) (Fernández-Eraso el al. in press; Tarriño et al. 2011b). Studies that differentiate Treviño flint varieties in the surrounding Neolithic sites are still not developed; only the generic type has been determined. This information would be interesting if it is compared with the variety extracted from each of the mining structures. In earlier dates than the ones of Araico, this flint appears in the level I of Mendandia site (Álava) (5479-5331 cal. BC 2 sigma) located at a distance of 14 kilometres from the mine (Tarriño 2006). Farther away, in "Sierra de Cantabria", but with similar chronologies, it has been certified Treviño flint: in the upper level IV (4974-4452 cal. BC 2 sigma) and level IV (5530-4550 cal. BC 2 sigma) of Peña Larga site (Álava), as well as in level XV (4599-4347 cal. BC 2 sigma, 4799-4517 cal. BC 2 sigma, 5225-4854 cal. BC 2 sigma) and level XVI (5326-5030 cal. BC 2 sigma) of Los Husos I (Álava) (Fernández-Eraso et al. 2005). For this period the presence of this raw material has been proved in further areas as the coast of Biscay, it is the case of Pico Ramos site where Treviño flint appears. Pico Ramos presents the following radiocarbon dates: 4331-4057 cal. BC 2 sigma, 4897-4547 cal. BC 2 sigma and 5210-4729 cal. BC 2 sigma (Zapata 1995; Tarriño 2003).

As we have already explained, the mining evidences along "Sierra de Araico" are innumerable. So it might be possible that the flint exploitation might have continued during the recent Prehistory. In fact, in the late Neolithic and the Chalcolithic there are multiple evidences of Treviño flint presence, as in archaeological sites close to the mine —Kanpanoste Goikoa case (Álava) — (Tarriño 1998), as in others further —Arenaza I and Picos Ramos (Bizkaia) — (Tarriño 2003) or in megalithic architecture distributed all along the Basque Country (Tarriño & Mujika 2004; Tarriño et al. 2009).

6. Conclusions

The lacustrine-palustrine carbonated outcrops of Treviño ("Sierra de Araico – Montes de Cucho and Busto") are one of the most important silicifications that have been exploited since Prehistoric times in the Western Pyrenees.

One of the varieties of nodular flint is identified and also their exploitations. They have generated mining evidences as vast dumps and trenches with dimensions of thousands of metres long which follow the silicificated geological layers. They are nodular flints in dark colour (high quantity of organic matter), of good purity (few carbonated content as impurities), thin grain (microcrystalline and cryptocrystalline), homogeneous (without clefts or interior structures that condition the fracture) and with a very thin cortex (micrometric thickness that favours the flint to drop easily from the calcareous host rock).

We have identified three types of mining structures along the excavation sector: trenches, linear dumps and crescent-shaped dumps. The excavation was carried out on the mining area previously mentioned, that is a filling structure forming a little depression of 20-30 m diameter. In this way, the layer of flint, in its original position, would outcrop many metres uphill and the exploitations might had advanced until the height reached by the exploitation front might made unviable the flint extraction. In addition, it has been detected that the slag heap overflows on the original mountainside 10-12 metres downhill, drawing the typical crescent-shaped form that is presented in this type of dump developed on mountainsides (Figure 17).

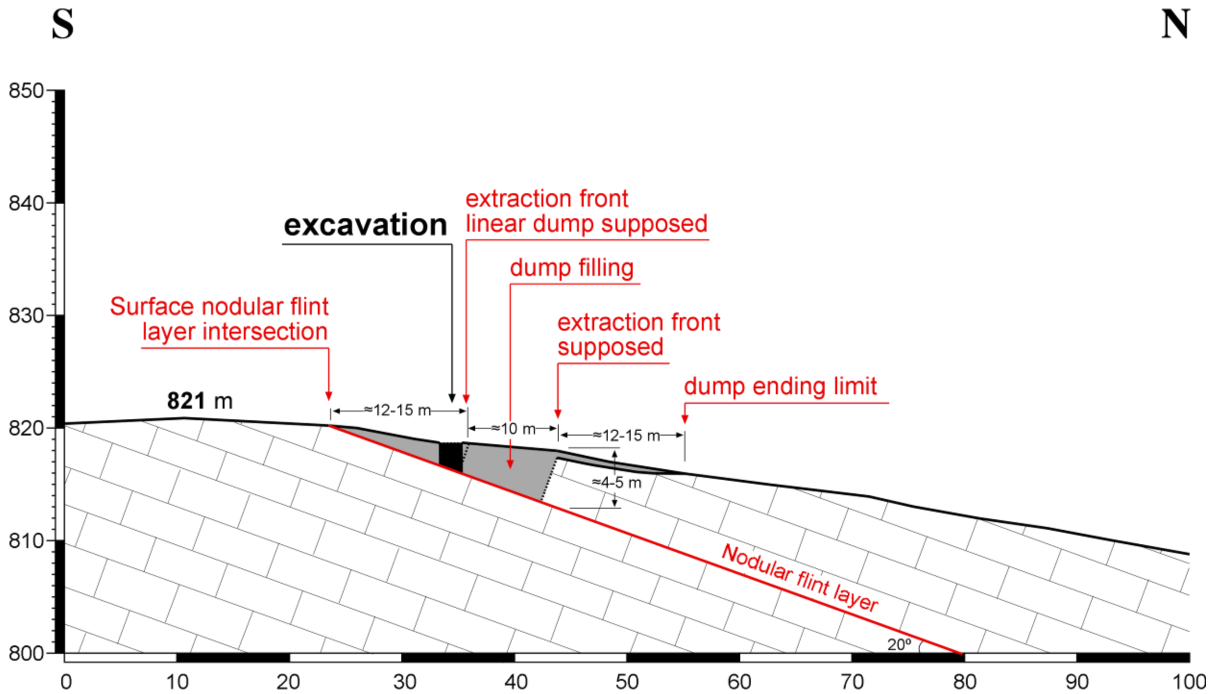

Figure 17. Cross-section of the excavated crescent-shaped dump allows interpreting the mining structure. The layer of flint might crop out many metres uphill and the exploitation have advanced till the height reached by the extraction front might make impossible its acquisition.

The dating made on a charcoal fragment (*Quercus robur sp*) and a piece of deer antler revealed an antiquity ca. 5000 cal. BC. The dates fit in with the Middle Neolithic of the chronological sequence for the Basque Neolithic period. At present, the gathered data are not clarifying to understand who the people that exploited the mines were and their socio-economic behaviours derived from this activity. However, we know the existence of a Neolithic and Chalcolithic settlement of La Renke in the Rojo River, which is located in the south of “Sierra de Araico” (Lobo-Urrutia 1997). In the same way, in the field surveys carried out by Estavillo and later by the Rojo River survey team, there were found numerous remains that proved other settlements in the area. Therefore we consider the possibility that these places were directly related to the exploitation and control of the flint mining. Nevertheless, this is one of the principal hypotheses that must be corroborated as long as the investigation progresses. Additionally, the obtained dates fit in with the approaches which explain the neolithization process from the Ebro Basin (Fernández-Eraso 2008).

In a quantitative level, the huge amount of *débitage* products and natural chunks opposite to the retouched products, cores and core sharpening. Almost the totality of the products presents cortex. The flint nodules with marks have the same morphological and volumetric characteristics, what we interpret as a testing to check their quality and possibilities.

In a qualitative level we noticed various groups; tools for the mining exploitation, hammers and percussors, picks and wedges. Another set standardised and with common characteristics of any prehistoric context, as scrapers, end scrapers, denticulates, etc. And finally a group of artefacts that are out of the typological classifications that we can interpret as fortune tools, where hard formats are searched and with double-face laterals for performing some work, possibly a mining work.

Furthermore, the mining exploitation forms have been confirmed and defined, specifically those structures which were assumed from the information of surface materials. The excavation revealed an intensive open-air exploitation that is developed longitudinally. This exploitation method is determined by the Geology that does not allow the construction of underground galleries. That is why the flint nodules extraction is developed along the unconsolidated lacustrine-palustrine limestones.

Finally mention that the prehistoric mining structures of Treviño that have been described are an exceptional mining complex for the Iberian Peninsula. The most complete information about mining exploitation is the work of Casa Montero (Madrid), dated ca. 5000 cal. BC (Díaz-del-Río & Consuegra 2011). However, the flint exploitation techniques and structures are different in both cases, although they have similar chronology. This is why it is necessary to go in depth into Treviño mines knowledge: i) Delimitation of the mining complex, one of the most extensive of Europe discovered till the moment with more than 2,000 Ha; ii) Continue the identification of new mining exploitation structures by excavations and field surveys; iii) Track flint in prehistoric sites (Palaeolithic, Mesolithic, Neolithic and Chalcolithic) and in an interregional perspective; iv) Continue the characterization of new varieties of Treviño flint; and v) Definitely, understand the socio-economic impact of the exploitation in the prehistoric societies.

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Summary, synthesis, and annotated bibliography articles

Identifying the signs: The Middle to Upper Palaeolithic transition in northern Iberia from the perspective of the lithic record

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Abstract:

The lithic record, together with archaeozoological remains, makes up the most abundant assemblages at European Palaeolithic sites. During many decades in the twentieth century, the classical typological analysis (the Bordesian paradigm) has been used to articulate the sequencing of the different cultural and chronostratigraphic units. At the same time, since the 1960s an alternative methodology known as Analytical Typology, proposed by Georges Laplace, has been available. The sophistication of the statistical procedures used by Analytical Typology is the reason given by many prehistorians for avoiding this approach, in the same way that the limitations in the quantification of the results ended up discrediting Bordes and Sonneville-Bordes' method. As a first paradox, the same reasoning (in the opposite direction) rules out both methodologies. In addition, by ignoring the typological approach, we give new life to technological analysis, where qualitative information is provisionally prioritised over quantitative data. If we aim to describe the process of transition or change, then, as we have said on various occasions, the reading of the lithic record should be holistic, and cover typometrical features, the raw materials, technology, function and certainly typological traits. The alleged difficulties about the description of the different variables, their quantification and statistical analysis have been solved for some time in Laplace's methodological proposal. Ignorance of this methodology cannot be given as an excuse, fifty years after it was first formulated.

Keywords: Palaeolithic, lithics, Typology, Technology, Raw Materials, Historiography

1. Introduction

By far the largest part of the objects found in the course of archaeological excavations consists of the lithic assemblage, together with faunal remains, in comparison with other

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aspects of the Palaeolithic record, such as evidence of symbolic behaviour, anthropological remains and even artefacts made from organic matter. It should be noted that the interpretative weight of each part of the record cannot be directly proportional to its physical weight. It is true that the positivist urge that gripped Palaeolithic archaeology for over a century gave a disproportionate weight to industrial assemblages and Archaeology still suffers the inertia of such excesses. However, the pendulum of Epistemology should reach a position of balance between granting disproportionate importance and ignoring data which, from a quantitative point of view, is sometimes of overwhelming value.

2. Short historical summary of the methodology of obtaining and analyzing lithic information

To obtain a precise view of the method used to study lithic assemblages in the Middle-Upper Palaeolithic transition, we must examine the question from a diachronic perspective. Indeed, the transposition of the concept of the fossil-guide used in Geology to particular types of lithic implements marked the first decades of the articulation of the Palaeolithic in general. Until prehistoric Archaeology underwent its first great crisis of thought, with the Processualist debate in the 1950s and 60s, the level of the reading of lithic techno-complexes was schematic and sometimes caricaturesque (Arrizabalaga, 1998). The identification of supposed fossil-guides in small European regions tended to mark the start of new proposals for cultural systematizations, which spread uncontrollably across Eurasia.

After the 1960s, the science reorganised its ideas in accordance with the new parameters. There were three sides to the reawakening of lithic studies applied to this period: the quantitative aspect (which was considered essential for it to be a true Science); the holistic view (to typology that had been predominant until then were added aspects such as raw materials, typometry, technology and functionality); and a more universal ambition, which included a description of these techno-complexes outside Europe. Although it took place in a disorderly way, the progressive implantation of protocols for the study of raw materials, typometry, technology, morphotypology and use-wear analysis has enabled, above all since the 1980s, an advance in our knowledge that had previously had been unimaginable. At the present time, the lithic record possesses enormous potential to explain the circumstances of a site, its position in chronocultural coordinates, the way of life of its occupants, its functionality, adaptive strategies and the exploitation of the environment, and so on. The internal dynamics of the studies have varied in different geographical areas, although in general, typological analyses have lost part of their interpretative weight in favour of other approaches, to varying degrees. Whereas French specialists have apparently ousted Typology radically in favour of studying raw materials and technological analysis, in the Anglo-Saxon world, more attention has been paid to use-wear analysis, and Typology has not been displaced, even if this aspect never held a preferential place within the concerns of the latter School.

Therefore, in the last three decades, there has been an accumulation of alternative approaches to the classic one, playing down the importance of typological research and stressing the value of the new disciplines. In the mid-1960s, to study the lithic techno-complexes of hunter-gatherer groups, there were two main proposals, both of which originated in France. These were, on one hand the accumulative method of François Bordes and Denise de Sonneville-Bordes (Bordes 1961; Sonneville-Bordes and Perrot 1954, 1955, 1956a and 1956b; Sonneville-Bordes 1985), and, on the other hand, Georges Laplace's method (Laplace 1954, 1957, 1964 and 1966). The Bordes - Sonneville-Bordes method is very well-known in its premises. It begins with a definition of a series of lithic types, which are regarded as characteristic of different periods and which are given a number in a Type-list.

The statistics of these types in the archaeological units being described is visualised by simple indices (of end-scrapers, burins, etc.) and an accumulative graph which shows the "typical" profile of the period represented by each level, as it adds the different tools included in the reference list to the total. Following the publication of a direct criticism to the fundaments of the method (Kerrich and Clarke 1968; Sonneville-Bordes, 1975), the validity of the criteria used to define the types, their quantitative value and the meaning of the graphs began to be questioned.

Almost at the same time, G. Laplace developed so-called Analytical Typology (Laplace, 1966). The theoretical fundaments of this approach are much more elaborate, and thus avoid the most obvious faults to the Bordes - Sonneville-Bordes method. Instead of establishing the associations of characters (types) thought to be significant a priori, the articulation of retouching on a tool is broken down into successive hierarchical levels, individually described according to the successive structures that are discriminated. The quantitative evaluation of the real meaning of all the variables described is performed with a sophisticated statistical method which filters out the noise generated by small ensembles or those exhibiting little internal contrast. In this way, it is thought that the information used to reconstruct the techno-complexes is sufficiently hierarchic, detailed and statistically significant to tackle the second part of the method, referring to its quantitative and statistical reading. Due to its characteristics, this method also allows easy comparison between the different assemblages studied with the same methodology, thus multiplying its interpretative potential.

G. Laplace's approach is much more than an alternative Typology (Laplace 1963). In the first place, in its successive stages it foresees the mechanisms to include the main variables that can be described (physical, typometric, technical, modal and morphological structure), except for functional information. Secondly, it is less pre-determined that the Bordesian method, in that it applies an identical protocol to the techno-complexes, irrespective of their initial cultural classification, which can give some surprising results (and is especially suitable for the description of transition processes). Thirdly, it involves a theoretical conception of the material reality, technology and its diachronic evolution, which enables new proposals to be made for cultural systematization and firm proposals in terms of the techno-typological development of Palaeolithic communities, in a geographical and temporal setting. We might add that the method is open to new proposals, as long as these can be systematised within a general framework with no special difficulties. Finally, it adds an elaborate statistical treatment to the analysis of the data, which places the measurement before all else, in terms of the statistical significance of the sample we are working with, in comparison with the wider context of analysis. Consequences of the application of this method to large areas of southern France and northern Spain (Arrizabalaga, 1995a) have been, among others:

- the vindication of the transitional nature of the Chatelperronian.
- the proposal of endowing special importance to the Proto-Aurignacian (in the successive French sequences, Correzian, Perigordian II, Aurignacian 0 or Archaic Aurignacian) as a techno-complex representing a sudden acceleration in the leptolithisation process. (The latter terminology has been trivialised by making the Leptolithic equivalent to the Upper Palaeolithic).
- the proposal of simplifying the EUP sequence, from the embers of the model originally proposed by D. Peyrony, reignited by D. Sonneville-Bordes. This is in terms of the Chatelperronian-Aurignacian-Gravettian succession and not of the parallel development of two Aurignacian and Perigordian phyla, as had been proposed previously (Peyrony, 1936, 1948). As Laplace foresaw, no stratifications have been documented between the Chatelperronian and the Aurignacian, as might have occurred if both phyla had developed in parallel (Zilhao et alii, 2008).

In view of the premises noted above and the perspective several decades of work has given us since the seminal proposals of both interpretation systems, it might seem logical to think that the best of each method would have been added to the techno-typological reading of EUP lithic assemblages. However, this is not the case. The criteria of the school dominating in French Palaeolithic circles for three decades imposed the Bordesian paradigm and disregarded (or eluded, ignored and boycotted) Laplace's proposal of Analytical Typology. Analytical Typology, which was received better outside France (in northern Italy and Spain) than in France itself, would only be reappraised later (in the 1990s) when almost all French Palaeolithic scholars had forsworn typological proposals in favour of the technological approach. In this epistemological shift, which affected new generations massively, all typological systems were accused of the defects attributed by Kerrich and Clarke, among others, to the type-list criterion as originally proposed by Bordes and Sonneville-Bordes. These included deficient quantification, of which Analytical Typology cannot be accused.

From a historiographic point of view, it is much more difficult to explain why a methodology is ignored, than why an alternative is accepted. Indeed, practically all the papers on lithic assemblages at Palaeolithic sites published in France in the 1960s, 70s and 80s tacitly or explicitly adopted François Bordes' (Lower and Middle Palaeolithic) or Denise de Sonneville-Bordes' (Upper Palaeolithic) type-lists. The arguments put forward for their use include their simplicity, intuitive nature, easy visualization and even "proven value". These arguments are even used after the construction of units of formal value on the basis of an accumulative type-list had been shown to be wrong. In contrast, we know of no detailed account explaining why the approach proposed by Laplace was not taken up. We have to resort to unwritten reasons: that it was a "complicated" approach, that it treated lithic techno-complexes as if they were a living creature (undervaluing the human factor and creativity) or that it used excessively sophisticated statistic calculations that make one forget, once again, that we are dealing with human production. Obviously, the weight wielded in this decision by the criterion of school is never expressed frankly.

Thus, the first striking paradox in this explanation is consummated. The dominant criterion used to abandon the Bordesian method (the deficient quantification of its interpretations) is the same one used, in the opposite sense, to elude the alternative proposal, which solved that aspect satisfactorily ("it includes excessively sophisticated statistics", they say). If, with the perspective given by time, we are unable to evaluate the essential role of statistics in the articulation of Human and Social Sciences, there is no point in making evenemential historiography. However, in addition, the massive shift of new generations of French Palaeolithic scholars towards technology has not led to the adoption of more sophisticated quantitative protocols, and this is one of the problems most often regarded as unsolved within that approach.

Unfortunately, the main actors in this personal and methodological lack of understanding disappeared a long time ago. Perhaps it is now time to make a methodological and historiographic assessment of what one or other school has contributed towards an understanding of EUP societies and the transition process from the Middle Palaeolithic. While this transition is acknowledged, since the Bordesian paradigm uses different type-lists (between which there are no connections) to study Middle Palaeolithic and Upper Palaeolithic techno-complexes, it will be very difficult to observe common traits denoting an industrial transition between both traditions.

3. Major developments and main contributors to research about the transition to the Upper Palaeolithic in Cantabrian Spain (north-west Iberia)

As in the whole of Western Europe, the study of the EUP or the transition between the Middle and Upper Palaeolithic has made unprecedented progress since the early 1980s. Few significant sites with levels attributed to the late Mousterian, Chatelperronian, Proto-Aurignacian or ancient Aurignacian have not been excavated or re-excavated. This is the case of key sequences in the regions of Asturias (El Conde, La Viña, Sopeña, La Güelga), Cantabria (Cueva Morín, Covalejos, El Pendo, El Castillo, Cobrante, Esquilleu) and the Basque Country (Axlor and Antoliñako Koba, in Bizkaia; Lezetxiki, Amalda, Zerratu, Labeko Koba and Aitzbitarte III, in Gipuzkoa). To these sixteen main excavations, we can add a similar number of smaller-scale actions at open-air sites (with much simpler stratigraphy) or in caves (isolated levels, such as at Balzola in Bizkaia, or containing very few remains, such as at Ekain, in Gipuzkoa). The publications with the proceedings of two conferences (Montes and Lasheras, eds., 2005; Cabrera, Bernaldo de Quirós and Maíllo 2006) reflect the recent state of the art in this part of Spain. In our opinion, this proliferation of work has not led to an equal multiplication in the information, partly because of the lack of a common methodology and an epistemological reflection on the characterisation of the periods in the transition.

Just as at other sites of a similar chronology, the imbalances in the record we noted in the first part of this paper can also be seen in Cantabrian Spain. Owing to the low number of artefacts made from organic materials that have been conserved in these levels, by far the largest part of the remains found at the main sites consists of faunal remains (accumulated either by humans or carnivores) and lithic industry. The improvements in excavation methodology, with the generalized wet or dry fine screening of the sediment, have favoured the exhaustive recovery of the lithic assemblage, unlike in old excavations, which has enabled an integral view of the chaîne opératoire.

Empirical Typology (Sonneville-Bordes and Bordes' type-lists) has been applied to nearly all the ensembles that have been cited, although it has only been used descriptively for the retouched portion ("tools") of the chaîne opératoire. Some considerations have occasionally been added related to the primary level of the raw materials used (flint, quartzite, limestone, ophite, etc.) and a typometric graph of the kind proposed by Bagolini. Similarly, as an alternative to the "classic" typological analysis, the protocol of technological analysis has been applied exhaustively to certain lithic assemblages. Among the various collections to which this kind of analysis has been applied, we can highlight the studies published of Amalda (Baldeón 1990) and Esquilleu (Baena et alii.2002, 2005 and 2006), with a marked technological character.

For the reasons given above, spreading from a Basque and Catalan nucleus, Analytical Typology has been used above all at sites in the eastern sector of northern Spain, with a different view. The research associate variables related to the five structures recognised by Laplace in his works, and listed above (physical, typometric, technical, modal and morphological). Technological study, as it was understood from the empirical viewpoint, represents a fundamental complement when describing the dynamics of the assemblages, but these variables are difficult to codify and, even worse, to treat quantitatively in a way that has any meaning. To give a rather schematic example: a refitted Levallois core, in a collection with another 100 insignificant cores, does not meet the requirement of minimum numerical pertinence to be treated quantitatively, but it does require a singular qualitative assessment when the collection is being described, above all if it is supported by the presence of other remains in the same series, such as Levallois flakes supposedly made from another core. The significance held by singular elements in the description of an assemblage is corrected drastically, in this method, in accordance with their numerical weight. Among the authors who have contributed especially to this approach, we can cite Sáenz de Buruaga, Aguirre and Arrizabalaga, with monographs on lithic techno-complexes at sites such as Gatzarria (Sáenz de Buruaga 1991), Antoliñako koba (Aguirre 2000), Cueva Morín (Arrizabalaga 1995b, 1999d) and Labeko Koba (Arrizabalaga 2000), as well as synthesis for the eastern part of northern Spain (Arrizabalaga 1995b and 1999c).

All these contributions, together with the studies referring to particular levels or the technological dynamics of particular stratigraphic series at La Güelga (Menendez et al. 2009), Sopeña (Pinto-Llona et al 2012), El Castillo, Covalejos, Amalda, Axlor, Lezetxiki and Aitzbitarte III (Ríos-Garaizar et al. 2011) have laid on the table an open and varied range of methodological proposals, to be discussed below.

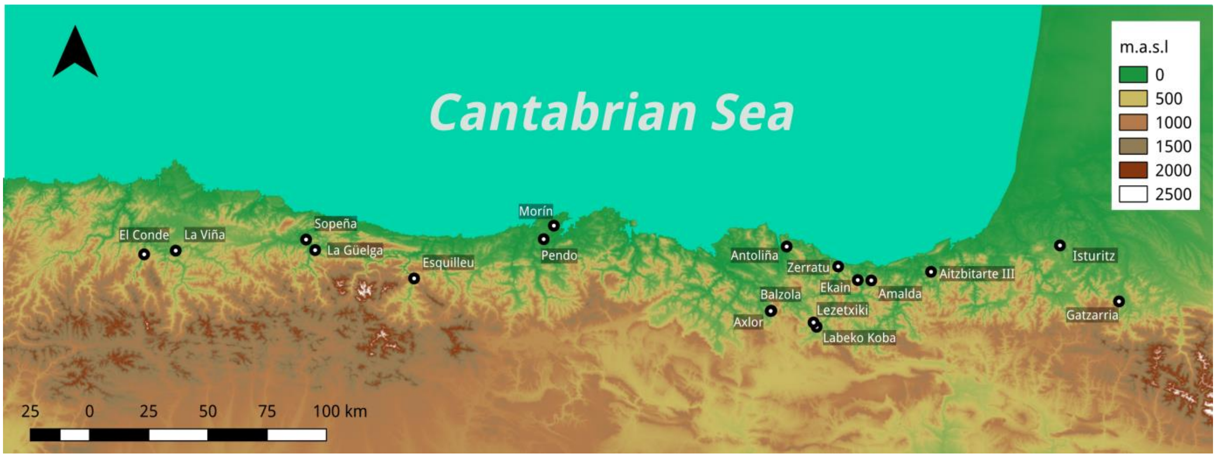

Figure 1. Map of the Cantabrian Iberian, with the cited sites.

4. Discussion

In the first place, we must state that this presentation aims to discuss and propose a methodology, and not to review the historiography and seek responsibilities for how we have reached the present situation. From this viewpoint, taking into account the trends that have consolidated in modern research on the transition from the Middle to Upper Palaeolithic, we would like to make a constructive proposal of a protocol for studying lithic assemblages, which will have to be adapted to the circumstances of each site. Not only the unique conservation conditions at each site, but also the methods of excavation, screening and recording, influence greatly in the last state of the assemblage.

We propose that we should lead the study of lithic evidences towards a holistic approach where all the evidences of lithic record will be analyzed in an integrated perspective to get a full view of a complex manifestation of prehistoric human behaviour.

From this reason, the protocol used for lithic assemblages should consider, as far as possible, many significant features connected with the distribution, including raw materials, the typometric characterisation of the assemblage, several technological aspects, a morphotypological description, functional assessment and as much topographical meta-information as it is possible to add. The information should be ranked and codified in such a way that it can be compared both with other sites and other stratigraphic units in the same deposit. Finally, there must be a statistical treatment of sufficient detail to be able to filter out those ensembles that are irrelevant because of their numbers, accumulation of elements on a category or excessive fragmentation of the sample.

A first approximation in this line suggests an adaptation of the general framework proposed by Laplace (which includes the systematization and ranked arrangement of characters, and advanced statistical treatment). It should be enlarged to include information about the raw materials and the technological description, implementing sampling of use-wear marks, with a systematic comparison of the spatial distribution of the different variables used. Within a generic framework of the neutral description of the series and primary types, it is reasonable that, for empirical study, some types formed by repeated associations of proven chronocultural value (for example, Mousterian and Chatelperronian points, Noailles burins and Dufour bladelets) should be assessed in an individualised way. This in no way stops these primary types from being included in the overall statistical calculations in identical conditions.

If the objective for each assemblage of objects is to accumulate a sufficiently large sample to be able to obtain significant conclusions, before all else we should take care in not losing sight of what we are studying and why. The universe we are characterising will give rise to different samples depending on the variables we are analysing. If, for example, we only describe the typometry of whole artefacts when they conserve the platform, by adding all the proximal fragments, the previous sample will be increased considerably. According to this principle, the primary division of the whole assemblage will be based on whether the pieces are retouched or not. Much of the fair criticism made of Typology and Technology comes precisely from the respective lack of interest in one of those two parts of the assemblage (Arrizabalaga & Maíllo-Fernández, 2008). It is essential to study both of them at the same time with a rigorously equal protocol, enabling the reading of the entire assemblage and of its parts, when this might be significant. This will be the case, not only of morpho-technical or "typological" analysis (a form of retouch can only be described for retouched artefacts) but also of other, less obvious kinds of analysis, such as functional features. A final general consideration refers to the use of Statistics to characterise lithic ensembles. Before applying techniques specifically designed to be used with lithic assemblages, a $\chi 2$ test should be carried out to evaluate the pertinence of later tests based on the proven significance of the sample.

Lithic raw material can be described universally, in the whole assemblage being studied, though in greater detail in the dominant part of the sample. For statistical purposes, one difficulty is often the regional attribution of a reference raw material (flint or quartzite in Cantabrian Spain) which makes up over 90% of the assemblage and unbalances the statistical perception of the whole noticeably, hindering a reading of its dynamics. The inclusion of sub-types (based on the provenance if it can be determined) in the dominant raw material may help to correct this perverse effect of statistics (Tarriño, 2006).

The typometric characterisation of lithic industry has traditionally been performed in two different ways. The most common one, as proposed by Bagolini (1968), discriminates a set of modules of length and elongation (bidimensionality) obtained by a division of the linear base of the dispersion plane of the dimensions of each unfragmented object. Laplace's proposal is slightly different (Laplace 1974a and 1977), as it refers to the three dimensions of each object (tridimensionality), provides a measurement criterion (insertion in the smallest rectangle or cube) and various synthetic indices, and divides the space with logarithmic curves (based on Fibonacci's series). Laplace's proposal is more complete but more complicated to carry out and monitor. If we had to adapt a single proposal, we would propose to systematise the measurement criterion (Laplace's method or any other is acceptable, as long as it is explicit and consistent, and affects the three main dimensions). We would maintain the indices proposed by Laplace, even if they cannot be treated statistically, as they are not a continuous variable, unlike direct measurements. As regards the position on the length/breadth dispersion plane, both Laplace's and Bagolini's methods finally require a graphic representation, as modules cannot be assigned easily based on the measurements themselves. We could accept either of the methods or develop a third with modules assigned directly based on the objects and their indices, with numerical thresholds that are indicated explicitly.

Other perspective can be proposed for typometrical analysis based on non aprioristic classifications or indices, even if used for archaeological purposes not directly related to lithic analysis. Many statistical methods as K-means (Kintigh 1990) or Mixture analysis (Monchot et al. 2005) serve to distinguish size groups within a continuous distribution. This has been successfully used to identify size-related specific productions in Middle and Upper Palaeolithic (González-Urquijo et al. 2006; Rios-Garaizar 2010).

We believe this last aspect to be of high value, because the characterisations of the assemblages corresponding to the transition in Europe are full of imprecise descriptions that avoid the quantification: “assemblage with many blades”, “series still with debitage on flakes”, “tendency towards microlithics”, etc. Whatever criteria are adopted to measure the objects, represent and interpret their distribution and assign them to modules that are later studied statistically, these should be made clear and explicit in the publication of the results. As has already been stated, the basis of the statistical treatment of Typometry could be the distribution of ranked modules that combine various intervals of different of the dimensions taken. However, other alternatives have also been considered (Arrizabalaga 1997, 1999a and 1999b).

In the last decades, lithic technology has substituted somehow the bordesian typological classifications as the method to describe and name a given lithic assemblage in Western Europe. Born with a different purpose, technological approaches have slid from the analysis and description of technical processes to the recognition of particular features or technical systems, that can be linked with determinate cultures or periods, becoming so the new taxonomy of lithic industry. Improved with Experimental Archaeology, the refitting of punctual lithic sequences and the reading of diacritics, this updated technological approach has been able to define real techno-types and to give us an accurate tool for a better understanding of the lithic production mechanisms. That can be exemplified in the works of Pellegrin about Chatelperronian, or the current structuration of Aurignacian based on the features of the bladelet production. The main potential problem of this view is that they could fail in the same errors as typology, trying to fit discrete and contextual behaviours into cultural classifications. Nevertheless the precise definition of different technical procedures has been crucial for the use of technological approaches as a way to understand technological organization. This economic focus is more present in the US technological approaches (Kuhn 1995, Tostevin 2000) and has been used also by some French and Spanish scholars (Moncel et al. 2011).

Use wear analysis had played a less relevant role in these studies. There are different problems with this method derived from the expertise based, non-quantitative, recognition of wear traces; the problems of conservation that bias the possibilities of use interpretation; the dependence on true experimentation and the impossibility to produce direct cultural interpretations as was intended in the Binford-Bordes discussion. This tendency has been turned in the last decades and use wear has been applied to recognize concrete and highly significant types of tools as points or armatures (Galván Santos et al. 2007-2008; Normand et al. 2008; Plisson and Schmider 1990; Porraz et al. 2010; Rios-Garaizar 2008; Villa et al. 2009) and to assess questions about technological organization or space use (Bourguignon et al. 2008; Grigoletto et al. 2008; Ortega et al. 2006; Ríos-Garaizar 2010; Texier et al. 1998).

The technological variable is probably the most difficult to rank and quantify in a systematic study. There is clearly the possibility of classifying the whole assemblages according to concepts that will give information about its integrity (fragmented pieces compared with whole pieces), or the Chaîne Opératoire (balance between the different parts of it) or the functional characterisation of the site (workshop, hunting post, settlement, etc.). Equally, there is evidence that can help us to situate the assemblage chronoculturally (such as the classification according to the platforms that have been preserved). Certain portions of the

Chaîne Opératoire which are usually abundant and may have interesting technological readings (cores, refreshing flakes, burin spalls, etc.) may be classified and analysed individually. However, most of the variables with technological importance tend to be under-represented and should be analysed specifically, from a qualitative viewpoint. Thus, if a re-fit can be completed, if the presence of knapping techniques such as Levallois, Kombewa and centripetal, is observed, the assessment of this data will be qualitative rather than quantitative. The same can be said about the main analytical tools of the French Technological School for the study of Palaeolithic assemblages: refitting, "mental refitting", a diacritical reading and the articulation of the functional study with the most technological part of the reconstruction (Inizan et al. 1995; Karlin 1992; Pelegrin et al. 1988). All these, although they provide very relevant information for an understanding of the series, hardly meet the conditions laid down for strict quantitative analysis: ranking of characters, codification of the variables and crossing a statistically provable threshold of significance. This does not reduce the analysis to irrelevance, from a quantitative point a view, but it does force us to think of this information on a different level until the difficulties can be overcome at least partially.

Nevertheless the identification, classification and measurement of certain technological traits (as typometry, section morphology, platform morphology and dimension, knapping angles, number and orientation of previous scar removals, section curvature, presence of cortex, etc.) can be produced to obtain sufficient base to characterize statistically different productions and the degree of reduction sequence fragmentation. Controlled knapping experimentations offer also a quantitative base to compare the expected panoply of lithic remains derived from each production with the real lithic assemblage.

The last level to be studied is the modal-morphotechnical one, which mainly affects retouched ensembles, "tools" and "implements". In general, the classification and description of forms of retouch, typological groups and primary types proposed by Laplace (Laplace 1974b and 1987) was formulated bearing in mind the described protocol of quantification, which does not imply that it cannot be improved, particularly for some typological groups, such as the Bc (becs) for example. Recently, from the viewpoint of technology, complementary, and not alternative, analytical mechanisms have been proposed for primary groups, such as burins, end-scrapers and backed artefacts. In our opinion, the association of characters recognised as significant and specific (not attributable to chance or convergence) may equally be taken into account, to enrich the descriptive discourse of the assemblages. However, in our own experience, these are somewhat intangible in more detailed research, because of their very nature: the association of characters that are related to a particular type is usually so intuitive and intricate that no variable is exclusive to the type or exclusive for its classification. In short, they are typological paradoxes, unusual but recognisable.

At this modal-morphotechnical level, Analytical Typology reaches the status of meta-methodology. As well as the classification, description, breaking-down into characters and systematization of the lithic material record of Palaeolithic groups, it then proposes its use according to the elementary rules of Statistics to reach conclusions about the diachronic evolution of the material culture. Leaving other considerations on one side, the level of descriptive standardisation enabled by Analytical Typology favours a rapid comparison between the results of assemblages from a diachronic sequence, between deposits believed to be coetaneous, and across wide regional contexts, using both viewpoints. This gives Analytical Typology high potential for wider use, unfortunately underemployed.

Finally, outside the range of the direct application of this discipline lies the exploitation of the topographic meta-information about the lithic record. If we include the position of each object in the deposit together with the rest of the information, we will obtain an extremely powerful tool to explain the functionality of the site and its possible differentiated activity areas, the integrity of the stratigraphic record, the character of simple occupation or "palimpsest" of the unit being studied, and so on. However, this level of the analysis should be the topic of a different study, owing to the quality of the information it provides. To say the truth, this approach should be placed among the great contributions to technological studies made by French Palaeolithic scholars in recent decades.

5. Conclusions

The reconstruction of the evolutionary processes in lithic techno-complexes during the Palaeolithic in general and the Middle-Upper Palaeolithic transition in particular has been hindered by the diversity in the methodologies used to approach it (Clark, 2009). Some proposals are even teleologically hostile to the description of transition processes as they use different premises according to whether the ensemble is thought to belong to the Middle Palaeolithic or the Upper Palaeolithic. Underlying this first choice between Bordes' or Sonneville-Bordes' type-lists is certain biological prejudice about which human species was responsible for the respective material cultures and the impossibility of any information being transmitted between each species. As can be argued from a superficial reading of the Middle Stone Age in Africa, attributed to modern humans, it is not even necessary to foresee any transfer of technological information between the species, though this is not the discussion that interests us here. In our opinion, if we aim to advance in the right direction, in the first place we should adopt methodological conventions that allow us to compare the results obtained for different chronologies (particularly from both sides of the transition process), stratigraphic series and regions, confident that the similarities and differences are not related to the different approaches used. We are proposing some general lines for this reshaped analytical methodology for the lithic record, after explaining the reasons that have guided us in the adoption of different alternatives. As a final goal, we always pursue the verification of our impressions through statistical tests that enable us to filter out background noise.

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Book reviews

Book review: Archaeological Concepts, Techniques, and Terminology for American Prehistoric Lithic Technology

Harry J. Lerner

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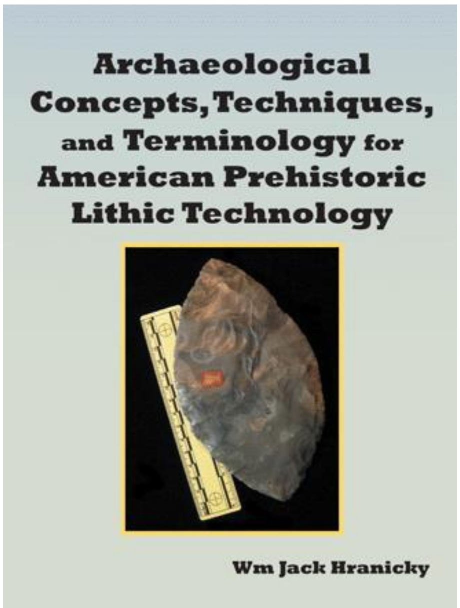

Archaeological Concepts, Techniques, and Terminology for American Prehistoric Lithic Technology
by Wm. Jack Hranicky
AuthorHouse, Bloomington, Indiana, 2013, pp. 611, ISBN 978-1-4817-5173-5
http://bookstore.authorhouse.com/Products/SKU-000628731/Archaeological-Concepts-Techniques-and-Terminology-for-American-Prehistoric-Lithic-Technology.aspx

Wm. Jack Hranicky's book *Archaeological Concepts, Techniques, and Terminology for American Prehistoric Lithic Technology* is a thorough and comprehensive compendium of all things lithic in North America. This book was originally published in 1986 as *Dictionary of Terms for American Prehistoric Projectile Points* (Special Publication No. 15, Archaeological Society of Virginia), then revised and expanded in 2004 as *An Encyclopedia of Terminology and Concepts for American Prehistoric Lithic Technology* (AuthorHouse).

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This third iteration is a truly exhaustive reference work that is organized into two basic sections, an introduction to the discipline in general and to lithic research in particular, followed by an alphabetical listing of terms, techniques, and methodologies of interest to any lithic analyst.

The background section, occupying the first 70 pages, covers a wide variety of fundamental issues and questions, including: defining archaeology, the role of archaeology in the modern world, the concept of prehistory, conducting archaeological research, ecology and environment in archaeology, ethics in archaeology, the nature of technology in both theory and practice, history of lithic research, study of lithic technology, classification of lithic technology, defining tool types, tool types as culture history, role of Native Americans in archaeological thought and practice, people that do archaeology and the reasons that they do it, and many others.

The rest of the volume is an exhaustive alphabetical listing of concepts, terms, procedures, and principles that have, and continue to, inform lithic research across North America. The entries cover everything from basic definitions (e.g., chert, core, flake, etc.) to more advanced concepts (e.g., line of motion, means-end analysis, ocicular point, etc.)

This publication is designed to provide as full and diverse an analytical toolkit as possible for lithic researchers of all stripes. The author himself points out that this volume is not a 'how-to' manual but rather a comprehensive resource for describing the myriad concepts, techniques, and methods commonly used in lithic research. It is also aimed at as wide an audience as possible. It is geared to be an equally useful aid to academics, avocationalists, hobbyists, or anyone interested in lithic technology.

Although there is a tendency towards colloquialism in some of the phrasing, the considerable scope of this volume certainly makes up for any perceived informality. It offers a general overview of the origins and subsequent evolution of lithic analysis, highlighting both its limits and potential. It does not shy away from the many intrinsic complexities of archaeological inquiry, but its purpose is not to offer any easy answers to the many difficult issues routinely faced by lithic analysts. Rather, it serves up all options open to researchers so that they can make fully informed decisions in designing their individual studies. Hranicky does not offer any opinions or judgements, merely the kind of facts and information necessary to carry out proper lithic research.

Overall, *Archaeological Concepts, Techniques, and Terminology for American Prehistoric Lithic Technology*, is a useful reference work that should have a place in any archaeological library with a bias towards lithic analysis.

Book review: Environmental Changes and Human Occupation in East Asia during OIS3 and OIS2

Miyuki Yakushige

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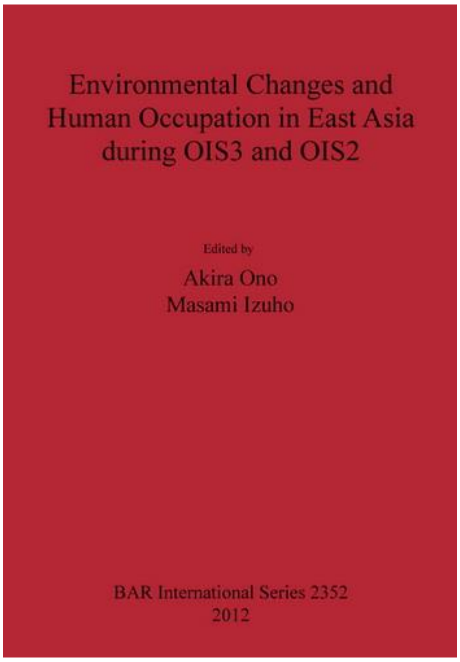

Environmental Changes and Human Occupation in East Asia during OIS3 and OIS2
edited by Akira Ono and Masami Izuho
BAR International Series Vol. 2352, Archaeopress, Oxford, 2012, pp. 146, ISBN 978-1-4073-0938-5
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This book represents the proceedings of presentations from the session "Quaternary Environmental Changes and Humans in Asia and the Western Pacific" at the symposium "Quaternary Environmental Changes and Humans in Asia and the Western Pacific," held from 19 to 22, November 2007, in Tsukuba, Japan.

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This book consists of 10 articles. Among them, six articles report the latest information about environmental data during Oxygen Isotopic Stage 3 (OIS3) and Oxygen Isotopic Stage 2 (OIS2) in East Asia, such as pollen analysis, carbon dating, terrestrial mammal fauna, and so on. Since these articles do not generally focus on lithic studies, they will not be mentioned here. The last four articles are about the chronology and technology of lithic assemblages in Northeast Asia.

First, Anatoly Kuznetsov discusses the origin of microblade industries in Northeast Asia during OIS2. He arranges information about the distribution, chronological data, and environmental settings of microblade industries in Northeast Asia and Siberia. He points out that the spread of reindeer during the Sartan period was related to the origin of microblade industries and concludes that the oldest data on pressure flaking and composite tools are from southern East Siberia, about 20,000 BP, according to current evidence.

Second, Yongwook Yoo discusses the chronology and technology of Paleolithic assemblages in the Imjin-Hantan River area, Korea. He arranges the history of research in this area, and points out the problems of previous studies. Yoo presents new data from dating of Paleolithic sites, and re-evaluates geological and archaeological site formation process in this area.

Third, Kazutaka Shimada discusses the earliest archaeological records of obsidian use and the emergence of modern human behavior in Japan. He explains assemblages of the Middle Paleolithic and the Initial Stage of the Upper Paleolithic, and how obsidian use changed alongside the development of lithic technology in Initial Stage of the Upper Paleolithic.

Finally, Masami Izuho, Fumito Akai, Yuichi Nakazawa and Akira Iwase discuss the chronology and lithic technology of assemblages in Upper Paleolithic Hokkaido, during OIS3 and OIS2. First, they explain about the paleoenvironment in Hokkaido. Second, they choose 13 sites which are representative of Upper Paleolithic Hokkaido, and divide them by reduction strategy into four categories: (1) Small flake, (2) Flake, (3) Blade, and (4) Microblade. They summarize the information about these sites, such as geochronological context, carbon-14 dating, composition of raw materials and tool types, sources of raw materials, and reduction sequence, and compare differences among those categories. They present the latest data obtained from the sites excavated by the authors and discuss the results of the geochronological and technological analyses. Third, they show the connections between changes in climate and in lithic assemblages. The most important result of their research reveals the temporal correspondence between lithic industries and floral and faunal groups. They also note that hunter gatherers changed their lifeway and hunting strategies as their floral and faunal environment changed. This article is one of the first to report to researchers in other countries about the flake industry of the Early Upper Paleolithic and up to the microblade industry of the Late Upper Paleolithic of Hokkaido.

In summary, all of the articles in this volume offer and discuss the latest information about currently popular topics in archaeological research in East Asia. The articles of lithic study and those of environmental data are complementary to each other. This book makes important contributions to our understanding of respective sites, lithic industries, and the environmental changes in this area during OIS3 and OIS2.

Event reviews

Event review: Center for American Archeology Flintknapping Workshop with Tim Dillard, Kampsville, Illinois, U.S.A.

Jeanne Day Binning

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The Center for American Archeology (CAA), located in Kampsville, Illinois, USA has been a leader in archaeological research, education, and cultural stewardship for over 60 years. The CAA continues to be an important and cutting edge institution in the development of innovative research, educational programing, and the promotion of heritage education in the United States. For much of its history, the CAA annually has taught flintknapping as a skill that facilitates the understanding of the archaeological record and a practice that generates interest in the past. Currently, the CAA offers the Flintknapping Workshop with Tim Dillard. This workshop is held each year during the last week of May and offers both experienced and novice knappers the opportunity to learn traditional flintknapping techniques.

"Flintknapping" is a popular recreational activity in the United States; however, most flintknapping activities, workshops, and events are more accurately characterized as folk-knapping. This is a tradition in which stone tools are made with non-traditional, non-authentic tools, techniques, and materials.

For the archaeologist who wishes to apply learned flintknapping skills to the understanding of the archaeological record, the five-day Tim Dillard Workshop hosted by the CAA is the best traditional (non-folk-knapping) flintknapping class known to this writer. Class activities included selecting appropriate chert from the local environment; spalling and preforming raw material with hammerstones; heat treating chert; using an antler billet to perform percussion biface reduction; and pressure flaking of both flakes and bifaces to produce projectile points, thrusting spear points, and knives. Dillard is an unmatched traditional flintknapper and an exceptional teacher. During the five-day experience, participants received one-on-one instruction. Every stage of the reduction process was explored from selecting nodules to finishing a well-crafted bifacial tool. Dillard makes time to work individually with all students attending the workshop and has the ability to teach towards any skill level. All participants received the (ample) attention needed to learn traditional flintknapping techniques. This workshop did not disappoint and is highly recommended for those who wish to acquire flintknapping skills to aid in experimental archaeology and lithic analysis.

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More information about this workshop can be found online at the Center for American Archeology's website: http://www.caa-archeology.org/programs/flintknapping/ Inquiries about the workshop can be received at caa@caa-archeology.org or 1-618-653-4316.

Figure 1. Expert traditional knapper, Tim Dillard, instructs students in where and how to remove flakes in the production of a biface. (Photo by Center for American Archeology.)

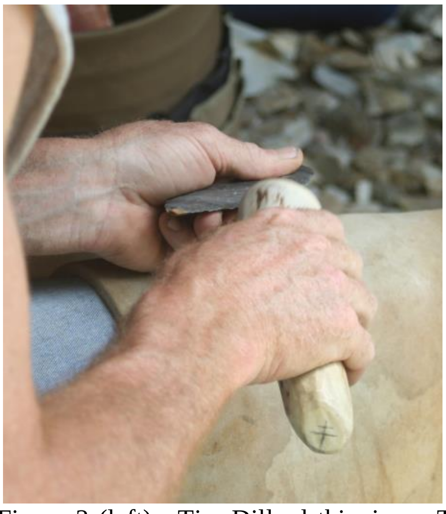

Figure 2 (left). Tim Dillard thinning a Turkey Tail biface. These artifacts were found in sacred contexts and exceptionally difficult to produce. Tim's skill level in billet percussion is unmatched. (Photo by Jeanne Binning.) Figure 3 (right). Biface performs, atlatl dart points, and knifes made by students and Tim Dillard with both local and non-local materials. (Photo by Center for American Archeology.)

Event review: 1st Annual Outdoors Without Limits (OWL) knap-in, Comer, Georgia, U.S.A.

Michael J. Miller

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In June of 2014, Outdoors Without Limits (OWL), a national non-profit organization that promotes awareness and teamwork between disabled and non-disabled individuals, sponsored their first knap-in and primitive skills gathering. The event took place in the small town of Comer located in the northeast corner of the state of Georgia, USA. The Madison county fairgrounds provided the venue and ample space for the event. Experts in flintknapping, traditional bow making, flintlock firearms, primitive furniture, hide working, wood carving, ceramics, food processing, falconry, and blacksmithing were in attendance and demonstrated their skills. A small fee was charged for admission and all of the proceeds went towards OWL programs that provide outdoor opportunities to disabled sportsmen and veterans.

Flintknappers from Georgia and the surrounding states were invited to setup at the knap-in and asked to teach their skills to disabled veterans interested in learning the art of flintknapping. Well over twenty flintknappers attended the event and shared their knowledge, tools, and stone with the eager and interested veterans. Many brought their wares for show and sale while others attended with only their tools and flintknapping in mind.

The author had the pleasure of working with a young marine who came to the event specifically to learn about the manufacture of handaxes. He is currently enrolled in an anthropology program. For his class project, he chose to study how and if language played a role in the process of learning and making handaxes. The experimental archaeological methodology he developed was interesting and fitting for the project. While at the knap-in, he not only had access to experts, he was able to get the stone and tools he needed for the project. The author hopes that the experience and insight he gained from our lesson informs his study and inspires his work.

The people who attended the event heard about it from numerous sources; the local newspaper and radio stations both helped advertise the knap-in. The role that social media played also seemed to be a key factor in helping to get the word out about the event.

While the impetus of the event was education, a certain social outlet was also created by the knap-in. The knappers in attendance, for the most part, all knew each other via other events they attend throughout the year. The camaraderie between many of these individuals shows close friendships, trust, humour, and respect that tend to go hand in hand with primitive skills worldwide. The overlap between the various skillsets of the demonstrators made for interesting conversation and opportunities for experts to learn from each other.

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Figure 1. Michael Miller (right) teaching handaxe manufacture. (Photo by Outdoors Without Limits.)

Figure 2. A selection of knapping material available for sale at the event. (Photo by Michael Miller.)

Event review: Introduction to Paleoamerican Lithic Technology at the University of Oregon Archaeological Field School, Rimrock Draw Rockshelter, Oregon, U.S.A.

Patrick O'Grady [1] and Michael F. Rondeau [2]

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Over the past five years, the University of Oregon Archaeological Field School has hosted a Paleoamerican lithic technology workshop taught by Michael F. Rondeau, a noted lithics expert specializing in western North American fluted projectile points and their related technology. The course has been taught at the field camp adjacent to Rimrock Draw Rockshelter (35HA3855), a Paleoamerican site dominated by Western Stemmed projectile points. The site also produces artifacts associated with fluted point lithic reduction practices. The two-day workshop is traditionally offered during the first week of the six-week field school, tailored for our students who require a good working knowledge of late Pleistocene-early Holocene lithic attributes to better understand the significance of their finds. The workshop provided training in basic lithic technology which can cover such subjects as flake attributes, cobble core types, percussion blade or microblade manufacture, bipolar percussion, percussion biface flaking, flaked stone tool types, impact damage and repair, and use wear and edge damage. The course also covered the diagnostic qualities of overshot flaking techniques and their relationship to biface production and consequent chipping waste. Evidence of overshot reduction techniques has been found regularly in the course of our excavations and as a result of surface surveys. Modules incorporated into the program have also focused specifically on Clovis technological attributes. Depending on student enrollment, serious students and researchers who were not enrolled in the field school have been considered specifically for this workshop.

One unique aspect of the workshop has been the post-instruction site surveys, which have been instrumental in boosting Paleoamerican artifact counts at the site. After each full day of training in the lab setting, Rondeau led students to the nearby rockshelter where they have had the opportunity to explore the dense surface scatter surrounding it for examples of the technological variants they learned about during the workshop. In the past, students have identified and collected Parman (Types 1 and 2), Haskett, Windust, Black Rock Concave Base, Cody, and Great Basin Transverse points. In addition, overshot flakes, bifaces with overshot flake scars, fluted bifaces and an occasional fluting flake were recovered from a concentration near the site. The opportunity to explore a Paleoamerican site and contribute to

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its significance with each new find has always had a unanimous appeal among the students, cementing newly learned skills and preparing them for artifacts they were to encounter within the rockshelter deposits during the weeks ahead.

The University of Oregon Archaeological Field School always begins in the last week of June and runs through July. Rondeau’s workshop takes place during the first week and frequently requires two sessions to keep class sizes manageable and accommodate the high numbers of students this field school attracts. For more information on past and future workshops, please contact Patrick O’Grady at pogrady@uoregon.edu, or visit our website at http://pages.uoregon.edu/ftrock/ for additional details about the lithic workshop and other course offerings.

Figure 1. Michael Rondeau instructing students on flake attribute analysis. (Photo by Patrick O’Grady.)

Figure 2. A sampling of the diagnostic projectile points recovered through surface collections and excavation at Rimrock Draw Rockshelter. (Photo by Katrina Lancaster.)

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