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POUR OBTENIR LE GRADE DE
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Par Camille LESAGE

**LEVALLOIS PRODUCTIONS IN ALTAI: IDENTIFICATION,
APPEARANCE, VARIABILITY**

LES PRODUCTIONS LEVALLOIS EN ALTAÏ : IDENTIFICATION, ÉMERGENCE, VARIABILITÉ

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Soutenue le 20 décembre 2019

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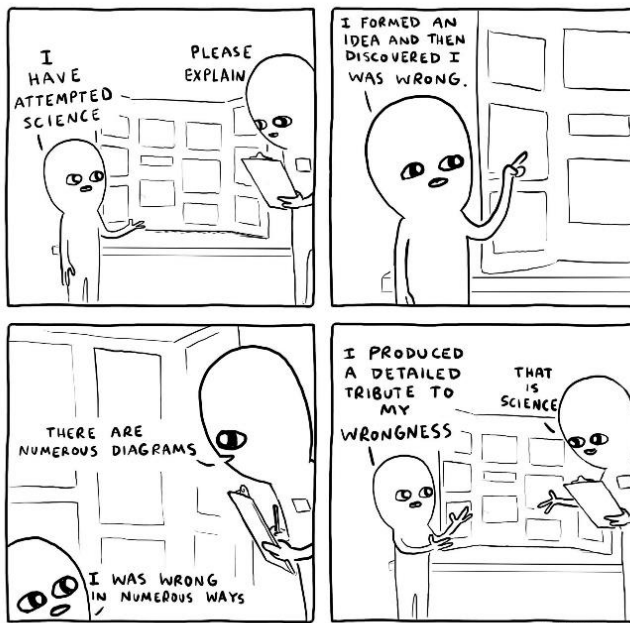
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Contents

ACKNOWLEDGEMENTS	5
<u>1 INTRODUCTION</u>	<u>15</u>
1.1 FOREWORD	17
1.2 MIDDLE PALAEOLITHIC OF THE ALTAI MOUNTAINS: PRESENTATION	18
1.2.1 GEOGRAPHICAL SETTING	18
1.2.2 HISTORY OF RESEARCH	20
1.2.3 GEOLOGY AND PALEOENVIRONMENT	22
1.2.4 ANTHROPOLOGY	24
1.3 THE LEVALLOIS REDUCTION: FROM TECHNIQUE TO CONCEPT	26
1.3.1 THE LEVALLOIS: A HISTORY	26
1.3.2 THE LEVALLOIS CONCEPT	27
1.3.3 THE LEVALLOIS REDUCTION SYSTEM IN ALTAI AND ITS SIGNIFICANCE	29
<u>2 METHODS</u>	<u>33</u>
2.1 MATERIAL	35
2.2 THE REDUCTION SEQUENCE APPROACH	36
2.2.1 THE “CHAÎNE OPÉRATOIRE”, OR OPERATIONAL SEQUENCE	36
2.2.2 THE CONCEPTUAL SCHEME	36
2.3 A NOTE ON MIDDLE PALAEOLITHIC NON-LEVALLOIS REDUCTION SYSTEMS	37
2.3.1 DISCOID REDUCTION	37
2.3.2 VOLUMETRIC LAMINAR REDUCTION	39
2.4 DATA RECORDING	40
2.4.1 TERMINOLOGY	40
2.4.2 CHARACTERISTICS OF THE DATABASE	43
<u>3 SITES PRESENTATION</u>	<u>49</u>
3.1 THE CAVE SITES	51
3.1.1 UST'-KANSKAYA	51
3.1.2 DENISOVA	61

3.2	THE OPEN-AIR SITES	91
3.2.1	UST'-KARAKOL.....	91
3.2.2	KARA-BOM.....	103
4	<u>LITHIC ANALYSES AND RESULTS.....</u>	117
4.1	UST'-KANSKAYA	119
4.1.1	RAW MATERIALS.....	119
4.1.2	TECHNOLOGICAL STUDY	120
4.1.3	SUMMARY	185
4.2	DENISOVA	193
4.2.1	RAW MATERIALS.....	193
4.2.2	TECHNOLOGICAL STUDY	193
4.2.3	SUMMARY	203
4.3	UST'-KARAKOL	204
4.3.1	RAW MATERIALS.....	204
4.3.2	TECHNOLOGICAL STUDY	204
4.3.3	SUMMARY	233
4.4	KARA-BOM	234
4.4.1	RAW MATERIAL	234
4.4.2	TECHNOLOGICAL STUDY	234
4.4.3	SUMMARY	248
5	<u>DISCUSSION AND CONCLUSION.....</u>	251
5.1	THE LEVALLOIS CONCEPT IN ALTAI	253
5.1.1	IDENTIFICATION AND VARIABILITY	253
5.1.2	APPEARANCE, FIRST ELEMENTS	254
5.1.3	TECHNO-ECONOMY	255
5.1.4	RELATIONS WITH OTHER CONCEPTS.....	257
5.1.5	WHO PRODUCED THE ALTAI LEVALLOIS?	261
5.2	INTER-REGIONAL COMPARISONS	263
5.2.1	CENTRAL ASIA.....	263
5.2.2	SIBERIA	272
5.2.3	MONGOLIA	273

5.2.4 CHINA.....	276
5.2.5 SUMMARY	279
5.3 CONCLUSION.....	282
REFERENCES	285
TABLE OF FIGURES.....	309
LIST OF TABLES	315
RÉSUMÉ EN FRANÇAIS	321

1 Introduction

1.1 FOREWORD

Research in the Altai Mountains, crossroads of the Northern and Central Asia, has provided record of an important Middle and Initial / Early Upper Palaeolithic occupation, both in caves and in open air sites (Derevianko and Markin, 1995; Derevianko and Zenin, 1997; Derevianko and Markin, 1998; Derevianko *et al.*, 2000b; Derevianko and Postnov, 2004; Rybin, 2004; Shunkov, 2005; Zwyns *et al.*, 2012). The recent discovery of a new group of archaic hominins in Denisova Cave (Krause *et al.*, 2010; Reich *et al.*, 2010) shed a singular light on this area that different hominin species (Neandertals, Denisovans and maybe Modern Humans; Fu *et al.*, 2014) shared within a few thousand years. It is now essential to come back to the archaeological context of these human remains, and to draw a comprehensive picture of the Altai region. Most of the Initial and Early Upper Palaeolithic assemblages, notably Kara-Bom and Ust'-Karakol, have been thoroughly studied (Rybin, 2000; Derevianko, 2009; Zwyns, 2012). On the other hand, the Middle Palaeolithic has been less investigated, as most of the collections have been studied according to a typological approach, whereas it is necessary to understand the whole chaîne opératoire of the production to figure out the methods implemented in each occupation unit (Leroi-Gourhan, 1964; Boëda *et al.*, 1990; Geneste, 1991; Tixier, 2012).

The Altai Middle Palaeolithic has been described as mostly characterised by the presence of the Levallois core reduction (Derevianko and Markin, 1995), but the status and evolution of this concept is yet to be clarified throughout a comprehensive technological study that allows the reconstruction of the reduction sequences present in each site. In this manuscript, we propose to examine the material from the cave sites of Ust'-Kanskaya and Denisova, and the open-air sites of Ust'-Karakol and Kara-Bom, trying to redraw the chaînes opératoires of production.

1.2 MIDDLE PALAEOLITHIC OF THE ALTAI MOUNTAINS: PRESENTATION

1.2.1 Geographical setting

The Altai Mountains are situated in Central Asia at the border between Russia, Kazakhstan, Mongolia and China (Figure 1). They are bordered by the Altai plain in the northwest, the Salair Range and Kuznetskiy Alatau in the northeast, and merges with the Western Sayan and the Tannu-Ola in the east. The Mongolian Altai gradually becomes lower in the southeast until it merges in the Gobi Plateau. In the southwest, the Irtysh valley separates the Altai from the Tarbatagai Mountains.



Figure 1: Location of the Altai range (modified after zoom.earth)

The Altai consists in intermediate mountain landscapes between 800 and 2,000 m asl (about half of the Altai territory), high plateaus of more than 2,000 m asl (about a third of the territory) and orogenic ridges like the Katun, Chuya or Chikhacheva ranges. The highest peak, mount Belukha (4,506 m asl), is situated at the border between Russia and Kazakhstan, on the Saylyugem range.

Most of the Palaeolithic sites, whether they are caves or open-air sites, are situated in the intermediate mountain zones between the northern Altai plain and the alpine ridges, between

300 and 1,000 m elevation (Chlachula, 2001). The main areas are the Anuy river valley (Denisova, Okladnikov, Kamminaya, Iskra for the cave sites, Karama, Anuy and Ust'-Karakol for the open-air sites), the Charysh river basin (Strashnaya and Chagyrskaya caves, Ust'-Kanskaya cave being located further upstream), and the Katun river basin (Maloyalomanskaya and Biyka caves, Kara-Bom, Tiimechin, Kara-Tenesh and Ulalinka for open-air sites; Figure 2).



Figure 2: Palaeolithic sites in the northwestern Altai; stars are cave sites, dots open-air sites. 1: Strashnaya cave; 2: Chagyrskaya cave; 3: Okladnikov Cave; 4: Iskra cave; 5: Karama; 6: Anuy; 7: Denisova cave; 8: Kamminaya cave; 9: Ust'-Karakol; 10: Ust'-Kanskaya cave; 11: Kara-Bom; 12: Tiimechin; 13: Maloyalomanskaya cave; 14: Kara-Tenesh; 15: Biyka caves; 16: Ulalinka (Zwyns, 2012).

1.2.2 History of research

Research on the Palaeolithic of Siberia began in 1871 with the discovery of bone and stone artefacts during the construction of the new military hospital in Irkutsk (Chersky, 1874). A few years later, while building a train station in Afontova Gora, close to Krasnoyarsk, the homonym Late Upper Palaeolithic site was discovered and excavated by I.T. Savenkov (Savenkov, 1886). The site was presented in the International Congress of Prehistoric Anthropology and Archaeology in Moscow in 1892, where it caught the attention of the French archaeologist J. de Baye, who reported the news to the French Academy of Sciences (de Baye, 1894), then visited the site in 1896. He was the first to make the Siberian prehistory public to foreigners, followed by the Austrian G. von Merhart in the beginning of the XXth century (Von Merhart, 1923).

In the Altai, research began in 1913 when M.D. Kopytov found artefacts and bones on the right bank of the Ob river at Fominskoye, and a few kilometres upstream on the right bank of the Biya river, at Yeniseyskoye (Field and Prostov, 1937). Later excavations in 1935 by G.P. Sosnovskiy in Fominskoye confirmed the Palaeolithic attribution, with the presence of species such as *Mammuthus primigenius* and *Coelodonta antiquitatis*.

Archaeological research was suspended during the Second World War, but as soon as 1947, S.I. Rudenko resumed investigations in the Altai, followed by A.P. Okladnikov in 1950. In 1954, the Altai Archaeological Expedition found a few artefacts in Ust'-Kanskaya cave, leading to its excavation under the direction of S.I. Rudenko. The artefacts were compared to the European Mousterian, with the identification of a Levallois industry; with a fauna that N.K. Vereshchagin defines as reflecting a relatively warm climate (Vereshchagin, 1956), S.I. Rudenko attributes this site to "the warm phase that preceded the last glaciation in the Altai, that is, the Upper Pleistocene" (Rudenko, 1961). Ust'-Kanskaya is thus the first site in Siberia that yielded a Middle Palaeolithic industry. Numerous other sites were discovered and excavated at the end of the 1950's, like Iskra Cave, Mayminskaya, Karaturuk or Ust'-Soma, all Upper Palaeolithic (Derevianko *et al.*, 2001d).

Most of the archaeological remains in Siberia were attributed to post-glacial periods, hence the idea of a late occupation of the region (Okladnikov and Pospelova, 1982). However, Ulalinka, which was discovered in 1961 on the bank of a tributary to the Maima River in the south of Gorny-Altaysk, yielded a pebble-tool industry that was attributed to a local Lower Palaeolithic culture that could be dated to the Late Pliocene (Okladnikov and Pospelova, 1982; Okladnikov

and Ragozin, 1984). The dates were debated, as well as the anthropological nature of the artefacts (Mochanov, 1976; Medvedev, 1983; Abramova, 1984). A.P. Okladnikov himself suggested that the pebbles could have been accidentally split by fire (Okladnikov, 1972b).

In 1966, a group of amateur speleologists discovered Strashnaya cave, which A.P. Okladnikov and N.D. Ovodov excavated in 1969-1970 (Okladnikov *et al.*, 1973). The caves of Denisova and Okladnikov (named Sibiryachikha at the time of its discovery), as well as Tiumechin and Kara-Bom open-air sites, were excavated in the following years, which resulted in an interest in the presence of the Levallois technology in Altai and its significance (Okladnikov, 1972a; Vasil'evskii, 1983). According to A.P. Okladnikov, the Levallois technology has a strong significance for the Middle to Upper Palaeolithic transition, and persisted until late into the Upper Palaeolithic (Okladnikov, 1981). The idea of a local tradition from the Levallois to the Yubetsu method, thus linking the Siberian Levallois to the peopling of the Americas, was formulated (Okladnikov, 1981; Vasil'evskii, 1990). It stemmed from the belief that the Siberian Upper Palaeolithic was nothing more than a “post-Mousterian”, characterized by the presence of Levallois technology, choppers, scrapers and other “primitive” tools (Grigoryev, 1977). The discovery of Kara-Bom, Anuy I-II, Maloyalomanskaya cave and Ust'-Karakol in the 1980's disproved this vision of the regional Upper Palaeolithic, as they yielded blade and bladelet assemblages.

More recently, other sites have been excavated, mostly by A.P. Derevianko – A.P. Okladnikov's successor at the Institute of Archaeology and Ethnography at Novosibirsk – and his team, like Karama (Derevianko *et al.*, 2001c) and Anuy-III (Derevianko *et al.*, 2000a) in the vicinity of Denisova cave, and Chagyrskaya cave on the left bank of the Charysh River (Derevianko *et al.*, 2008c; 2009).

In the 2000's, researchers criticized the previous studies on the Middle Palaeolithic material, that were following Bordes formal criteria (Bordes, 1961), saying it could not be applied to Altai. The Middle Palaeolithic represents a unique cultural tradition, and while different lithic techno-complexes can be distinguished, they are the results of environmental and functional variability (Derevianko, 2001b; Vasil'ev, 2001). Two main variants have been distinguished, the Kara-Bom, or “Levallois” variant, with a high proportion of Levallois cores and products, especially blades, notches and Upper-Palaeolithic tool types, and the Denisova, or “Mousterian” variant, with mostly radial and parallel non-Levallois reductions, as well as a toolkit dominated by scrapers (Derevianko *et al.*, 1998a; 2000b; 2003; Derevianko, 2001b; Derevianko and Postnov, 2004; Rybin, 2004; Shunkov, 2005). However, classifying whole sites

in one or the other variant erases the differences between different layers of the same site, for example in Denisova, which has yielded layers with numerous blades and Upper-Palaeolithic tools, but is attributed to the Denisova variant; it also probably exaggerates the differences between the assemblages (Wrinn, 2010).

These last years, new data came from the excavations at Chagyrskaya Cave; the lithic industries are based on radial flaking, for the production of thick, angular blanks, often *déjetés*, which are retouched as scrapers. This type of industry was only present in another Altai site, Okladnikov Cave. Together, they form a single Middle Palaeolithic tradition: the ‘Sibiryachikha facies’ (Derevianko *et al.*, 2008c; 2009; 2013; Derevianko and Markin, 2011). This facies is associated with human bones, identified as European Neanderthal (Derevianko and Markin, 2011; Viola *et al.*, 2011; 2012; 2017; Derevianko *et al.*, 2013).

1.2.3 Geology and paleoenvironment

The Altai Mountains, as all other major Central Asian mountain systems, were first formed during the Caledonian orogenesis. The Upper Cambrian bedrock, consisting notably in metamorphic sandstones, schists and limestones, is overlain by Ordovician, Silurian and Devonian sandstones and quartzites (Chlachula, 2001). The Cretaceous conditions created an accumulation of sandy silts, which are overlain by sedimentary rocks. Several episodes of denudation by erosion have been recorded, particularly in the early Mesozoic and late Palaeozoic, but the late Jurassic, Oligocene and Pliocene tectonic uplifts set up the current relief configuration. The Siberian mountain system was formed continuously from the Miocene uplift of the Baikal region on the east, to the late Pliocene uplift of the Altai range on the west, linked to the formation of the Himalayas. The last important tectonic activity is dated to the Middle Pleistocene, with a deepening of the valleys by up to 200 m in the central area (*i.e.* the Katun river valley), and an uplift of the mountain ranges, which resulted in an intense denudation. This exposed the Devonian-Carboniferous limestone bedrock, eventually forming the karstic system. During the MIS 6 and MIS 4 glaciations, glaciers expanded into ice fields, supporting pro-glacial lakes. The cataclysmic drainage of these lakes in warmer periods (MIS 5e, MIS 3) had an important impact on the current topography (Chlachula, 2011; 2017). It also impeded the conservation of earlier cultural records; only the sites situated above the lakes’ waterlines could still be preserved.

This complex geological history created a mosaic of environments through the times. The Siberian chronoclimatic sequence defined by Kind (1974) is still in use (Arkhipov, 1989a;

1989b; Astakhov, 2004; 2013), and has since be correlated with the marine isotopic stages (MIS) and other regional chrono-stratigraphic stages (Table 1).

<i>MIS</i>	<i>Siberian climato-chronological units</i>	<i>European Russia</i>	<i>Northern Europe</i>
2	Sartan	Ostashkov	
3	<i>Karginsky</i>	<i>Leningrad</i>	Weichselian
4-5d	Ermakovo	Kalinin	
5e	<i>Kazantsevo</i>	<i>Mikulino</i>	<i>Eemian</i>
6	Taz	Moscow	Saalian
7	<i>Shirta</i>	<i>Gorka</i>	<i>Dömnitz/Wacken</i>
8	Samarovo	Vologda	Fuhne
9-11	Tobol	<i>Likhvin</i>	<i>Holsteinian</i>

Table 1: Correlation of the main chrono-stratigraphic sequences; interglacials are in italics (Astakhov, 2013)

According to Derevianko *et al.* (2005), the Kazantsevo period was the warmest in Siberia, the tundra was limited to the Arctic coast, even disappearing at the climatic optimum, and most of Siberia was covered by taiga (larch, spruce and fir forests). The Altai Mountains were covered by coniferous and broadleaf forests, and the average temperature was higher than today. In the coldest periods of the Ermakovo (MIS 5c-d and MIS 4), the taiga and broadleaf forest receded, replaced by periglacial tundra (Chlachula, 2011; 2017). MIS 5a-b correspond to warmer periods within the Ermakovo, with a higher proportion of conifers. The human occupation of the central and southern Altai during MIS 4 was limited by the glacial conditions, with the expansion of the ice fields and proglacial lakes. The warming of the beginning of the Karginsky (55-35 ka) induced the cataclysmic melting of the glaciers and draining of the lakes, as well as a return of the taiga and broadleaf forest (birch, pine, spruce, fir, but also oak, lime, chestnut and maple trees), indicating an even warmer temperature than today (Chlachula, 2017). The second part of the Karginsky (35-24 ka) is marked by a cooling trend, causing a mosaic of environments: sub-alpine taiga, dark coniferous forest, parklands, steppes (*ibid.*). The cooling intensified with the Sartan (MIS 2), characterized by cold and dry climatic conditions, and the formation of glacial lakes. Due to its particular relief, the northern Altai presented some protected locations where milder conditions could have allowed the survival of the warm Pleistocene flora and the periglacial megafauna (Chlachula, 2001).

1.2.4 Anthropology

The Altai region was home to at least three different hominin species, Denisovans, Neanderthals and Anatomically Modern Humans (AMH).

1.2.4.1 *Neanderthals*

1.2.4.1.1 Okladnikov cave

Okladnikov Cave yielded dental and postcranial remains: teeth (one dm_2 , one P_3 , one M_1 , two M_3), an adult middle phalanx, an adult distal humeral fragment, and two distal halves of humerus and femur of potentially the same child (Shpakova and Derevianko, 2000; Krause *et al.*, 2007; Viola *et al.*, 2011). The teeth present plesiomorphic morphologies, but lack the Neanderthal autapomorphic features, such as midtrigonid crests (Viola *et al.*, 2011). The adult phalanx is robust and archaic, but its morphology is not specific enough to assign it to any precise taxon; the adult humeral fragment, while undiagnostic, is more similar to AMH than to Neanderthals (*ibid.*). The child humerus and femur also present undiagnostic morphologies, however they carry Neanderthal mitochondrial DNA (mtDNA) that links them to European and western Asian Neanderthals (Krause *et al.*, 2007).

1.2.4.1.2 Chagyrskaya cave

Chagyrskaya cave yielded numerous human remains, including axial skeleton, upper and lower limbs, as well as craniodental remains (Derevianko *et al.*, 2018). They are associated with a Middle Palaeolithic industry. They belong to at least five adult individuals and one juvenile. Morphological features of the postcranial and dental remains suggest they belong to Neanderthals. Moreover, Chagyrskaya 8, a hand distal phalanx, has yielded a high coverage Neanderthal genome sequence (Mafessoni and al., 2018).

1.2.4.1.3 Denisova cave

Denisova cave yielded fragmentary human remains, some of which have been attributed as Neanderthal, either morphologically or via DNA sequencing:

- Denisova 5 (“Altai”) is an adult toe phalanx, and yielded a complete mitochondrial sequence of Neanderthal (Prüfer *et al.*, 2014).
- Denisova 9 is a distal hand phalanx morphologically corresponding to Neanderthals (Mednikova, 2013).
- Denisova 15 is a bone splinter identified as Neanderthal by collagen peptide mass fingerprinting (Douka *et al.*, 2019).

1.2.4.2 *Denisovans*

1.2.4.2.1 Denisova cave

In Altai, Denisovans have only been identified in Denisova cave until now. Their morphology is still unknown, as it mostly consists in fragmentary or undiagnostic remains, and they are the first species to be defined first by their DNA (mtDNA). Denisova 3 is the child hand phalanx that has yielded the first Denisovan genome (Krause *et al.*, 2010; Reich *et al.*, 2010). Three teeth from different locus of the cave have been later identified as Denisovans, Denisova 2 in the Central Chamber (Slon *et al.*, 2017a), Denisova 4 in the South Gallery, and Denisova 8 in the Eastern Gallery (Sawyer *et al.*, 2015). The teeth are all very large, but very few other morphological information could be gathered.

1.2.4.3 *Hybrid*

1.2.4.3.1 Denisova cave

Denisova 11 is an undiagnostic splinter of a long bone that has been identified as hominin by collagen peptide mass fingerprinting; its DNA sequence demonstrated that it is the offspring of a Neanderthal mother and a Denisovan father (Slon *et al.*, 2018).

1.2.4.4 *Modern Humans*

1.2.4.4.1 Strashnaya cave

Strashnaya cave presents a complex stratigraphy, from Middle Palaeolithic to Holocene periods. It yielded an ensemble of eight teeth, probably belonging to the same juvenile individual (7 to 9 years old), and a very robust distal fragment of an adult humerus (Viola *et al.*, 2011). The remains have been found in a layer attributed to Upper Palaeolithic, but near the cave wall, where deposits are slightly mixed. The teeth are very large, over the range of variation of Modern Humans, and present an archaic morphology; however, they lack the Neanderthal autapomorphic features. One incisor presents characteristics reminiscent of recent North Asians.

1.2.4.4.2 Ust'-Ishim

The femur of Ust'-Ishim has been discovered outside the Altai range, on the banks of the Irtysh River, in Western Siberia, and dated to 46,880 – 43,210 years cal BP. Its morphology is similar to Upper Palaeolithic and recent Modern Humans, and distinct from Neanderthals (Fu *et al.*, 2014). DNA sequencing confirmed its Modern Human attribution, and showed that it carries Neanderthal ancestry, like modern-day non-Africans; however, no trace of Denisovan ancestry could be found.

1.3 THE LEVALLOIS REDUCTION: FROM TECHNIQUE TO CONCEPT

1.3.1 The Levallois: a history

In 1857, J. Boucher de Perthes described “flakes whose surface has first been prepared by shaping the flint block or nodule, which can be recognized by the two or three ridges that can be seen on their convex parts, and then that have been detached from this block with a single stroke”, discovered at Levallois-Perret, a western suburb of Paris (Boucher de Perthes, 1857). It’s the first description of Levallois flakes, already mentioning the preparation of the core, the convexities, and the predetermination. A more morphologic definition of Levallois flakes can be found in G. de Mortillet (1883): “they are very large and very wide flakes, oval, beautiful pieces with sharp ridges, the biggest of their time”. But F. Spurrel is the first to describe the series of steps that were taken by the knapper in order to produce such flakes: “a flint stone being selected, and trimmed coarsely round the sides, was worked on its upper surface into the form of a flat dome; then from one end the whole of this prepared surface was detached by a single blow, producing, when the operation had been well conducted, a “turtle-backed” flake” (Spurrell, 1884). V. Commont made a similar description, even more precise and accurate, depicting the shaping of the two hierarchized surfaces, the management of the convexities, the platform preparation and the removal of a preferential flake (Commont, 1909). V. Commont later added that the preparation was by faceting (Commont, 1913), inducing the misconception that faceting was essential for the definition of Levallois. It went as far as proposing the suppression of the term Levallois to the benefit of “faceted platform technique” in the First Pan-African Congress on Prehistory in 1947 (Leakey, 1952, quoted after Bordes, 1961). F. Bordes and H. Kelley were the first to explain the difference between “faceted platform” and “Levallois reduction” (Bordes, 1947; 1955; 1961; Kelley, 1954), thanks to experimentation and refitting studies. They showed that faceting is a helpful tool but not essential for obtaining the desired shape and angle of the platform, and insisted that the definition of the Levallois reduction resided on the production of predetermined flakes or blades on a prepared core, with or without faceting.

Over the years, the discovery of many “Levallois” industries, in Europe, Western Asia and Africa, exposed the divergence between Bordes’s definition and the actual lithics that were found, creating debates between researchers. For example, the notions of standardization, predetermination and “intended product” were challenged by different authors:

- for some, the standardization of Levallois products is not higher than non-Levallois flakes (Dibble, 1989); however, a recent study using morphometric analysis showed that the degree of standardization of experimental Levallois products was quite high, especially compared to non-Levallois products (Eren and Lycett, 2012).
- For others, finding the intent of the prehistoric knapper is a nearly impossible task (Reynolds, 1990; Baumler, 1995);
- For others, the supposed “predetermined” products are only a by-product of the reduction of the core, in order to maintain a uniform core shape (Sandgathe, 2004); an experimental study contradicts this hypothesis (Eren and Bradley, 2009).

Moreover, the “textbook” definition, solely based on the production of predetermined flakes, was considered too vague, especially since different types of cores can produce “Levallois” pieces (Marks and Volkman, 1983; Dibble, 1989; Chazan, 1997). It is in this context that Boëda established his criteria for the definition of Levallois, that are still largely used today (Boëda, 1986; 1988b; 1993; 1994; 1995). The focus shifts from the products to the cores and their morphologies, in order to obtain a better technological reading of the reduction sequence. In the same period, other authors come to the same conclusions through slightly different methods (Geneste, 1985; Van Peer, 1988).

1.3.2 The Levallois concept

1.3.2.1 Definition

According to Boëda, the Levallois reduction is based on a specific volumetric conception, characterized by six indivisible technical criteria (Boëda, 1986; Boëda *et al.*, 1990):

- **The volume of the core is designed in two asymmetric convex intersecting surfaces;**
- **The two surfaces are hierarchically related:** one constitutes the striking platform and the other one the reduction surface from where the predetermined blanks are removed; their roles cannot be switched during the same sequence of production (Figure 3, 1).
- **The reduction surface is shaped** in such a way that the morphology of the product is predetermined: the technical criteria for the management of the surface are the lateral and distal convexities that will guide the shockwave (Figure 3, 3 and 4);
- **The striking platform shape is adjusted** to allow removal of predetermined and predetermined flakes according to the desired objective;

- The **fracture plane for removing the predetermined product is subparallel to the plane of intersection** of the two surfaces (Figure 3, 5);
- The technique is exclusively **direct percussion with a hard hammer**.

This definition, while keeping the structural unity of the Levallois reduction, encompasses a wide variability of the different methods that can be implemented according to the different objectives.

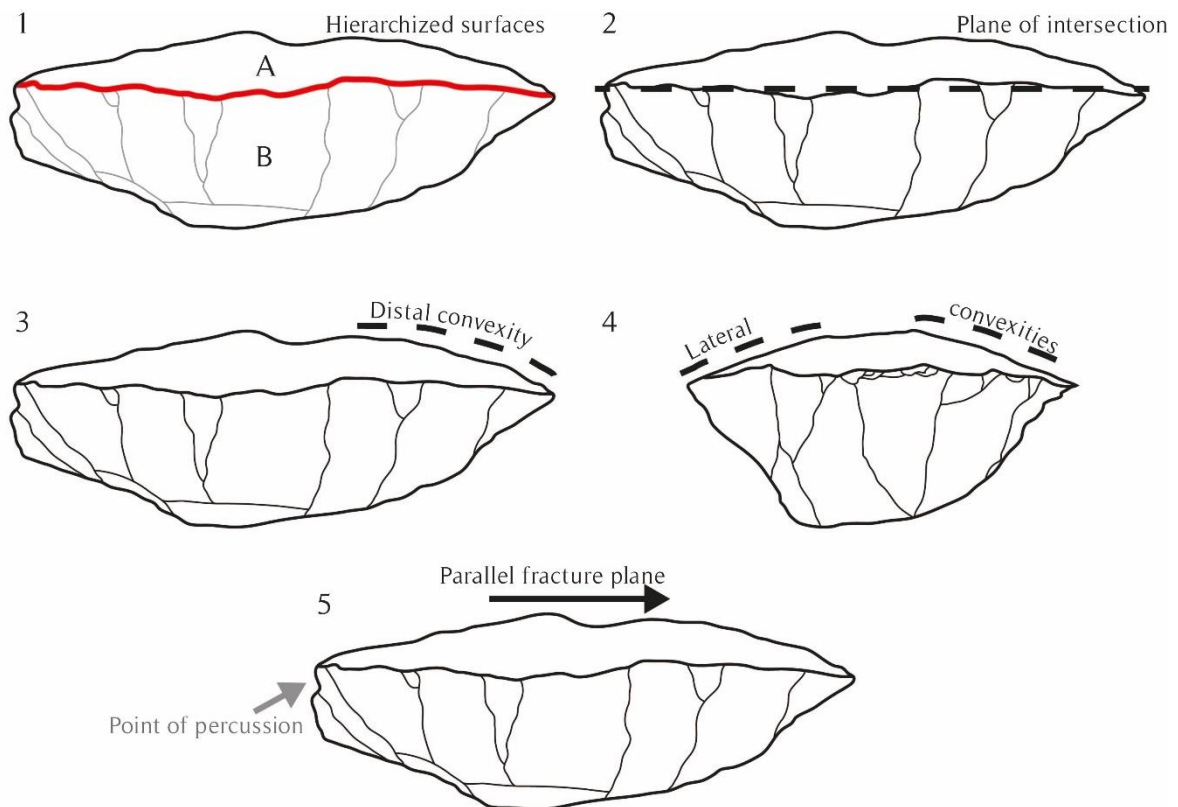


Figure 3: General illustration of the Levallois criteria.

1.3.2.2 Variability of the methods

From the Middle Palaeolithic series studied from the North of France, two main methods have been recognized by E. Boëda (Boëda, 1986; 1990; 1991; 1993; 1994; Inizan *et al.*, 1995):

- The **lineal**, or **preferential**, method aims for the production of a unique predetermined removal. Once the desired removal is obtained, a re-organization of the core surfaces will be necessary if the knapper wants to pursue the reduction.
- The **recurrent** method aims for the production of several predetermined removals on the same prepared flaking surface. These removals will then be predetermined and predetermining, since they shape the core to allow further knapping.

For each method, the preparation of the core can be implemented in different ways – *modalités* in French –, according to the general orientation of the removals: unipolar parallel or unipolar convergent, bipolar parallel or bipolar orthogonal, or centripetal. A. Delagnes add variants due to the change of direction during the reduction sequence – *e.g.* from unipolar to centripetal (Delagnes, 1992).

The products are equally variable, since the Levallois reduction system can be aimed for the production of points (or “triangular flakes” if they are atypical), blades or flakes.

1.3.2.3 Specificities

The originality of the Levallois concept mainly resides in the production of a variability of products within a normalized production sequence. This diversity of productions could explain its chronological and geographical extension – it is the most widespread reduction system in all the Middle Palaeolithic (Jaubert, 1999). Moreover, the characteristics of the products present a series of practical and functional benefits: a greater capacity for retouch (Kuhn, 1994), a certain robustness (Eren and Lycett, 2012), a balance of weight distribution during use (Simão, 2002), and a maximum of cutting edge efficiency for a minimum of raw material waste (Brantingham and Kuhn, 2001).

On a technological point of view, the Levallois system has a special status in the history of techniques: it portrays an integrated reduction structure (Boëda, 1997). Throughout the ages, there is an evolution of the production modes, to obtain removals that will have the closest characteristics of the desired tool: the Levallois cores, generating a great diversity of products, are likely to be exploited to the maximum of their capacity (Boëda, 2005).

1.3.3 The Levallois reduction system in Altai and its significance

As we saw in 1.2.2, two main variants of Middle Palaeolithic have been recognized in Altai, first the Denisova or Mousterian variant with radial and parallel non-Levallois reductions, then the Kara-Bom or Levallois variant, with Levallois cores and products. Those two variants would be the result of different adaptive strategies to environmental, economic and seasonal factors (Shunkov, 2005). They can be compared to the industries that are found in other regions of Central Asia, where sites like Obi-Rakhmat (Uzbekistan) or Khudji (Tajikistan) yielded assemblages presenting the same features than the Kara-Bom variant, and “long-term occupation sites” like Teshik-Tash (Uzbekistan) yielded radial and parallel non-Levallois cores and products with numerous scrapers, characteristic of the Denisova variant (Ranov and Nesmeyanov, 1973; Shunkov, 2005). The validity of this model has been questioned by some

authors (*e.g.* Wrinn, 2010), and since the discovery of a new variant, the Sibiryachikha facies, defined by radial flaking of thick supports that are transformed into scrapers, no new model of the Middle Palaeolithic in Altai has been proposed. Moreover, the typological reasoning, functioning on an “absence/presence” model, does not allow the recognition of subtle differences in assemblages.

Research questions

The Levallois concept includes a great variability of methods (*modalités*), and spans a large geographical and chronological era. Its presence or absence alone in an assemblage do not bear enough significance for regional and inter-regional models, especially in a region with a complex peopling history like the Altai, which has been the home of at least three different types of hominins in the same time span. In Europe, the Levallois is only associated with Neanderthals, and the emergence of the Upper Palaeolithic, with the arrival of Anatomically Modern Humans, led to its disappearance, replaced by other volumetric concepts, and the use of soft hammer percussion. In Altai, there seems to be a different scheme, with a persistence of Levallois pieces in Upper Palaeolithic assemblages (*e.g.* in Ust'-Kanskaya cave), and the presence of a third hominin species, the Denisovans. It is thus critical to clearly define the reduction sequences that were implemented in the region.

The present study is based on a sample of lithic material from cave and open-air sites, including the two eponymous sequences, Kara-Bom open-air site and Denisova cave, but also Ust'-Kanskaya cave and Ust'-Karakol open-air site. It addresses these main research questions:

- What are the characteristics of the Levallois reduction sequences in the Altai? What degree of variability can we recognize in the region?
- What is the meaning of the variability or lack of variability? Can we identify different techno-cultural areas defined by the same technical characteristics?
- What is the chronological span of the presence of the Levallois reduction system in Altai?
- How does the Altai Levallois reduction system compare to neighbouring techno-complexes?

2 Methods

2.1 MATERIAL

The Altai is one of the richest archaeological regions in the Russian Federation, and certainly in Northern Asia, with many multi-layered caves and open-air sites. Most of them display a full sequence, spanning Middle Palaeolithic (MP), transitional Middle-Upper and Upper Palaeolithic (UP). For the purpose of this study, we selected assemblages that have been described as predominantly Levallois. These come from four sites, two caves and two open-air sites:

- Ust'-Kanskaya cave: it is the first MP assemblage identified in Siberia (Rudenko, 1961); for this study we chose to analyse the assemblage excavated in a more recent campaign led by Postnov (1999-2007). Since this site has been said to show a persistence of Levallois artefacts in the Upper Palaeolithic levels, we studied the whole sequence and not only the MP attributed layers.
- Denisova cave: its long stratified sequences suggest that it was occupied since the Middle Pleistocene (early MP), until the UP and even in historical times. Due to the great number of artefacts yielded by the different locus of the cave, we selected the assemblages from two locus, the Central chamber and the Eastern gallery, where the Middle Palaeolithic assemblages are the richest.
- Ust'-Karakol: this open-air site is located less than 2 km from Denisova cave. It has also yielded a long sequence of occupation, with the most ancient non-sterile layer dated to 133 ± 33 ka. We have selected all the material coming from the layers attributed to Middle Palaeolithic.
- Kara-Bom: located at the foot of a schist cliff, the site offers a clear view of the valley, as well as an easy access to good-quality raw material. For this study, we selected the assemblage from the lowest Middle Palaeolithic level, MP2.

A fifth site was supposed to be integrated to the study; Tiimechin 1, an open-air site, yielded an assemblage with a very strong Levallois component, described by Shunkov (1990). However, the archaeological assemblage is in secondary position in the alluvial gravels and no datable material is available (Goebel, 1993). In addition to the fact that the conservation conditions of the assemblage were very poor, we have not been able to access this collection.

2.2 THE REDUCTION SEQUENCE APPROACH

The technological approach we opted for in this work is based on the operational sequence process and the conceptual scheme concept.

2.2.1 The “chaîne opératoire”, or operational sequence

If the term “chaîne opératoire” was first used by A. Leroi-Gourhan in the first volume of *Gesture and Speech* (1964), and is strongly associated with his name, he didn't formalize it. However, it has largely been theorized by numerous ethnologists and prehistorians ever since (Lemonnier, 1976; Cresswell, 1983; Perlès, 1987; Pelegrin *et al.*, 1988; Balfet, 1991; Geneste, 1991b; Schlanger, 2004), and can be summarized as follows: “the *chaîne opératoire*, in the analysis of a lithic industry, takes into account all processes, from the raw material procurement to the artefact's disposal, through all the steps of its manufacture and use. It provides a structure for man's use of materials, putting each object within a technical context, and offers a methodological framework for each interpretation level” (Inizan *et al.*, 1995, p. 14¹).

The chaîne opératoire can be divided into three main steps:

- Obtaining the raw material,
- Transforming it (shaping the core, producing the flakes, retouching...),
- And using the artefact.

The archaeological object is a link between the external environment (or natural environment) and the internal environment (specific to the human group) (Leroi-Gourhan, 1945). The context in which an object is created is thus as important as the manufacture itself: this is the technical system (Geneste, 1990; Pigeot, 1991).

2.2.2 The conceptual scheme

The conceptual scheme, or *schéma opératoire*, represents the second axis of the technological analysis: where the *chaîne opératoire* is the succession of the technical processes towards an objective, the conceptual scheme is the “cognitive aspect”, or mental template, of this *chaîne opératoire* (Boëda, 1991). The conceptual scheme can be exposed and defined by three elements:

¹ In French: « La chaîne opératoire, dans l'étude d'une industrie lithique, prend en compte tous les processus, allant de l'approvisionnement en matière première jusqu'à son abandon, en passant par toutes les étapes de fabrication et d'utilisation d'un outillage. Elle permet de structurer l'utilisation des matériaux par l'homme, en resituant chaque objet dans un contexte technique, et offre un cadre méthodologique à chaque niveau d'interprétation. »

- The **concept**: mostly developed by Boëda (Boëda, 1991; 1994; 1997), the concept is the mental representation of a volumetric structure, that will guide the knapping operations.
- The **method**: according to Inizan *et al.* (1995, p. 30), “the method is the pattern following a reasoned progression of a certain number of gestures, each executed thanks to a technique (or techniques). The term method most often implies an elaborate conceptual template leading to the production of predetermined products, whether from shaping or flaking. Predetermination must therefore be identified.”² Methods are a reflexion of the group’s knowledge and constitute its cultural and technical heritage (Boëda, 1997).
- The **technique**: the way of knapping, through specific tools and movements. The technique is opposed to the method, since the technique is only the performance itself, while the method comes from the knowledge. The technique is “the hand and the hammer stone, not the organized and rational patterns of technical acts that the methods are” (Tixier, 1982).

This approach often refers to the French School of Technology, but there are of course different variants or comparable methodologies, which sometimes use a slightly different vocabulary. In their methodological practice, several American, British, Belgian-Dutch, German, Czech, Japanese and other authors have adopted similar approaches.

2.3 A NOTE ON MIDDLE PALAEOLITHIC NON-LEVALLOIS REDUCTION SYSTEMS

2.3.1 Discoid reduction

In the early XXth century, archaeologists identified “mousterian discs” in some assemblages, but they were at a loss to interpret them. F. Bordes is the first to define them, speaking about “Mousterian debitage”, where a “discoid” core produced a continuous series of removals, as opposed to “Levalloisian debitage”, which was aimed to the production of one preferential flake (Bordes, 1950; 1961). Here, the term “discoid” only refers to the morphology of the core. This definition was later clarified by different authors, in order to distinguish between a true

² In French: « La méthode est l'agencement suivant une marche raisonnée d'un certain nombre de gestes exécutés chacun grâce à une (ou des) technique. Le terme méthode implique le plus souvent un schéma conceptuel élaboré menant à l'obtention de produits prédéterminés, qu'il s'agisse de façonnage ou de débitage. C'est la prédétermination qu'il s'agit donc d'identifier. »

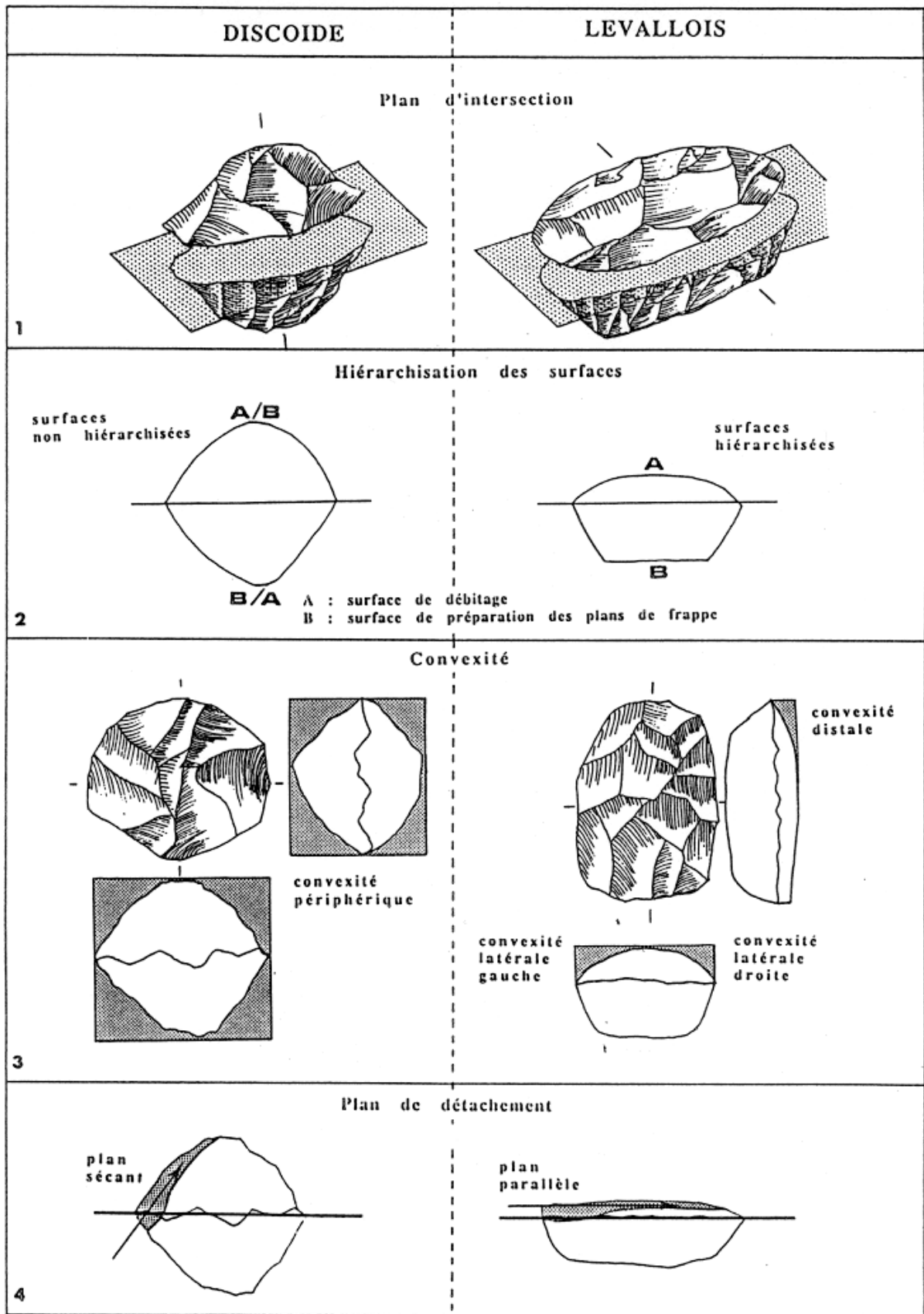


Figure 4: Comparison of technical criteria for the volumetric construction of Levallois and Discoid cores (Boëda, 1993)

“Discoid” reduction sequence, and the Levallois recurrent centripetal reduction (Guilbaud,

1986; Gouédo, 1990; Boëda, 1991; 1993). Boëda (1993) in particular developed a series of technical criteria that mirror the ones used for the Levallois concept (Figure 4):

- The core's volume is designed into two convex, asymmetric, secant surfaces marked by a plane of intersection.
- **The two surfaces are not hierarchized**, one is thought as a flaking surface and the other one as a striking platform but **their role is interchangeable** during the same operational sequence.
- The surface is prepared by a **peripheral convexity** to produce predetermined flakes.
- The striking platform shape is adjusted so that the debitage axis is perpendicular to the core's edge.
- The fracture plane for removing the predetermining/predetermined products is **secant** to the plane of intersection of the two surfaces.
- The technique is exclusively direct percussion with a hard hammer.

To avoid confusion with the morphological term meaning “in the shape of a disc”, the Discoid concept is written with a capital letter (Jaubert and Mourre, 1996).

As for the Levallois concept, the Discoid concept can be implemented according to various modalities, the main ones being unifacial, bifacial and multifacial (Jaubert and Mourre, 1996; Slimak, 1999a; 2003; Mourre, 2003; Terradas, 2003).

2.3.2 Volumetric laminar reduction

As they were often thought to be reserved to Upper Palaeolithic, laminar reduction sequences were not thoroughly described in Middle Palaeolithic assemblages until the 1980's, notably thanks to the study of Northern European sites (Tuffreau, 1984; Boëda, 1988a; Ameloot-Van der Heijden, 1991; Révillion, 1993; 1995) and Near-Eastern sites (Jelinek, 1975; 1982; Copeland, 1983; Meignen, 1994).

Four principles of core volume management have been identified (Delagnes, 2000; Figure 5):

- **Semi-rotating** reduction, which gives the core a semi-prismatic transversal section; the flaking surface is opposed to a flat unflaked surface; it is the most widespread mode during the Middle Palaeolithic.
- **Rotating** reduction, where all the faces of the core are flaked. The core presents a polygonal transversal section. This mode is often implemented at the end of the exploitation of a semi-rotating core.

- **Frontal** reduction, or narrow-faced reduction; if the blank is a flake, its edge serves as a guiding ridge for the first removal.
- **Facial** reduction, or flat-faced reduction: the flaking is carried out on the broadest face of the core.

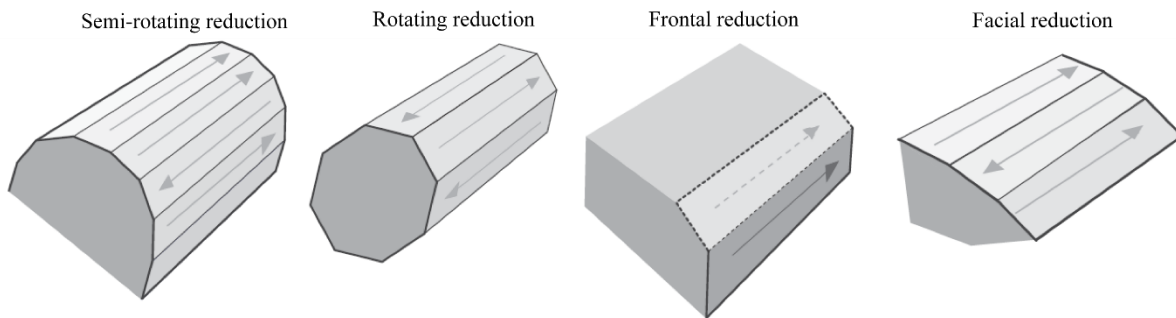


Figure 5: Principles of core volume management (after Delagnes *et al.*, 2007, modified).

In all these modes, the reduction can be uni- or bipolar parallel, and the technique is exclusively direct percussion with a hard hammer. The initialization by a crest blade is usual, but far from systematic (Delagnes *et al.*, 2007). Blade production is never the exclusive reduction system in a Middle Palaeolithic assemblage, but it coexist with a flake production, usually according to the Levallois concept.

2.4 DATA RECORDING

2.4.1 Terminology

Before we develop the criteria we used in this study, we will explain some aspects of the terminology we chose to characterize the artefacts.

Inside the Levallois reduction system, we distinguish between predetermined and predetermining blanks. **Predetermined blanks** are typically flaked parallel to the plane of intersection of the core two surfaces, and they are invasive. Boëda (1994) recognizes three types of predetermined blanks, according to their position in the production sequence (Figure 6):

- Type I blanks are the first predetermined product to be flaked, and thus display only the negatives of predetermining removals on their dorsal face.
- Type II blanks display one invasive negative on their dorsal surface, which is the scar left by the removal of a previous predetermined blank.
- Type III blanks display more than one invasive negative on their dorsal surface.

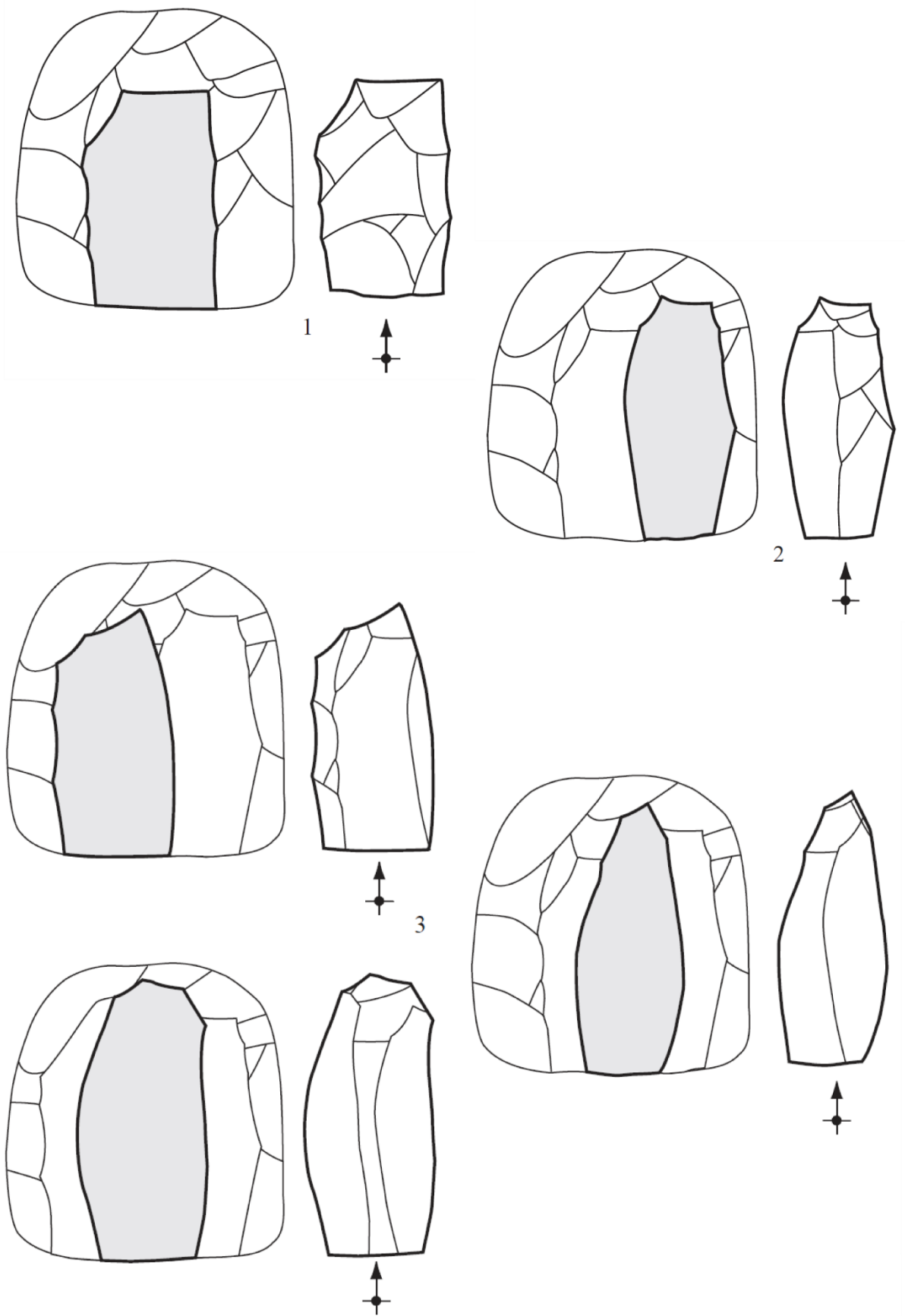


Figure 6: Characterization of type I (1), type II (2) and type III (3) blanks, in a recurrent unipolar parallel Levallois reduction (Soriano, 2000, after Boëda, 1994).

Predetermining blanks can have different characteristics, and most of them could also be produced by other *chaînes opératoires*, which makes their identification difficult. However, two types of predetermining blanks are typically linked to the Levallois reduction sequence:

- **Débordant flakes** (Beyries and Boëda, 1983) are backed flakes, invasive or not, that are knapped to manage the lateral convexities of the core. They are predetermining, but also predetermined, as they form a backed knife. It is important to take into account the general morphology and technological aspects of *débordant* flakes, as they could also be obtained through other reduction sequences.
- **Maintenance flakes** are usually centered, short, non-invasive and non *débordant* flakes, with a thick butt, often displaying hinges on their dorsal face. They are removed to clean and reorganize the convexities of the flaking surface.

A **blade** is an elongated blank whose length equals twice the width (e.g. Inizan *et al.*, 1995, p.34). We distinguish between blade and laminar blanks. While a blade presents regular, parallel edges, a laminar blank is elongated but its morphology is less regular. Blade and elongated blanks can be produced in the Levallois reduction system, or in non-Levallois reduction systems such as volumetric blade production. Generally, the latter will produce blades with characteristics that distinguish them from Levallois blades: the sides can be very secant, even abrupt, which is the strongest criteria to rule out a Levallois-type reduction sequence; besides, a thick, unprepared striking platform can be another sign of a non-Levallois reduction, but is not decisive in itself. However, an important proportion of products are ubiquitous, and could be obtained by either method.

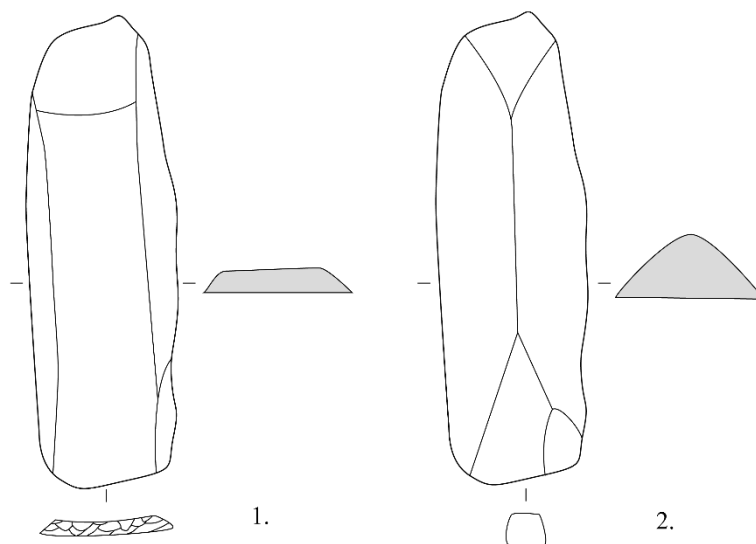


Figure 7: Theoretical blades, obtained by Levallois (1) or volumetric (2) reduction sequences.

A **bladelet** is a small blade. According to Tixier *et al.* (1980, p. 90), “it is within each considered industrial complex that we can establish and assess the limit blade/bladelet”. We chose to establish that limit at a width of 15 mm.

We used a conservatory approach of the term **tool**, which is defined as any support wearing a clear, intentional retouch that cannot be due to taphonomical processes.

2.4.2 Characteristics of the database

We recorded our criteria on FileMaker™, in two distinct databases, one for the core attributes and the other one for the products attributes. Depending on the artefact, some attributes may not have been recorded. In such a case, the mention “ND”, for “Not Documented” was reported, in order to prevent confusion with situations where the attribute is present, but indeterminate, then reported “Indet.” (*e.g.*, for a mesial fragment of blade, the entry “striking platform morphology” will be marked “ND” and not “Indet.”).

2.4.2.1 Cores

Cores are described according to a series of technological and morphological characteristics (Figure 8). These characteristics are organized in different categories:

The screenshot displays a FileMaker database record for a core. The interface includes a menu bar (Fichier, Edition, Affichage, Insertion, Format, Enregistrements, Scripts, Fenêtre, Aide) and a toolbar with navigation and action icons. The main content area is organized into several sections:

- Identification:** ID (UK05.8/30.571.8), Layer (8), Sublayer (empty), Length (46), Width (33.6), Thickness (11.5), X (846), Y (3091), Z (-298.5).
- Economy:** (Empty)
- Technology:** (Empty)
- Photo:** A drawing of the core with a 3 cm scale bar.
- Why Discarded?:** A dropdown menu set to "exhaustion" and a "Notes" field containing "Marked as scraper".

Figure 8: Example of a core recording on FileMaker™.

- Identification and size:
 - ID number, layer and coordinates when available.
 - Length, width and thickness are measured in millimetres and rounded at one decimal. They are recorded as illustrated in Figure 9.

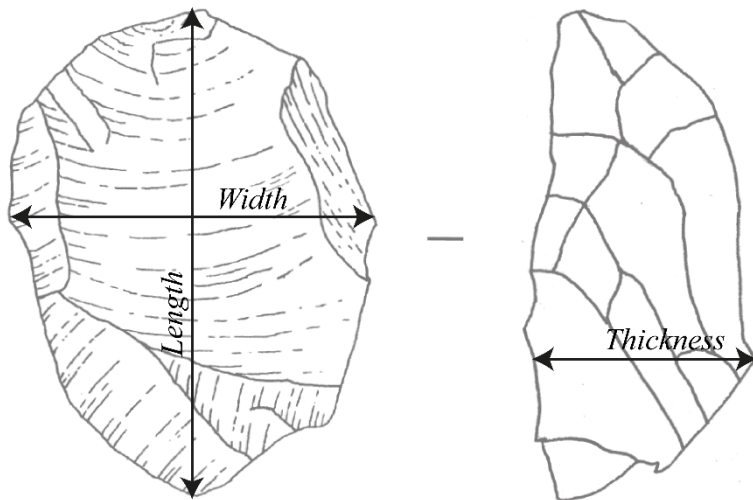


Figure 9: Core measurements.

- Techno-economical aspects:
 - Raw material.
 - Original volume: blocks and pebbles are distinguished by the presence of primary cortex and blunt edges vs neo-cortex and rounded edges. Flakes are identified by the presence of a ventral surface.
 - Surface condition: the surface can be fresh, patinated, and/or shows thermal alterations or concretions.
 - Presence of cortex and its extent.
- Typo-technological aspects:
 - Typological designation of the core: *e.g.* Levallois, Discoid, blade core, etc.
 - Number of flaked surfaces (FS).
 - General reduction pattern: centripetal, unipolar convergent or parallel, bipolar parallel or orthogonal, cordal, or without a visible organization.
 - Preparation of the striking platform.
- Then a description of each flaked surface (max. 4 flaked surfaces in our samples):
 - Status: is it a flaking surface, a striking platform, or both.
 - Number of visible removals.
 - Orientation of the removals.

- Flaking angle: subparallel, secant, variable.
- Last product: centred or débordant.
- Accidents: any accident visible on the core such as hinges or Siret, etc.
- Reason why the core was discarded.
- Additional notes.

2.4.2.2 Products

The description of the products is recorded in a different database (Figure 10).

The screenshot shows the FileMaker Pro interface for recording product data. The main window is titled 'FileMaker Pro - [Ust-Kan_Ecl]'. The menu bar includes 'Fichier', 'Edition', 'Affichage', 'Insertion', 'Format', 'Enregistrements', 'Scripts', 'Fenêtre', and 'Aide'. The toolbar shows various icons for navigation and data management. The main content area is divided into several sections:

- Identification:** Contains fields for ID (UK05.9/30.415.6b), Layer (6), Sublayer (2), Length (M) (50), Length (T) (50), Width (49.8), Thickness (14.2), X (903.5), Y (3085), and Z (-287).
- Photo:** Has tabs for 'Photo', 'Blueprint', and 'Drawing'.
- Retouche 1:** Contains dropdown menus for Side 1 (Left), Position 1 (Direct), Localisation 1 (Total), Distribution 1 (Continuous), Delineation 1 (Rectilinear), and Extent 1 (Invasive).
- Technical Characterisation:** Contains dropdown menus for Angle 1 (Abrupt), Morphology 1 (Stepped), Generation 1 (>1 indet), Morphology of Section 1 (Planoconcave), Edge 1 (Rectilinear), and Technological Attribution (Indet). It also has a dropdown for Typology (Backed Knife) and a text area for Notes.

Figure 10: Example of a product recording in Filemaker™.

It is organized as follows:

- Identification and measurements:
 - ID number, layer and coordinates when available.
 - Length (morphological), in mm: maximal dimension of the artefact.
 - Length (technological), in mm: length along the technological axis of the artefact.

- Width, in mm: maximal width, perpendicular to the technological axis of the artefact.
- Thickness, in mm: maximal width of the artefact.
- Raw material attributes:
 - Raw material.
 - Surface condition: fresh, patinated, glossed, rolled, thermal alteration, concretions...
 - Presence of cortex and its extent.
- Technological attributes:
 - Type of support: blade, bladelet, indeterminate flake, natural flake, shatter...
 - Condition: whole, fragment, distal, mesio-distal, mesial, mesio-proximal, proximal.
 - Accidents: break, overshoot, hinged, Siret, split, thermal splitting.
 - Number of visible removals on the dorsal surface.
 - Orientation of those removals: centripetal, unipolar parallel or convergent, bipolar parallel or orthogonal, cordal, multidirectional.
 - Flaking angle: measurement of the angle between the striking platform and the ventral surface.
 - Striking platform: plain, broken, cortical, dihedral, faceted, punctual, removed.
 - Lip: absence, presence.
 - Bulb: diffuse, strong, removed, bulb splinter.
 - Back: absence, presence. If the back is present, we documented its lateralization, type (cortical, plain or retouched) and orientation (longitudinal, oblique, oblique and limited).
- Morphological attributes:
 - Shape: quadrangular, triangular, oval, circular.
 - Profile: straight, concave, convex, undulated.
 - Section: triangular, trapezoidal, rectangular, semi-circular.
- If the artefact is retouched, we documented each retouched area according to the following points:
 - Localization: total, basal, proximal, mesial, distal.
 - Position: direct, inverse, alternate, alternating, crossed, bifacial.
 - Distribution: continuous, discontinuous.

- Delineation: straight, concave, convex, irregular, denticulated.
- Extent: marginal, short, long, invasive, covering.
- Angle: abrupt, semi-abrupt, low.
- Morphology: scaled, stepped, parallel, subparallel.
- Number of generations of retouch.
- Morphology of the section: planoconvex, planoconcave, planoplan, abrupt-convex, abrupt-plan (Figure 11).
- Edge: straight, concave, convex, undulated, concave-convex, convex-concave.

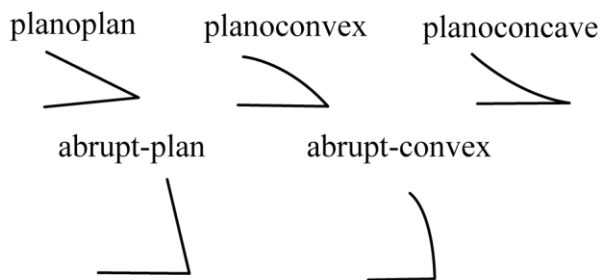


Figure 11: Morphology of the retouched section.

- And finally, typo-technological attributes:
 - Technical characterization: first flake, indeterminate flake, débordant flake, maintenance flake, retouch flake, shaping flake, predetermined product, blade, crest blade, undercrest blade, bladelet, tablet, tool.
 - Technological attribution: Discoid, Levallois, volumetric blade technology, bladelet technology.
 - Typological denomination (according to standard typology, such as (Bordes, 1961)).

3 Sites presentation

3.1 THE CAVE SITES

3.1.1 Ust'-Kanskaya

3.1.1.1 Localisation and history

Ust'-Kanskaya cave (N 50° 54' 40"; E 84° 48' 50") is located on the northern bank of the Charysh river, 3.5 km east of Ust'-Kan city in the Ust'-Kansky district of the Altai Republic (Figure 12, Figure 13). It opens on a limestone cliff, 54 m. above the river (1090 m asl).

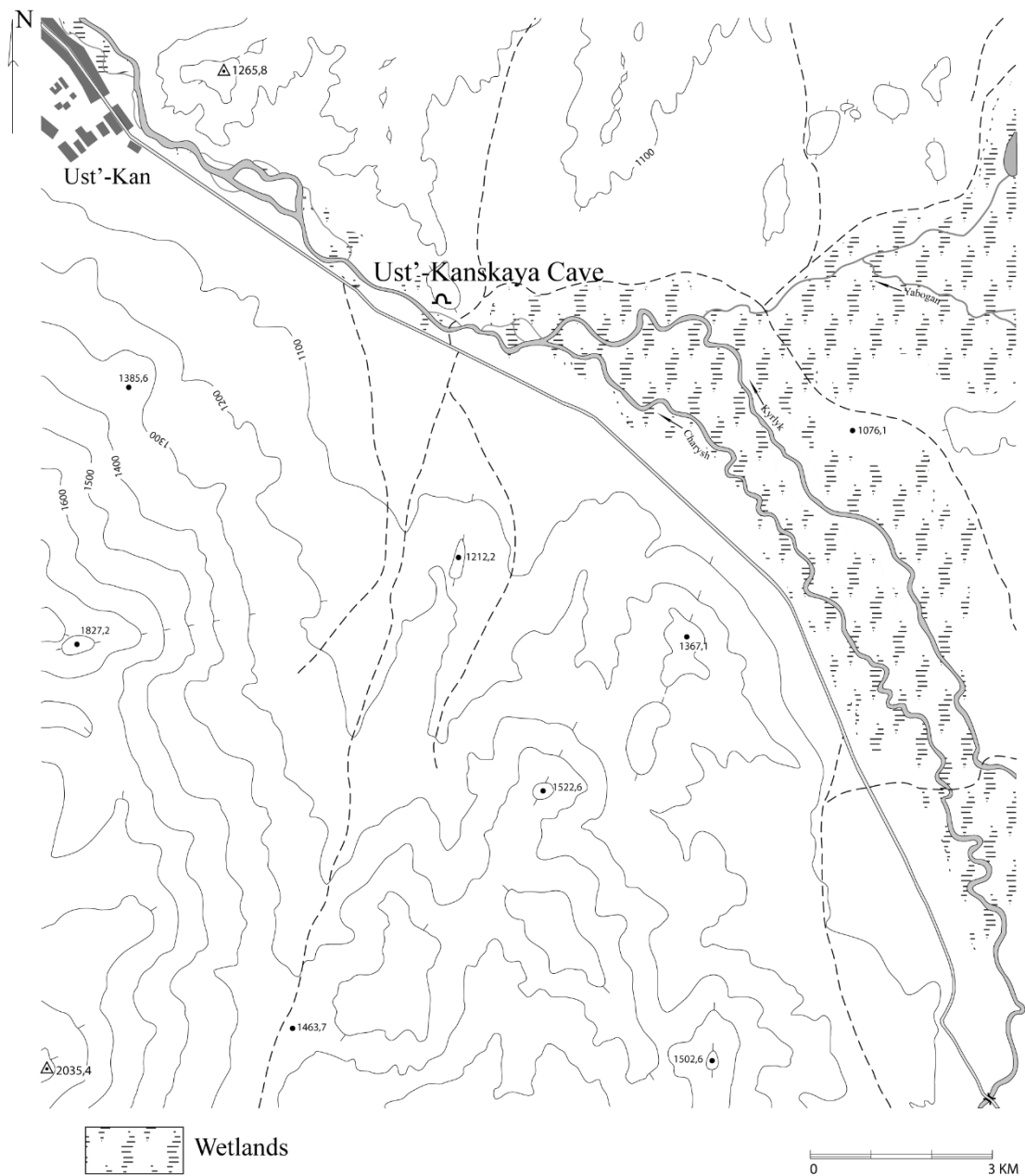


Figure 12: Topographic map of Ust'-Kanskaya Cave area (modified after Derevianko, 2000)



Figure 13: Ust'-Kanskaya cave, view from the south.

The cave was first investigated in 1954, by the Altai Archaeological Expedition. After the finding of a few stone flakes on the surface, a test pit was carried out, revealing lithic artefacts. This led to a first excavation of 20 m² under the direction of S. I. Rudenko, who identified one cultural layer 1.75 m. thick. The excavation only lasted a month, which, considering its extension, indicates a fast digging pace. According to him, “neither stratigraphic data, nor the character of the stone tools nor the fossil animal bones, give any basis for distinguishing several periods of human occupation of the cave” (Rudenko, 1961). The artefacts were compared to the European Mousterian, and the cave was thus the first Siberian site identified as Middle Palaeolithic.

In the 1970’s, the numerous discoveries concerning Early and Middle Palaeolithic in North and Central Asia motivated a return to the data of Ust’-Kanskaya cave. However, this only consisted in cleaning the section on the site and having a look back at the collection (Anisuytkin and Astakhov, 1970; Tseitlin, 1979). Thus, the main result was only a confirmation of Rudenko’s hypotheses: the lithic material is Mousterian, with a small Upper Palaeolithic component, and the occupation is associated with the Karginian Interstadial (MIS 3).

From 1999 to 2007, A. V. Postnov resumed the excavation of the cave. The total extent of the excavation reached 52 m², following an entirely numeric grid system of 1x1 m squares (Figure 14). Coordinates were taken for stone tools, flakes larger than 2 cm, identifiable bones or bones larger than 5 cm. Test pits were also dug near the bed of the river (Postnov, 2006) to correlate the sediments for a better understanding of the deposits of the cave.

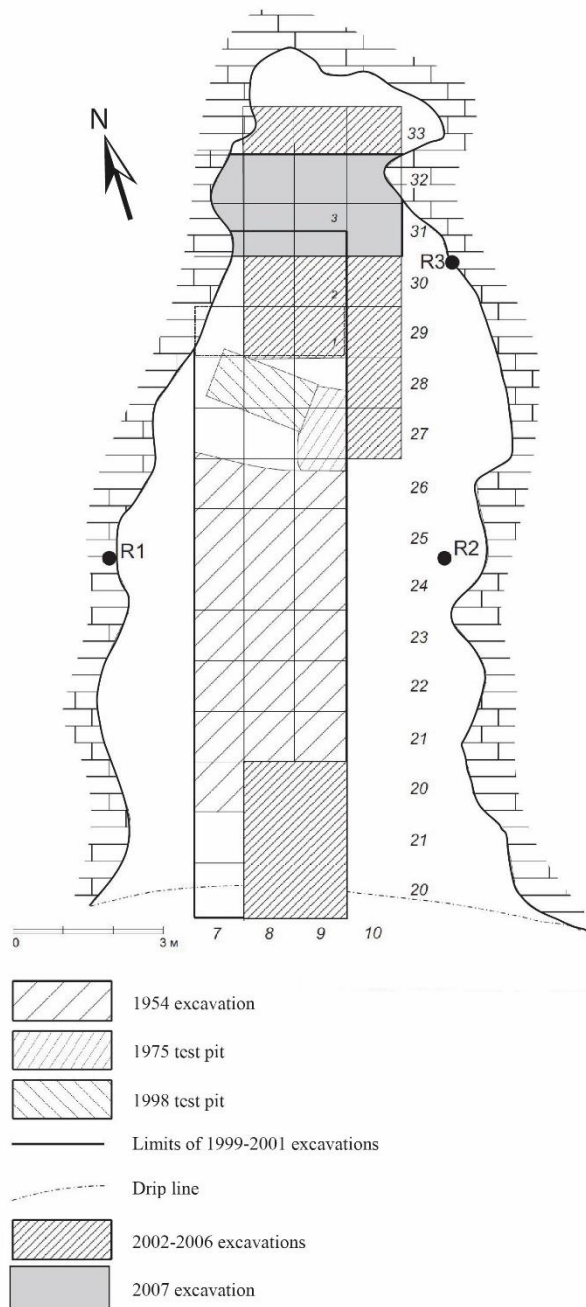


Figure 14: Ust'-Kanskaya, map of the excavation (modified after Postnov, 2008)

Postnov's interpretation of the site differs substantially from the previous ones. He recognized 10 archaeological layers, where he identified three main periods of occupation:

- Layers 1 to 3 are associated with Upper Palaeolithic, but with a persistence of Mousterian elements;
- Layers 4 and 5 are associated with Middle to Upper Palaeolithic transition;
- Layers 6 to 10 are associated with Mousterian.

At the beginning of the new excavations in 1999, a partially stone-lined hearth was discovered at the bottom of layer 10 (Derevianko *et al.*, 1999; Derevianko, 2000), towards the entrance of the cave (Figure 15). It is the only evidence of a hearth or fireplace in a Middle Palaeolithic context in Altai.

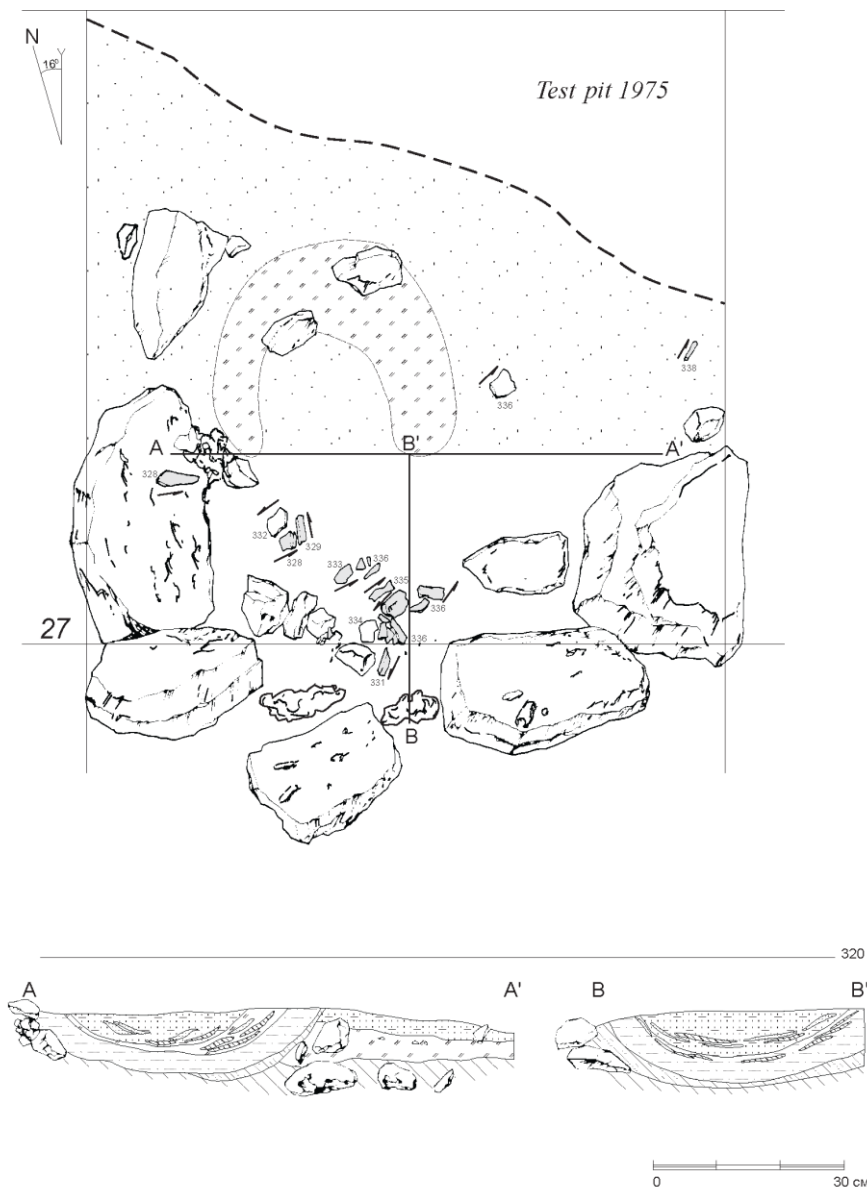


Figure 15: Ust'-Kanskaya. Hearth in square 8/26 and 8/27, layer 10 (modified after Derevianko, 2000)



Figure 16: View of the cave at the end of the excavation (Postnov, 2008).

3.1.1.2 Stratigraphy

Rudenko considered that all the findings belonged to the same cultural layer, as the artefacts and faunal remains were dispersed evenly enough throughout the sequence (Rudenko, 1961) – however, he noted a greater concentration in a depth between 0.4-0.5 and 1.0-1.2 m. On the contrary, while cleaning a section in 1973, Tseitlin identified six lithologic layers (Tseitlin, 1979), that he associated with different periods:

- Layers 1 and 2 : Holocene
- 3 and 4 : Late Sartan and Sartan (MIS2)
- 5 : Late Karginian (MIS3)
- 6 : Early Karginian

During Postnov's excavation, a total of 13 layers were recognized, 10 of which containing archaeological artefacts (Figure 16, Figure 17; Derevianko, 1999; Postnov, 2007):

- Layer 0: organic deposit
- Layer 1: fine-textured grey loamy sand with ash lenses
- Layer 2: silty loamy sand
- Layer 3: debris with loamy loess-like aggregates. Four sublayers have been distinguished based on variations of colour:
 - o 3A: pale ochre
 - o 3B: brownish yellow
 - o 3C: dark brown
 - o 3D: light grey
- Layer 4: loamy sand, separated in two sublayers :
 - o 4A has an intense black colour
 - o 4B is brownish-grey and has a laminated structure
- Layer 5: loams, separated in 5 sublayers:
 - o 5A: light brown, porous
 - o 5B: brown, darker and denser than 5A.
 - o 5C: red-brown to black, interlaced with bright ochre spots
 - o 5D: light brown and silty
 - o 5E: grey, brown, black, yellow intercalated
 - o 5F: red to black; the bottom of the level is layered with coals
- Layer 6: dark brown loams, separated in two sublayers by a filler of decomposed limestone

- Layer 7: red-brown loams with large blocks of limestone.
- Layer 8: grey loam with a porous structure
- Layer 9: debris including fragments of stalactites, filled with orange loam
- Layer 10: dark red loams
- Layer 11: pebbles and gravel, filled with ochre-green loam
- Layer 12: red loam with calcite inclusions and limestone rubble

The uneven repartition of artefacts through the layers led to the conclusion of different patterns of occupation through time; layers 1, 9 and 10 display very rare occupations; layers 2, 3, 6, 7 and 8, an average intensity of occupation, and layers 5 and 4 represent a uniquely high intensity of occupation for the Siberian Palaeolithic (Postnov, 2008).

A microfaunal study (Agadjanian and Serdyuk, 2001) established that the layers 12 to 9 indicate a forest environment, correlated with the Tazovsky horizon (MIS8 to 6); layer 8 indicates a warm and humid phase, the Kazantsevo interglacial (MIS5e), while layers 5 to 3 were associated with Ermakovo; the top of layer 3 suggest a warmer phase, the Karginian interstadial (MIS3), and layer 2 is associated with the beginning of the LGM, the Sartan stage (MIS2).

This site has never been dated by radiocarbon or other radiometric methods.



Figure 17: Ust'-Kanskaya, stratigraphy, northern wall (modified after Derevianko, 2000)

3.1.1.3 Faunal remains

The animal remains from Rudenko's excavation (NR=1749, in a poor state of preservation) were studied by Vereshchagin (Vereshchagin, 1956). He identified 17 mammal species, 6 of which being carnivores (including *Ursus arctos* and *Crocota spelaea*), and 12 bird species (Table 2). Incidentally, Vereshchagin noted traces of carnivore gnawing and of splinting of the mammal bones for the marrow. However, he concluded that carnivores played only a minor role in the accumulation of large mammal bones, mostly due to hominins, while the bones of smaller animals and birds could have been brought by owls.

<i>Species</i>	<i>Number of bones</i>	<i>Number of individuals</i>
Carnivores		
- <i>Ursus cf. arctos s.l.</i>	3	3
- <i>Canis lupus s.l.</i>	23	1
- <i>Vulpes vulpes s.l.</i>	1	1
- <i>Crocota spelaea</i> Goldf.	35	2
- <i>Mustela erminea s.l.</i>	1	1
- <i>Meles meles s.l.</i>	1	1
Perissodactyls		
- <i>Rhinoceros tichorchinus</i> Fisch.	10	1
- <i>Equus caballus fossilis s.l.</i>	62	4
- <i>Equus hermionus</i> Pall.	40	3
Artiodactyls		
- <i>Gazella sp.cf. gutturosa</i> Gmel.	30	2
- <i>Ovis ammon s.l.</i>	159	5
- <i>Spiroceros Kjakhtensis</i> M. Pavl.	19	1
- <i>Peophagus gruniens s.l.</i>	27	2
Lagomorpha		
- <i>Lepus tolai</i> Pall.	105	7
Rodentia		
- <i>Citellus undulates</i> Pall.	35	3
- <i>Marmota</i> sp.	15	1
- <i>Microtus (not definitely identified)</i>	1	1
Fragments of long bones of mammals, mainly ungulates	1164	-

Birds	
- <i>Lagopus lagopus s.l.</i>	2
- <i>Lyrurus tetrrix s.l.</i>	6
- <i>Perdrix perdrix s.l.</i>	2
- <i>Tetrao urogallus altaicus</i> Gebler	5
- <i>Anser anser s.l.</i>	1
- <i>Casarca ferruginea</i> Pall.	2
- <i>Anas Crecca s.l.</i>	1
- <i>Anas platyrhynchos s.l.</i>	5
- <i>Asio flamuncus</i> Pontopp.	1
- <i>Pyrhcorax pyrrhcorax s.l.</i>	5
- <i>Pyrhcorax graculus graculus s.l.</i>	3
Indetermined bird bones	18

Table 2: Fauna from Ust'-Kanskaya first excavation (Rudenko, 1961, modified)

In terms of paleoenvironment, the faunal remains indicate a complex of dry, unforested Asiatic tablelands, and a relatively warm climate (Rudenko, 1961).

More recently, a zooarchaeological study was carried out on faunal remains from layer 6 (Wrimm, 2010). When compared to assemblages from other Altai caves, Denisova and Strashnaya³, the bone collection from Ust'-Kanskaya presents few indications of carnivore activity, and a larger quantity of burned and cut-marked bones. This may be a consequence of the situation of the cave, high on the limestone cliff, which limits its accessibility, whereas the other caves may have represented attractive dens for large carnivores.

3.1.1.4 Lithic industries

As it is usual in most sites of the Altai, a wide diversity of raw materials has been identified in the lithic assemblage: porphyritic and aphyritic igneous rocks, sandstone, chert, jasperoids, gritstones, tuff, schist, quartz, quartzite, aleurolite, dyke, etc. However, most of these materials can be collected in the same place, the Charysh River (Rudenko, 1961; Kulik and Postnov, 2001), and present the same petrophysical and clastic qualities (Kulik and Postnov, *ibid.*). This is due to the geological history of this area: the Charysh-Teretkinsky fault induced a uniform transformation of the diverse rocks that were present. Thus, if different in genesis, they are

³ And Okladnikov, which is not included in Wrimm study, but where coprolites and wolf and cave hyena were found in high proportions (Ovodov and Martynovich, 2004).

similar in general chemistry, acquiring a close mineral composition and a fine-grain structure well adapted to knapping activities.

The artefacts issued from the first excavation, considered archaic, consisted mainly in flakes and blades, with a few cores (Figure 18; Rudenko, *op. cit.*). They were identified as significantly more ancient than the other Palaeolithic sites of Siberia known at the time, and thus compared to the European Mousterian. The inventory counted “massive forms”, Levallois flakes, chopping tools, scrapers, massive blades, etc., that were inconsistent with all the Late Palaeolithic Siberian sites known at the time. However, some very small artefacts with a finely executed retouch and a single bone pendant were found as well. Although compared to Siberian Late Palaeolithic artefacts, they were considered as an evidence of Middle Palaeolithic hunters-gatherers’ skills.

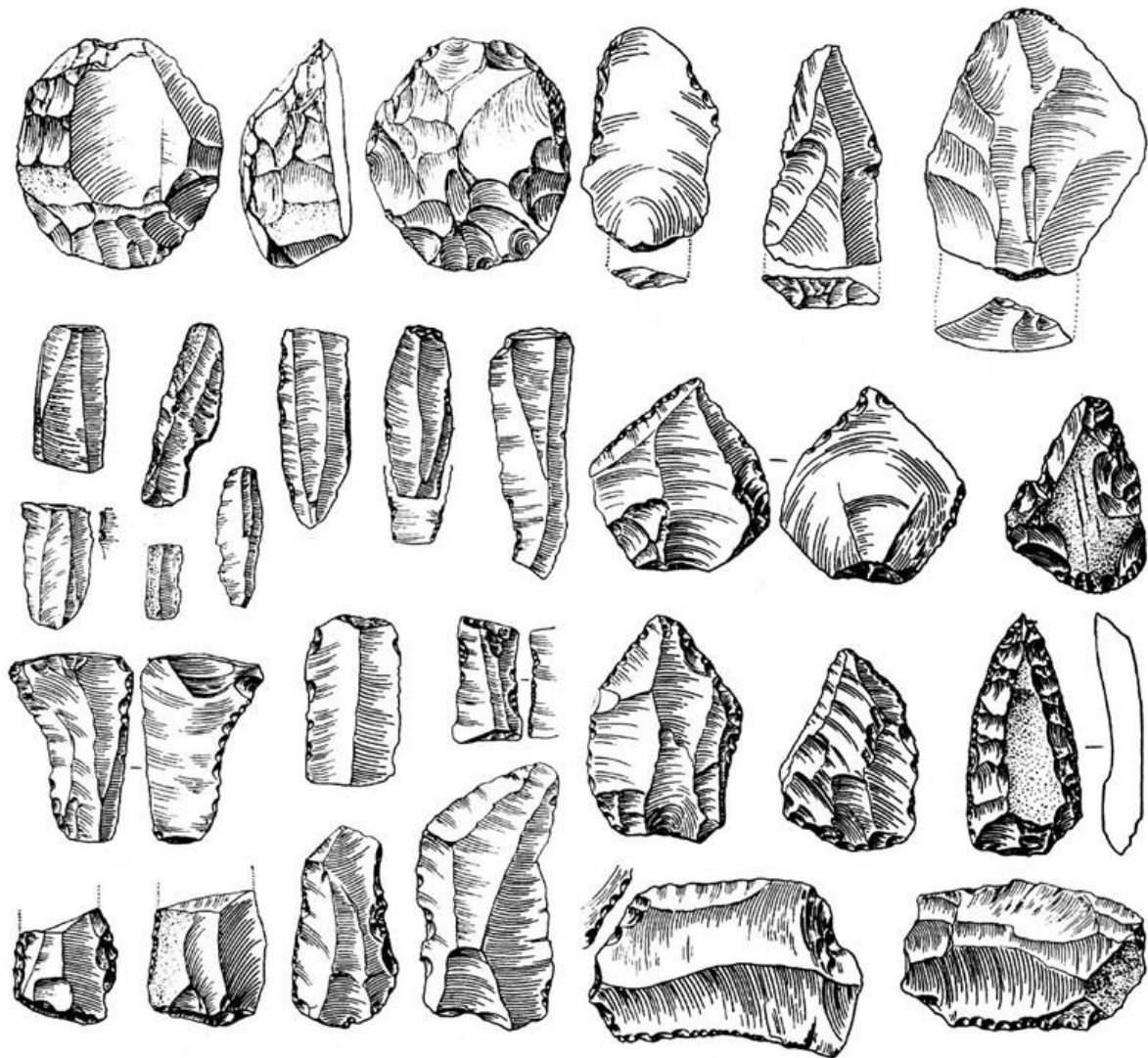


Figure 18: Ust'-Kanskaya. Artefacts from Rudenko's excavation (Rudenko, 1961)

The new excavations confirm the homogeneity of the assemblage, highly dominated by the Levallois technique – which may be attributed to the raw material (Derevianko, Postnov, rapports). However, according to Postnov’s study, the assemblage presents not only Middle Palaeolithic but also Upper Palaeolithic artefacts: endscrapers, retouched blades, burins, considered typical enough to correlate layers 2 and 3 to Upper Palaeolithic despite the absence of microblades and microcores (Derevianko, 2001a). Layers 4 and 5 were associated with a Middle to Upper Palaeolithic transitional industry. This could be due to an association of Middle and Upper Palaeolithic artefacts more than to the presence of typical transitional reduction sequences.

3.1.2 Denisova

3.1.2.1 Localisation and history

Denisova cave (N 51°23’48’’; E 84°40’35’’) is situated on the right bank of the Upper Anuy river, in Altai Krai near the border of the Altai Republic. It opens 24m above the river level (690 m asl), on top of a gentle slope of accumulated alluvium (Figure 19, Figure 20).

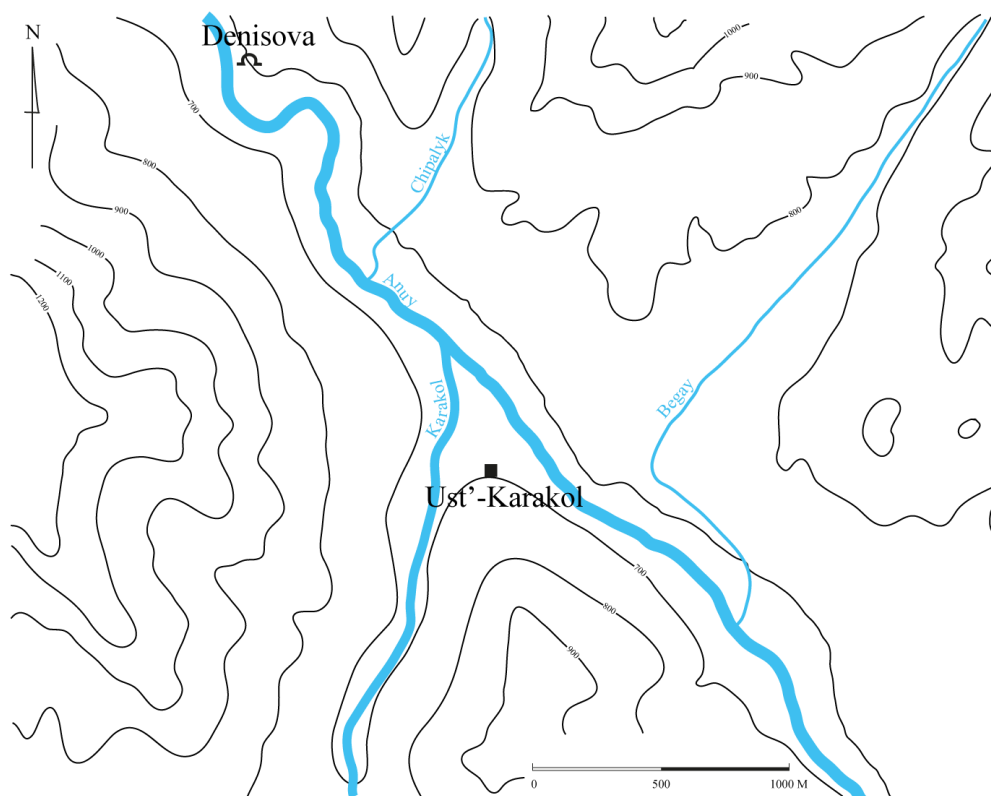


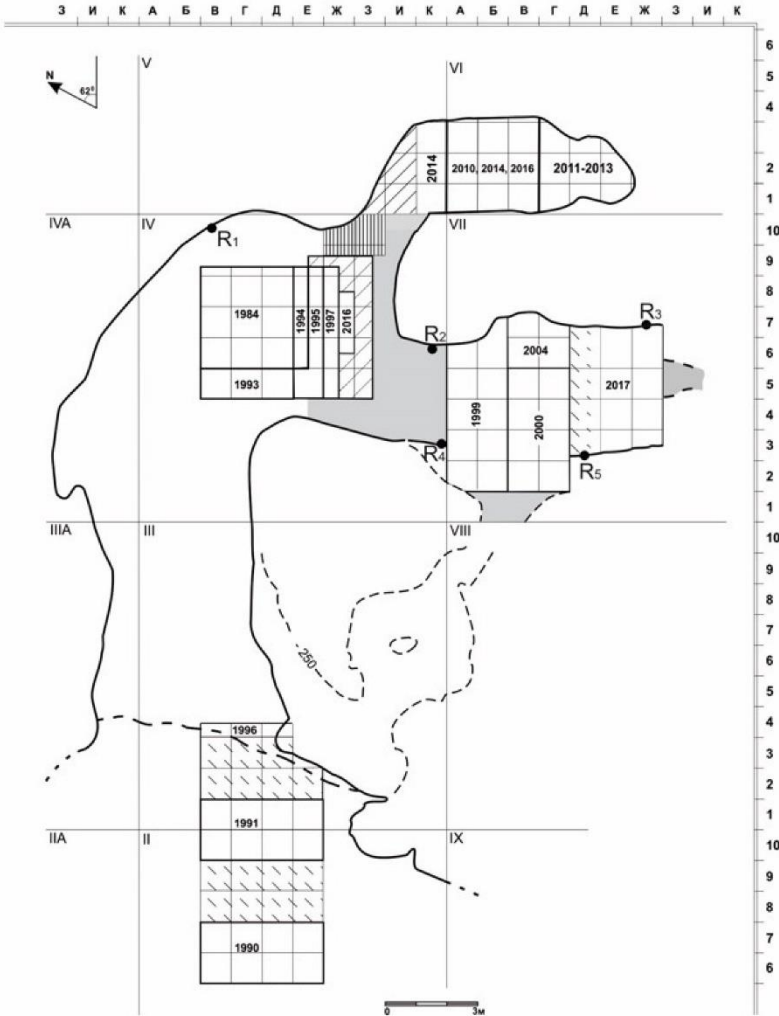
Figure 19: Topographic map of Denisova and Ust-Karakol area (redrawn after Derevianko et al., 2003)

Investigations began in the cave in 1977, when Ovodov opened a 4 meters deep test pit in the central chamber (Okladnikov and Ovodov, 1979). As the results of the test pit were positive,



Figure 20: Denisova cave.

Derevianko began the excavation campaigns in 1982, both in the entrance and in the central chamber, where he identified Holocene (from Late Medieval to Metal Ages) and Pleistocene deposits. The excavations of these two sectors went on until 1996 for the entrance, 1998 for the central chamber, then new areas were also opened, first the south gallery in 1999 then the eastern gallery in 2004. More than 90 m² were excavated altogether (32 m² in the entrance, 20 m² in the central chamber, 22 m² in the eastern gallery and 21 m² in the southern gallery; Figure 21).



- R₁ - Reference points
 - IV - Sector
 - - Modern surface
 - - - Drip line
 - (white) - Excavation of Pleistocene layers
 - ▨ (diagonal lines) - Holocene layers, unearthed in 1995
 - ▩ (cross-hatch) - Holocene layers, unearthed in 2005
 - ⋯ (dotted) - Talus
 - ▮ (vertical lines) - Holocene layers, unearthed in 2015
- | | X | Y | Z |
|----|--------|--------|-------|
| R1 | 12,369 | 39,529 | 0,000 |
| R2 | 19,532 | 35,600 | 1,000 |
| R3 | 25,935 | 35,625 | 1,000 |
| R4 | 19,765 | 32,368 | 1,000 |
| R5 | 24,510 | 33,555 | 1,000 |

Figure 21: Denisova, map of the excavation (modified after Ulianov et al., 2017)

3.1.2.2 Stratigraphy

The different sectors present various stratigraphies, which have not been correlated.

3.1.2.2.1 Entrance

Derevianko *et al.* (2003) have defined 15 layers of Pleistocene deposits on this 8.5 m profile (Figure 22), divided into two sedimentary units, 11-15 and 1-10. Only layers 5 to 10 present Palaeolithic artefacts:

- Layers 5 and 6 are Upper Palaeolithic,
- Layer 7 represents the first stage of Upper Palaeolithic,
- Layer 8 the transition between MP and UP,
- Layers 9 and 10 are attributed to Middle Palaeolithic.

The upper unit (1-4) consists of coarse deposits, predominantly from eboulis, with a loam filling. Rocks and blocks can be of important sizes, and display a random organization:

- Layer 1: blocks and gravels cemented in a dark loam including organic elements (humus).
- Layer 2: blocks and gravels cemented by a filler of *grus*.
- Layer 3: horizon of gravels with a crushed stone filler.
- Layer 4: blocks and gravels cemented by a filler of whitish-grey loam and crushed stone.

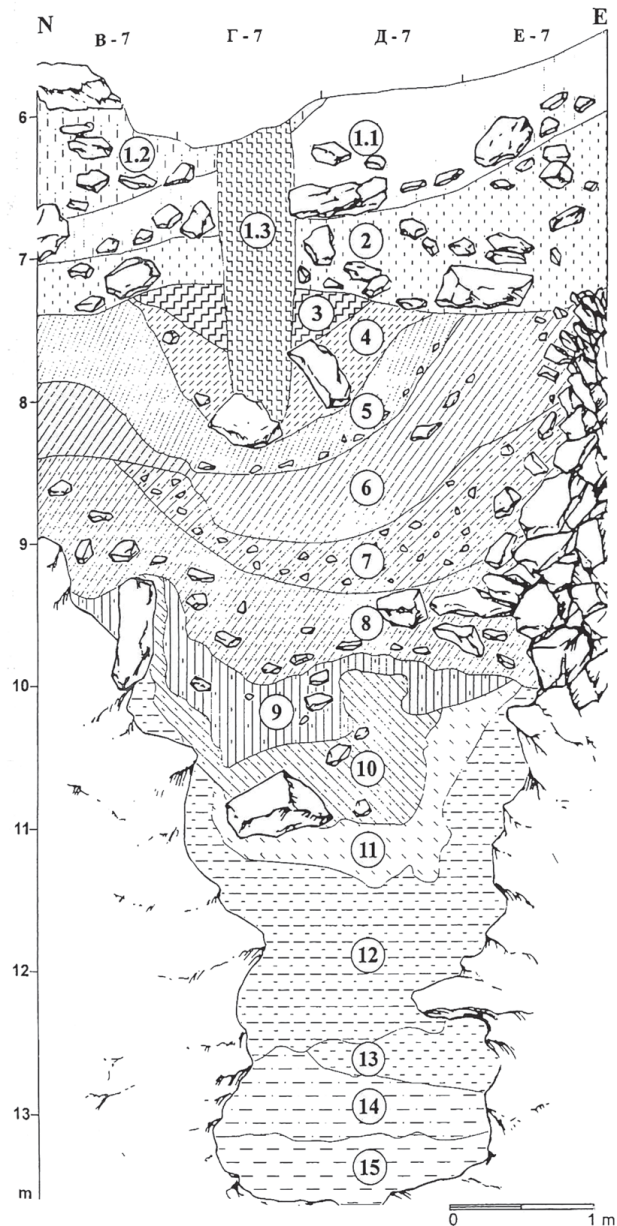


Figure 22: Denisova cave, entrance zone, stratigraphic profile (Derevianko *et al.*, 2003)

The middle unit (5-10) contains all the Palaeolithic material. It consists of an alternation of sandy loams and cemented loams:

- Layer 5: brown cemented, clay-like loam, with inclusions of gravel, crushed stone and lenses of sandy loam.
- Layer 6: light grey and brown grey loam with some gravel and small rocks. The transitions between colours are gradual.
- Layer 7: horizon of rocks and crushed stone, with a light grey loamy filling. There are a lot of inclusions: bone fragments, small pebbles...
- Layer 8: horizon consisting of rocks and gravels, with a brown loam filling.
- Layer 9: mostly brown loam, with inclusions of small rocks constituting 10 to 40% of it. The deformation of the layer is clearly visible, because of the underlying layers and the uneven leaking of sandy loams in a breach.
- Layer 10: heterogeneous, cemented bright ochre loam, with fine, sooty inclusions and distinctive inclusions of brown loam.

The lower unit (11-15) is characterised by an alternation of laminated sands, sandy loams and clays:

- Layer 11: light grey to ochre clay, with interlayers of washed-out brown sandy loams. This layer displays the signs of important post-depositional processes.
- Layer 12: sandy loams with thin interlayers of clay.
- Layer 13: alternation of fine-grained yellow-ochre sand and light grey sandy clay
- Layer 14: alternation of white, grey, beige, brown, orange clay, with fine-grained, yellow-brownish sand.
- Layer 15: yellow-grey clay, in varying degrees of sandiness.

This stratigraphy is the result of a spring water filling a small reservoir, formed by the outcrop. The deposits were driven in the pit by the action of the Anuy River.

3.1.2.2.2 Central chamber

The 4.5 m profile (Figure 23) has been subdivided in 14 Pleistocene lithological layers, numbered 9 to 22 (Derevianko *et al.*, 2003); the uppermost layers belong to the Holocene, and contain archaeological material related to Paleometal and Middle Ages. Some of the Pleistocene layers have been identified only in the middle of the excavated area (15, 16 and 18), while others were subdivided in smaller horizons (9, 11 to 14, 19 and 22).

- Layer 9: loess-like loam, gross lenses and kaolin spots. Maximal thickness 0.5 m.
 - o Layer 9.1: light brown loam, friable, with a lot of kaolin spots. Its maximum thickness is in the eastern part of the profile (up to 0.25 m).

- Layer 9.2: light pale loam of a similar texture than 9.1, but containing fragments of limestone in addition to the kaolin spots.
- Layer 9.3: light brown loam, with weathered debris, coprolite and bone fragments.
- Layer 10: thin layer of heavily eroded detritus and gruss. Ferrous-manganese stains attest a relatively slow sedimentation process.
- Layer 11: subdivided in five sublayers.
 - Layer 11.1: light grey loam with reddish nuances, with a heavy admixture of debris. Its maximum thickness reaches 0.3 m.
 - Layer 11.2: grey loam with a heavy admixture of debris, thickest in the eastern part of the profile (up to 0.5 m). These two sublayers are probably the result of a landslide and desquamation processes.
 - Layer 11.3: light grey loam with debris and animal bones. The maximal thickness was attained during the 1995 excavation, at 0.15 m.
 - Layer 11.4: light grey-brown loam with debris and charcoal inclusions. The thickness ranges from 0.05 to 0.2 m.
 - Layer 11.5: dense brown loam with reddish nuances, with a thickness of 0.15 m.
- Layer 12: subdivided in three sublayers.
 - Layer 12.1: grey brown loam with lenses of pale yellow to dark brown loam with a heavy admixture of debris. Its thickness ranges from 0.15 to 0.25 m.
 - Layer 12.2: light brown loam, with bone fragments covered in manganese; ranging from 0.05 to 0.1 m thick.
 - Layer 12.3: dark brown and reddish sandy loam, with inclusions of crushed stones; from 0.15 to 0.2 m thick.
- Layer 13: subdivided in four sublayers.
 - Layer 13.1: grey-brown crumbly loam, with spots of dark-grey loam. Thickness up to 0.2 m.
 - Layer 13.2: light brown loam with inclusions of charcoal and coprolites.
 - Layer 13.3: fine-grained grey sandy loam, with a notable decrease in the admixture of debris compared to the overlaying levels. The deposit is lens-shaped. Thickness up to 0.15 m.
 - Layer 13.4: brown loam with thin ochre interbeds, and inclusions of charcoal, coprolites and bone fragments. Maximal thickness: 0.1 m.

- Layer 14: subdivided in three sublayers.
 - Layer 14.1: silty grey loam with reddish spots, with a maximal thickness of 0.15 m.
 - Layer 14.2: compact, silty grey loam with brown nuances, 0.3 m maximal thickness.
 - Layer 14.3: grey-brown loam with irregular reddish nuances and gravel. Its maximal thickness is 0.2 m.
- Layer 17: grey sandy loam with gravel and bone fragments. The thickness ranges from 0.05 to 0.1 m.
- Layer 19: subdivided in three sublayers.
 - Layer 19.1: brown sandy loam with irregular inclusions of gravel and small rocks. Maximal thickness 0.5 m.
 - Layer 19.2: lenticular cluster of randomly oriented rocks and gravel, with a filler of reddish brown loam. Maximal thickness 0.4 m.
 - Layer 19.3: reddish brown loam with grey nuances, with inclusions of gravel, bone and coprolites. Maximal thickness 0.2 m.
- Layer 20: grey-brown loam with inclusions of gravel, bone and charcoal fragments. The layer is quite thin (0.15 m maximum in square E6).
- Layer 21: dark silty loam, saturated by organic material (charcoal and soot), with a thickness of 0.15 m. This accumulation of organic material is probably linked to a development of plants on the walls of the cave (Nikolayev, 1994), related to a change of conditions in the cave (increase in the amount of light, moisture, etc.).
- Layer 22: pale yellow loam, with an admixture of debris. This layer has been formed by the physical and chemical weathering of the sandstone bedrock. It has been subdivided in three sublayers:
 - Layer 22.1: ochre and red loam, with inclusions of gravel, splintered bones and coprolites. Its thickness reaches 0.7 m.
 - Layer 22.2: ochre loam with admixture of speleothem and bone fragments. Its thickness reaches 0.8 m.
 - Layer 22.3: ochre sandy loam with grey nuances, up to 0.6 m thick.

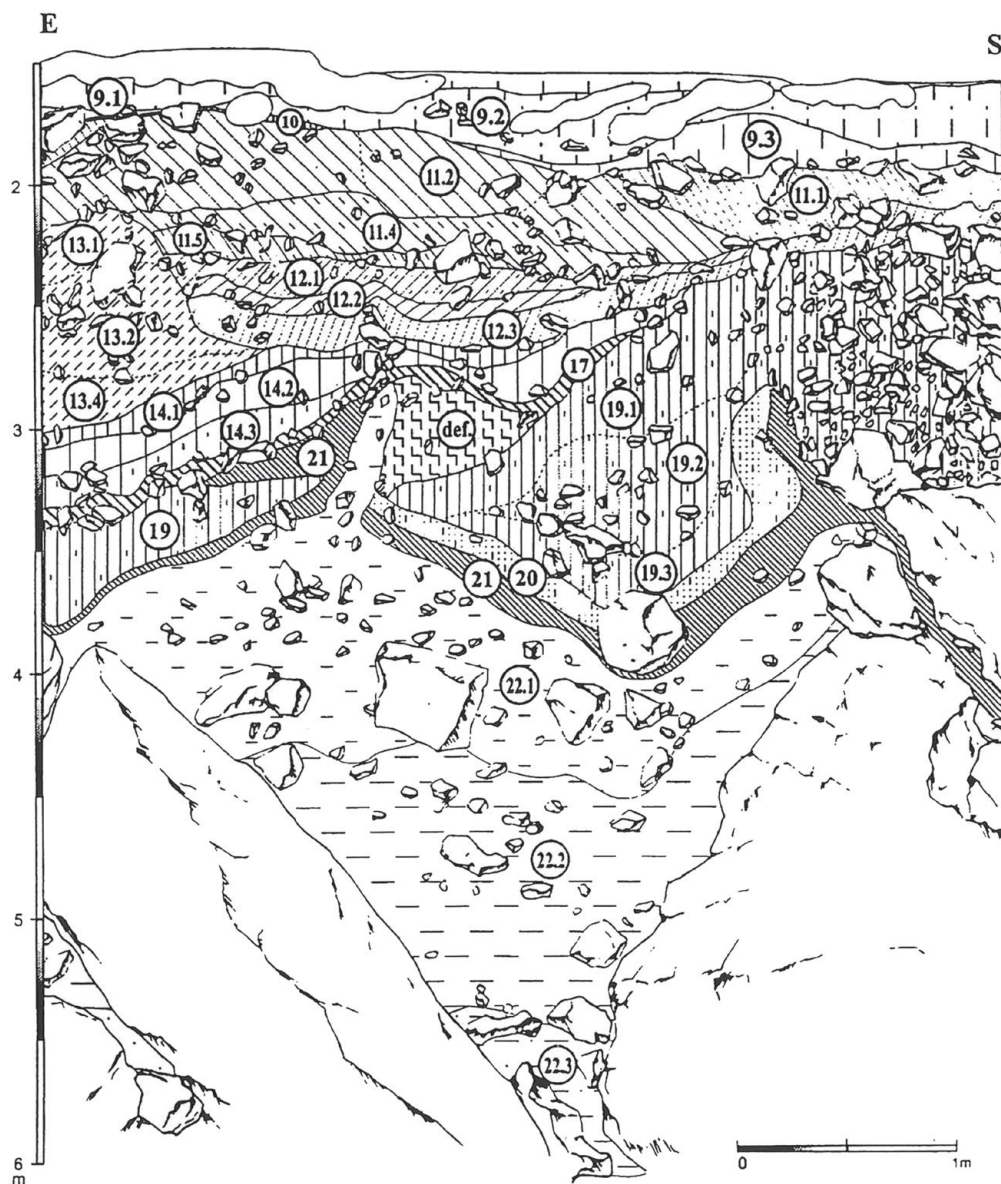


Figure 23: Denisova Cave, central chamber, stratigraphic profile (Derevianko et al., 2003)

3.1.2.2.3 Eastern gallery

Three sections can be described in the profile (Figure 24), separated by well-marked interruptions in the sedimentation (Kozlikin, 2017). The upper section consists of layer 9, the middle section by layers 11.1 to 16, characterised by lenticular clays and gravel with a light loam filler. The lower section consists of layer 17, a heavy ochre loam, which corresponds to the most ancient stage of the sedimentation, when the cave was still closed.

According to Kozlikin (*ibid.*), layer 17 to 14 were deposited during the warm Shirlin period (MIS 7). Then, a break of the sedimentation process can be linked to the Tazovo period (MIS

6). Layer 13 was deposited at the end of the Tazovo. This layer is characterised by a very low number of artefacts compared to the over- and underlying assemblages, and a high concentration of traces of hyena activity. The deposition of layers 12 and 11.4 would correspond to the Kazantsevo interglacial (MIS 5e), while the paleontological remains of layers 11.3 indicate a transition to the colder conditions of the Ermakovo period (MIS4). Layers 11.2 and 11.1 were deposited in the Karginian period (MIS 3) and layer 9 corresponds to the Sartan stadial (MIS 2).

A detailed description of the stratigraphy is available in Jacobs (*et al.*, 2019):

- Layer 9: light, brown loam with black interbeds, with inclusions of decomposed bones. 0.2 to 0.3 m thick.
- Layer 11 is divided in 4 sublayers:
 - Layer 11.1: sandy loam with debris and some bone fragments. The layer is deformed by post-depositional sinking. Thickness 0.3 to 0.4 m.
 - Layer 11.2: dark brown loam with an admixture of debris and reddish bones. As layer 11.1, this layer is deformed by post-depositional sinking. Maximal thickness 0.5 m.
 - Layer 11.3: brown loam with a heavy admixture of debris. 0.2 to 0.3 m thick.
 - Layer 11.4: grey loam with a heavy admixture of debris and bone fragments. 0.25 to 0.35 m thick.
- Layer 12 is divided in 3 sublayers:
 - Layer 12.1: brown loam with greyish tones, with a heavy admixture of debris. Maximal thickness 0.25 m.
 - Layer 12.2: brown loam, with a heavy admixture of debris, deposited in a lens shape. Maximal thickness 0.3 m.

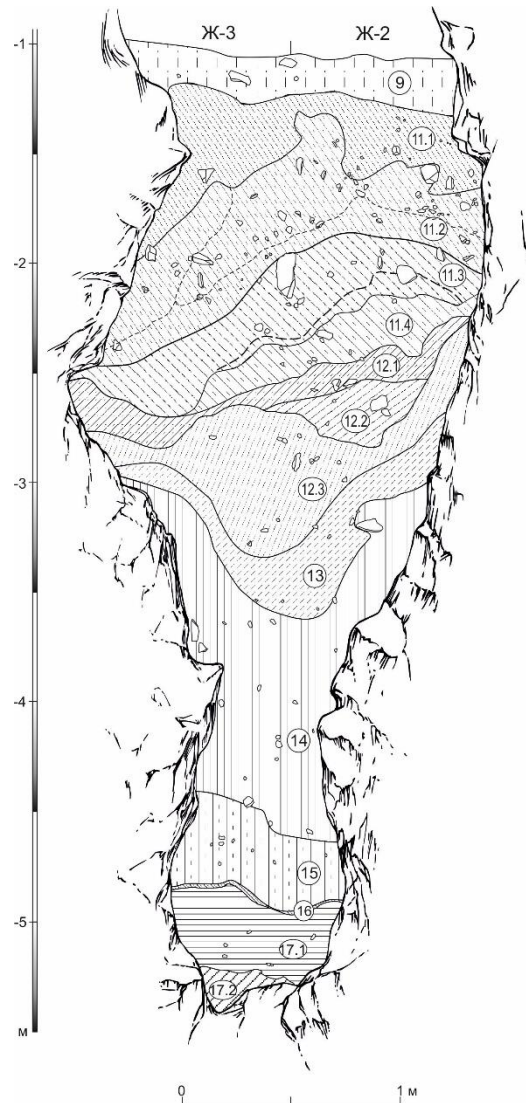


Figure 24: Denisova Cave, Eastern Gallery, stratigraphic profile (Ulianov *et al.*, 2017)

- Layer 12.3: grey-brown loam, with fine debris and numerous coprolites. Maximal thickness 0.6 m.
- Layer 13: brown sandy loam, with numerous coprolites and bone fragments. 0.3 m thick.
- Layer 14: dark brown sandy loam, with numerous limestone and bone fragments. 0.9 m thick.
- Layer 15: brown to grey sandy loam, with a heavy admixture of debris, crushed coprolites and splintered bone fragments. Maximal thickness 0.35 m.
- Layer 16: brown sandy loam, with some coprolites. This is a very thin layer, only 1 to 5 cm thick.
- Layer 17 is divided in 2 sublayers:
 - Layer 17.1: yellow dense loam, with weathered clasts and speleothems. 0.7 to 1 m thick.
 - Layer 17.2: yellow loam, with large concretions; 1 m thick.

3.1.2.3 Chronology

3.1.2.3.1 Entrance zone

Layers 14-11 were deposited in a warm and moderately humid climate, with a high proportion of exotic and broad-leaved species; a RTL date of 163 ± 40 ka (RTL-610) indicates that this warm climate would be related to the MIS 7 (Derevianko *et al.*, 2003).

A paleomagnetic analysis shows an opposite polarity from the base of layer 9 to the top of layer 11, attributed to the Blake inversion (104-120 ka; Derevianko *et al.*, 1992a; 1993a). This would be consistent with the pollen and micromammal analyses, which indicate a warm climate linked to an interstadial landscape (Malaeva, 1995; Shunkov and Agadjanian, 2000). A RTL date on layer 10 gave a surprising result of 66 ± 16 ka (RTL-549; Derevianko *et al.*, 1992b), but this seems to be due to a contamination by sediment coming from layer 9 (Derevianko *et al.*, 2003). There is a break in sedimentation between layers 10 and 9, associated with MIS 5d-5c, and the deposit of layer 9 is attributed to the MIS 5b. However, the topmost part of layer 9 has yielded a RTL date of 50 ± 12 ka, as well as an AMS radiocarbon date of 46 ± 2.3 ka BP (GX-17602-AMS) on charcoal (Goebel, 1993).

Another break of sedimentation occurs between layers 9 and 8, the latter being deposited during a deterioration of climatic conditions, probably at the end of the Ermakovo stadial. Layer 7 shows an increase of the coniferous forest and an expansion of grasslands, in a relatively cold

and humid climate; it is similar to layer 11 of the Central Chamber and corresponds to the Karginian period in MIS 3. Layer 6 displays the traces of a cold and dry climate that could be associated to the Sartan period (or MIS 2). It is confirmed by an AMS radiocarbon date of $14,190 \pm 140$ BP (GX-17896) on charcoal (Goebel, *op. cit.*). The coldest period of the Sartan seems to be represented by layers 4 to 2. Layer 1 yielded three radiocarbon dates on charcoal: $10,800 \pm 40$ BP (SOAN-2865), $10,690 \pm 65$ BP (SOAN-2866) and $9,890 \pm 40$ BP (SOAN-2864) (Derevianko *et al.*, 1993a; 2003).

3.1.2.3.2 Central chamber

The first dates were obtained through radiocarbon on layer 21 – $39,360 \pm 1,310$ BP (SOAN-2499), $> 34,700$ BP (SOAN-2488), and $35,140 \pm 610$ BP (GX-17599)⁴ – and layer 11 – $>37,235$ BP (SOAN-2504) (Orlova, 1995; Derevianko *et al.*, 2003). Then the lower part of the sequence was dated with the RTL method by Kulikov (Table 3). The RTL results are consistent with the paleomagnetic studies conducted by Gribidenko, where he recognized two inversions, one in layer 22.1, attributed to the Biwa I (220-176 ka), the second in 22.2, attributed to Biwa II (300-266 ka) (Derevianko *et al.*, 2003). However, the RTL dating technique is controversial as in caves the sediment can be contaminated by unbleached particles which may result in an overestimation (Wynn, 2010). According to the micromammal remains, layer 22 is not older than the Kazantsevo period (MIS 5e) (Agadjanian and Serdyuk, 2005). The polar inversion should then not be correlated to the Biwa but the Blake episode (Wynn, *ibid.*).

<i>Layer</i>	<i>RTL</i>	<i>Lab number</i>
<i>14</i>	69 ± 17 ka	RTL-611
<i>21</i>	155 ± 31 ka	RTL-546
<i>22.1</i>	171 ± 43 ka	RTL-737
<i>22.1</i>	182 ± 45 ka	RTL-738
<i>22.1</i>	223 ± 55 ka	RTL-739
<i>22.1</i>	224 ± 45 ka	RTL-547
<i>22.2</i>	282 ± 56 ka	RTL-548

Table 3: Denisova Cave, Central chamber, RTL dates (Derevianko *et al.*, 1998a)

However, a recent optical dating campaign of all the layers revealed that the RTL dates were mostly correct, stating that layer 22 accumulated before 287 ± 41 ka, and layers 21 and 20

⁴ Contrary to the first two dates, this one was obtained through AMS and not conventional radiocarbon (Kuzmin and Orlova, 1998).

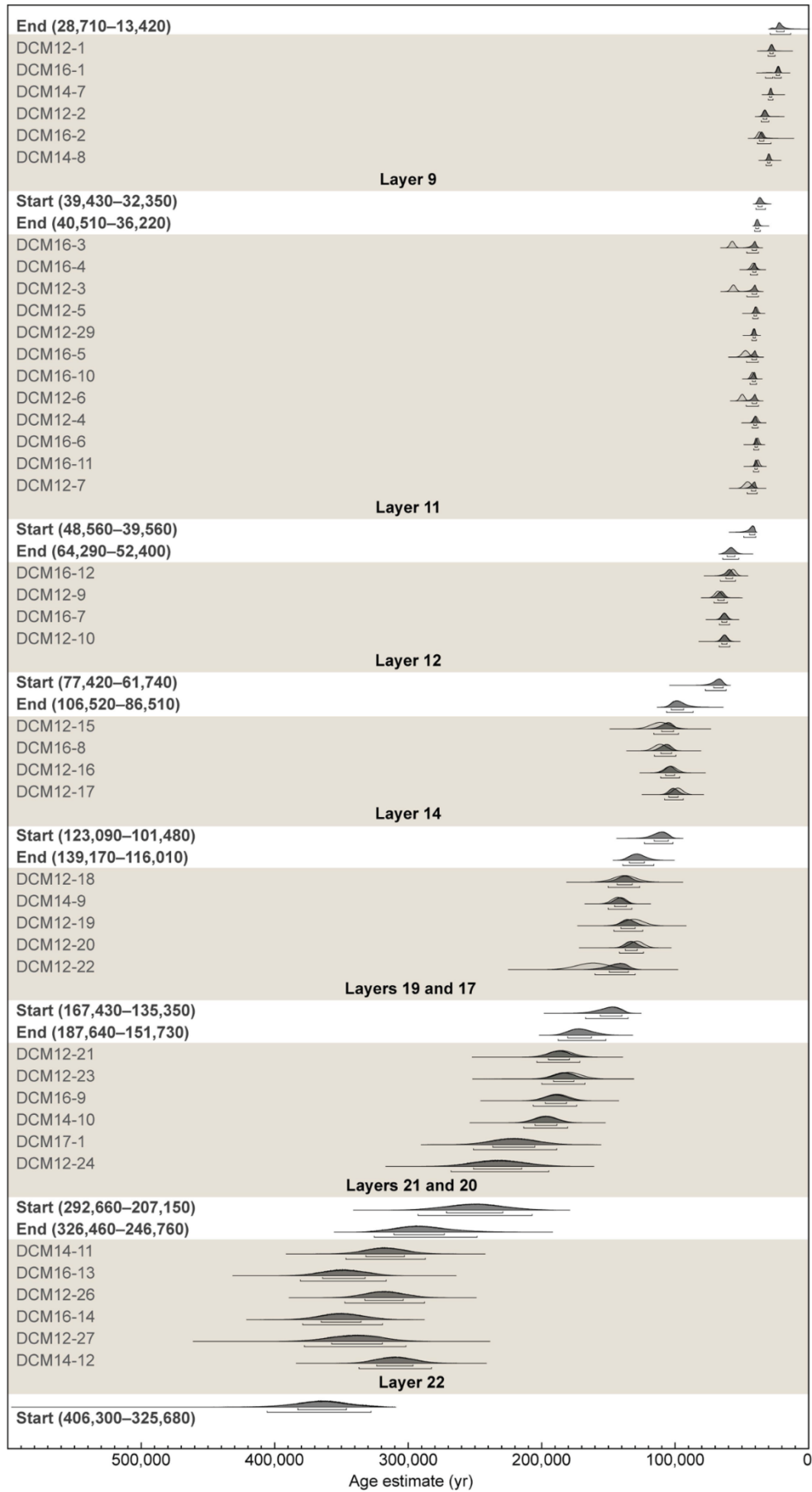


Figure 25: Denisova cave, Central chamber. Bayesian model of optical ages (Jacobs et al., 2019).

were deposited between 250 ± 44 ka and 170 ± 19 ka (Jacobs *et al.*, 2019). Samples were taken on all the layers, and the optical ages are mostly in stratigraphic order (Figure 25).

AMS radiocarbon dates were obtained in layer 11.2 ($48,650 \pm 2,380$ BP, $>50,000 \pm 1,900$ BP and $>50,900 \pm 2,200$ BP) and at the border between layers 11 and 10 ($29,200 \pm 360$ BP) (Derevianko, 2009; Derevianko *et al.*, 2014).

More recently, a radiocarbon dating campaign of Denisova has yielded three dates for the Central chamber: one for layer 11.1, at 37.5 ± 1 ka BP (OxA-29861) and two for layer 11.4, 42.9 ± 2 ka BP (OxA-29872) and 41.2 ± 1.4 ka BP (OxA-30271; manufactured bone point) (Douka *et al.*, 2015). This dating campaign was completed in 2016 and 2017 with the addition of 63 dating samples in both the Central chamber and the Eastern gallery (Douka *et al.*, 2019). These samples included two bone points and a tooth pendant in the Central chamber (Figure 26).

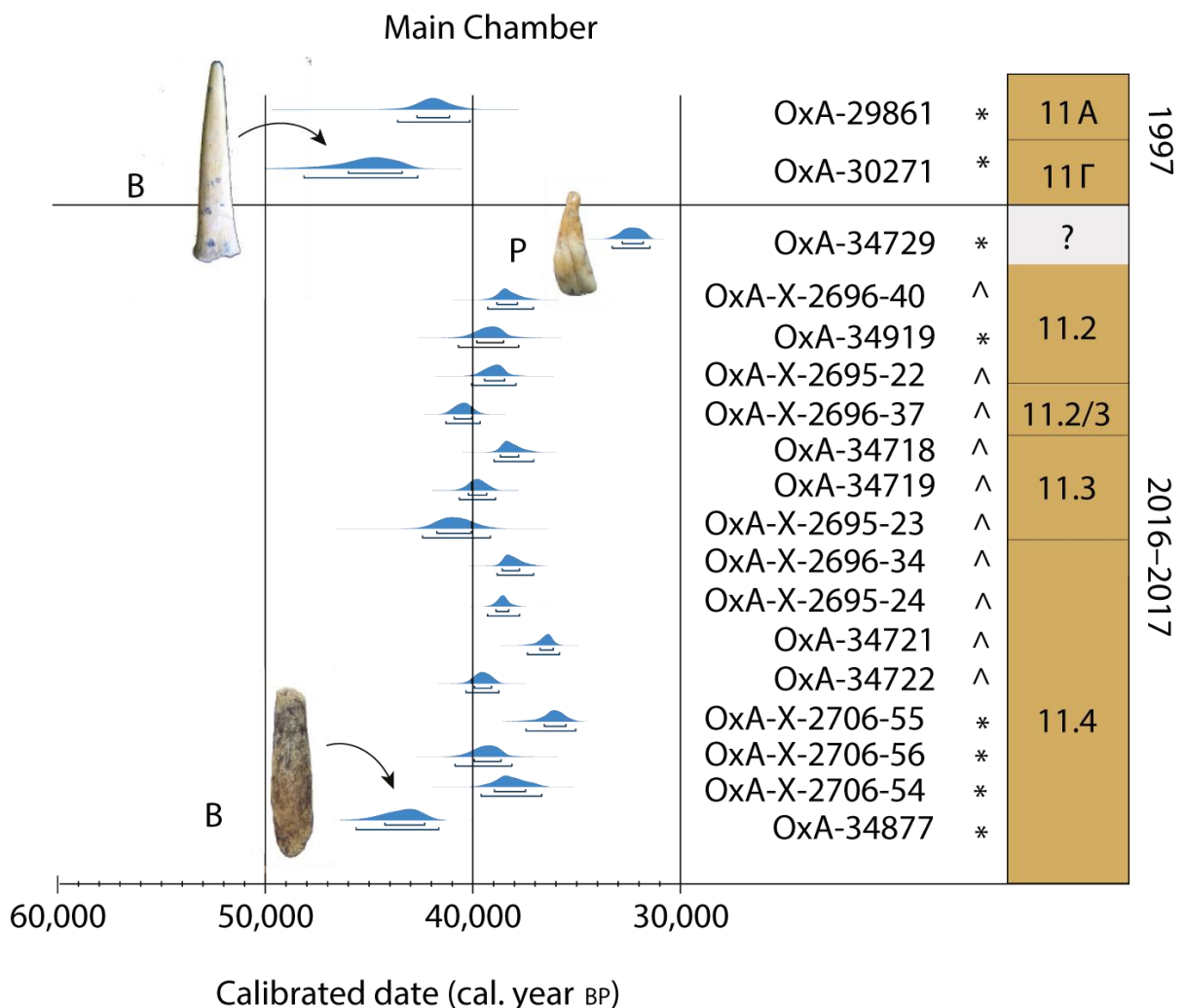


Figure 26: Denisova cave, Central chamber. Radiocarbon age determinations. B: bone points; P: pendant; *: bone sample; ^: charcoal sample (modified after Douka *et al.*, 2019).

3.1.2.3.3 Eastern gallery

After the discovery of *Denisova 3*, a phalanx whose DNA revealed the existence of a new species, named Denisovans (see below, Human remains), a campaign of radiocarbon dating has been undertaken, focusing on layer 11 where the bone has been found (Table 4; Reich *et al.* 2010).

<i>Layer</i>	^{14}C	<i>Lab number</i>	<i>Taxon</i>
11	15,740 ± 65 BP	OxA-V-2359-15	<i>Ovis/Capra</i> , cutmarked
11	23,170 ± 110 BP	OxA-V-2359-21	Bone tool blank
11	30,100 ± 210 BP	OxA-V-2359-20	Rib w/regular markings
11.2	>50,000 BP	OxA-V-2359-16	<i>Ovis/Capra</i>
11.3	>50,000 BP	OxA-V-2359-14	<i>Bison</i> , cutmarked

Table 4: *Denisova Cave, East Gallery, radiocarbon dates (Reich et al., 2010)*

The results are very variable and do not overlap, which suggests a disturbance in the layer, leading to an artificial association of Upper and Middle Palaeolithic material. To clarify the stratigraphy, other radiocarbon dates were obtained on layer 11, as well as on the first fully Upper Palaeolithic level, layer 9 (Table 5; Douka *et al.*, 2015).

<i>Layer</i>	^{14}C	<i>Lab number</i>	<i>Taxon</i>
9.2	45,500 ± 2,300 BP	OxA-29859	<i>Equus</i>
11.1	27,820 ± 340 BP	OxA-30006	<i>Cervus</i> (bead)
11.1	47,900 ± 3,100 BP	OxA-29855	<i>Crocuta</i>
11.2	35,400 ± 900 BP	OxA-30005	<i>Cervus</i> (bead)
11.2	41,300 ± 2,400 BP	OxA-30963	<i>Alces</i> (bead)
11.2	41,300 ± 900 BP	OxA-31506	charcoal

Table 5: *Denisova Cave, East gallery, radiocarbon dates (after Douka et al., 2015)*

Seven other dates (2 on layer 11.2, 1 on 11.3 and 4 on 11.4) have yielded infinite results. The ones from layer 11.2 were on bones which were closely associated with the human phalanx, excavated the same year in the same square.

The overall results seem to confirm the existence of post-depositional movements in the layers. Layer 9, which material is clearly Upper Palaeolithic, yielded a surprisingly old date at 43-47 ka BP or 45-49 ka cal BP (Douka *et al.*, 2015). This date has been recently confirmed by the

radiocarbon dating of a second bone⁵ at $46,300 \pm 2,600$ BP (OxA-36011; Douka *et al.*, 2019). Conversely, the beads from layer 11.1 and layer 11.2 yielded more recent dates (Figure 27).

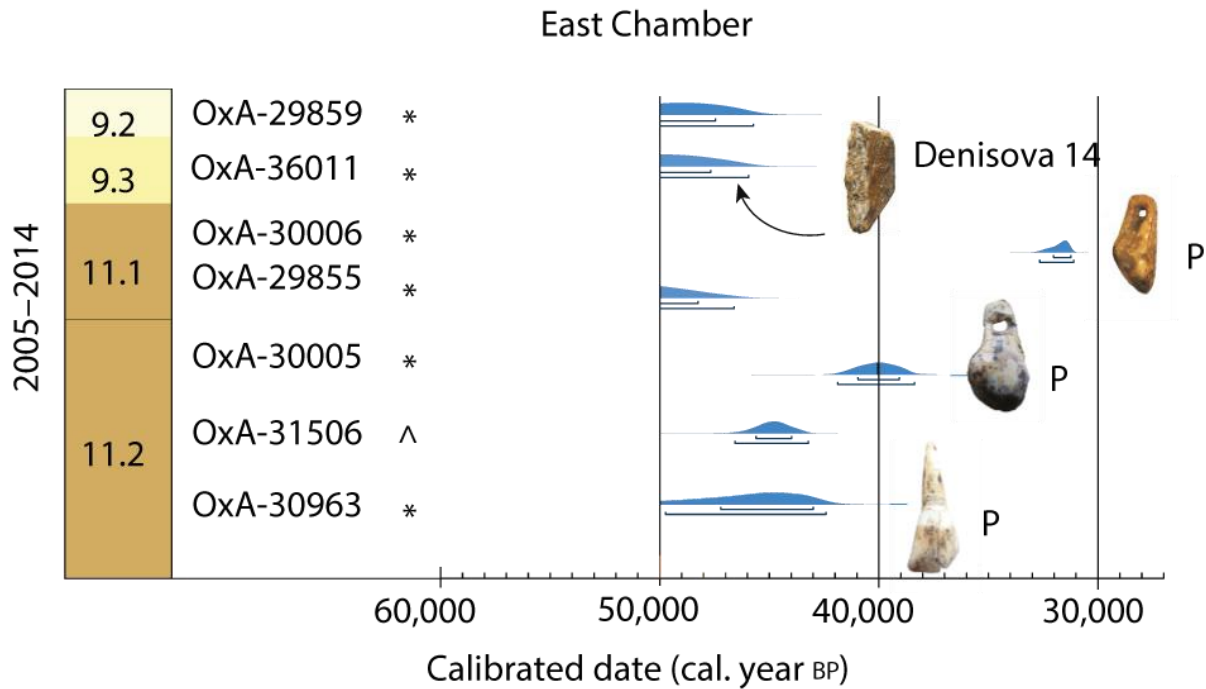


Figure 27: Denisova cave, Eastern gallery. Radiocarbon age determinations. B: bone points; P: pendant; *: bone sample; ^: charcoal sample (modified after Douka *et al.*, 2019).

Concurrently to the radiocarbon dating, 37 samples were taken for optical dating all throughout the layers (Jacobs *et al.*, 2019). No important post-depositional disturbance could be observed for layers 17 to 11.3, whose deposits have a stratigraphically coherent chronology (Figure 28). Likewise, half of the samples from layers 11.2 and 11.1 show a good integrity. However, the other half, as well as samples from layers 9 and 8, display undetermined results that could be explained by the mixing of grains of various ages, probably due to burrowing animals.

⁵ Denisova 14, identified as a human bone by the ZooMS method.

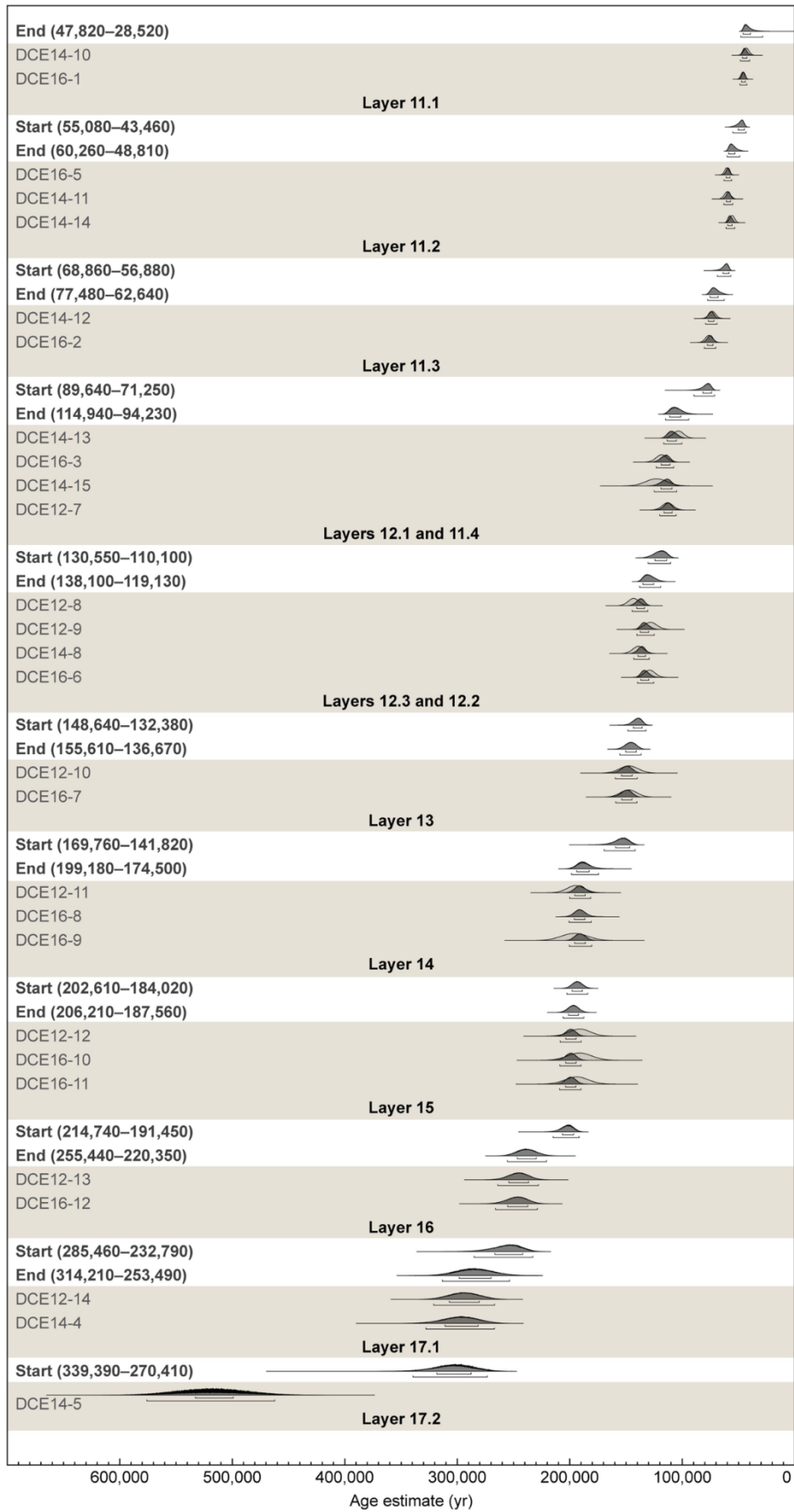


Figure 28: Denisova cave, Eastern gallery. Bayesian model of optical ages (Jacobs et al., 2019).

3.1.2.4 Fauna

3.1.2.4.1 Entrance zone

Bones were only preserved in the middle part of the section. For the macrofauna, 21 species were identified (Derevianko *et al.*, 1998a):

- Carnivores
 - *Alopex lagopus*
 - *Vulpes corsac*
 - *Vulpes vulpes*
 - *Canis lupus*
 - *Ursus arctos*
 - *Ursus rossicus*
 - *Martes zibellina*
 - *Mustela eversmanii*
 - *Crocuta spelaea*
 - *Panthera spelaea*
- Proboscidiens
 - *Mammuthus primigenus*
- Perissodactyles
 - *Coelodonta antiquitatis*
 - *Equus hydruntinus*
 - *Equus ferus*
- Artiodactyles
 - *Capreolus pygargys*
 - *Cervus elaphus*
 - *Bison priscus*
 - *Procapra gutturosa*
 - *Saiga tatarica*
 - *Capra sibirica*
 - *Ovis ammon*

The repartition of the bones in the layers is very uneven. The richest layers of fauna are layer 7 (NISP=244), and layer 6 (NISP=178), while in layers 8, 9 and 10 no more than respectively 65, 56 and 50 bones were identified, and only 8 for layer 5 (Derevianko *et al.*, 2003). It is thus difficult to draw conclusions from layers comparison.

More than 17,000 remains of microfauna have been identified, representing 39 different taxa, 34 of which being micro-mammals (Derevianko *et al.*, 2003; Agadjanian and Serdyuk, 2005). They do not differ from modern-day micro-mammals – indicating that they cannot be older than Middle Pleistocene –, but the composition of the assemblage is very different from the Holocene situation of the Anuy Valley. It suggests a warm, dry episode in layer 10, with woodland species appearing only in layer 9 (Shunkov and Agadjanian, 2000); then layer 8 displays a cold and very arid climate, which becomes damp in layer 7, with the progression of forests and grasslands. Finally, layer 6 displays the traces of a steppic climate.

3.1.2.4.2 Central chamber

In the Central chamber, 27 macrofaunal species have been identified (Derevianko *et al.*, 1998a; 2003):

- Carnivores
 - *Alopex lagopus*
 - *Vulpes corsac*
 - *Vulpes vulpes*
 - *Cuon alpinus*
 - *Canis lupus*
 - *Ursus arctos*
 - *Ursus rossicus*
 - *Martes zibellina*
 - *Mustela eversmanii*
 - *Mustela ermine*
 - *Mustela altaica*
 - *Mustela nivalis*
 - *Crocuta spelaea*
 - *Panthera spelaea*
 - *Lynx lynx*
- Proboscidiens
 - *Mammuthus primigenus*
- Perissodactyles
 - *Coelodonta antiquitatis*
 - *Equus hydruntinus*
 - *Equus ferus*

- Artiodactyles
 - *Capreolus pygargus*
 - *Cervus elaphus*
 - *Poephagus mutus*
 - *Bison priscus*
 - *Procapra gutturosa*
 - *Saiga tatarica*
 - *Capra siberica*
 - *Ovis ammon*

On the whole, the species composition represents a mosaic landscape characteristic of mountainous regions. There are no important changes in the species representation between layers, except that no forest taxa were found in layer 9. According to Wrinn (2010), the cave was primarily used as a bear den in layer 22, and the overlaying levels were occasionally used as a hyena and wolf den. In all the layers studied, hominins played a very limited role in the accumulation.

More than 40 microfaunal species were identified, 37 of which being mammals (Shunkov and Agadjanian, 2000; Derevianko *et al.*, 2003; Agadjanian and Serdyuk, 2005). There is a relative stability in the species representation between layers, except a notable decrease of the number of chiropters above layer 21, which cannot be explained environmentally. It is possible that the human presence – attested by an increase in the number of artefacts, and the appearance of coals in layer 21 – was the reason of their disappearance. As for the Entrance zone, the microfauna present in the cave is different from present-day microfauna of the Anuy valley, which indicates a different landscape. The most common taxa, *Stenocranius gregalis* and *Alticola strelzovi*, suggest an arid mountain steppe environment. A few forest taxa, like *Clethrionomys*, are present in the whole profile, but more numerous in the lowermost layers, 22 and 21. There could be an evolution from a forest environment to a more steppic landscape around layer 20.

3.1.2.4.3 Eastern gallery

In the Eastern gallery, more than 162,000 bone remains were excavated, belonging to more than 52 different species (Table 6; (Vasil'ev *et al.*, 2017). The bones are heavily fragmented, and as a result only 2.5% of them are larger than 5 cm. Carnivores represent from 27.3% of the assemblage in layers 14-15 up to 31.1% in layer 12, and are likely the main accumulator (Vasil'ev *et al.*, *ibid*). Traces of human activity, such a burned bones, are more present in layers 11.3, 14 and 15. An ongoing study confirms the accumulation by predators for layers 11.1 to

11.4, but the carnivore traces are less numerous in the lower layers, and human is recognized as the main accumulator for layers 14 to 17 (Rendu *et al.*, 2018).

The faunal spectrum is dominated by steppe species (up to 68%), with a small presence of forest taxa (up to 7.5%) for layers 9 to 13, but there is a strong forest component in layers 14 and 15, with the presence of roe deer, red deer, and brown bear, in a typical interglacial forest environment (Vasil'ev *et al.*, *op. cit.*). However, steppe taxa are also present, which indicates a mosaic landscape, consistent with the spectrum of the Central chamber.

Taxa	Layer											
	9	11.1	11.2	11.3	11.4	11 d*	12	13	14	15	17	Total
<i>Erinaceus auritus</i>	-	-	-	-	-	-	1	-	-	-	-	1
<i>Asioscalops altaica</i>	5	14	47	45	16	5	47	6	33	3	-	221
<i>Chiroptera</i> gen. indet.	1	1	2	-	-	-	-	1	-	-	-	5
<i>Lepus tanaiticus</i>	1	8	29	16	10	3	23	2	7	3	-	102
<i>Lepus tolai</i>	-	7	34	7	4	5	8	-	2	-	1	68
<i>Ohotona</i> sp.	1	5	9	10	4	1	8	1	2	-	-	41
<i>Pteromys volans</i>	-	-	3	-	-	-	1	-	-	-	-	4
<i>Tamias sibiricus</i>	-	-	-	1	-	-	-	-	-	-	-	1
<i>Spermophilus</i> sp.	1	33	70	32	8	12	31	4	22	3	3	219
<i>Marmota baibacina</i>	3	6	42	59	26	-	78	12	85	14	-	325
<i>Castor fiber</i>	-	-	2	9	2	-	-	-	-	2	-	15
<i>Allactaga</i> sp.	-	-	-	-	-	-	-	-	1	-	-	1
<i>Cricetus</i> sp.	-	-	14	7	1	2	18	-	-	-	-	42
<i>M. myospalax</i>	15	92	271	223	67	18	225	31	105	17	-	1064
<i>Rodentia</i> gen. indet.	8	66	153	105	25	18	88	26	71	10	-	570
<i>Canis lupus</i>	5	9	82	64	46	1	120	17	66	24	-	434
<i>Vulpes vulpes</i>	1	9	49	37	33	-	76	6	20	7	-	238
<i>Vulpes corsak</i>	-	-	15	13	14	-	18	4	8	-	1	73
<i>Cuon alpinus</i>	-	2	8	27	17	1	55	9	54	13	1	187
<i>Ursus arctos</i>	-	-	2	12	-	1	23	1	20	6	-	65
<i>U. (Spelaearctos) savini</i>	-	1	3	-	-	-	-	-	-	-	-	4
<i>Martes zibellina</i>	-	-	-	3	-	-	-	-	-	-	-	3
<i>Gulo gulo</i>	-	-	2	1	-	-	-	-	-	-	-	3
<i>Mustela erminea</i>	-	-	1	1	2	-	-	-	-	-	-	4
<i>Mustela nivalis</i>	-	-	-	1	-	-	1	-	-	-	-	2
<i>Mustela sibirica</i>	-	-	1	2	-	-	-	-	-	-	-	3
<i>Mustela altaica</i>	-	-	3	1	6	-	1	-	2	1	-	14
<i>Mustela eversmanni</i>	-	1	2	-	2	-	8	1	2	-	-	16
<i>C. crocuta spelaea</i>	10	30	99	133	51	9	182	14	33	3	-	564
<i>Panthera spelaea</i>	-	-	3	-	2	-	1	-	-	-	-	6
<i>Uncia uncia</i>	-	-	3	2	1	-	-	-	-	-	1	7
<i>Lynx lynx</i>	1	-	-	-	-	-	-	-	-	-	-	1
<i>Felis manul</i>	-	-	-	1	-	-	-	-	-	-	-	1
<i>Mammuthus primigenius</i>	1	1	3	13	9	-	19	2	4	4	-	56
<i>Equus (E.) ferus</i>	3	5	6	8	2	-	13	1	4	-	-	42
<i>E. (Sussemionus) ovodovi</i>	1	2	14	36	13	2	33	1	11	8	-	121
<i>E. ovodovi/ferus</i>	2	16	88	97	49	6	180	25	113	7	-	583
<i>Coelodonta antiquitatis</i>	2	6	16	44	19	-	43	14	53	9	-	206
<i>Cervus elaphus</i>	3	3	27	43	28	3	30	4	30	26	2	199
<i>Megaloceros giganteus</i>	1	-	4	5	5	-	3	-	5	3	-	26
<i>Alces cf. alces</i>	-	-	-	1	1	-	1	-	-	-	-	3
<i>Capreolus pygargus</i>	2	1	28	46	29	7	51	6	109	49	2	330
<i>Rangifer tarandus</i>	-	-	3	1	-	-	4	-	-	-	-	8
<i>Bison priscus</i>	10	22	116	97	50	14	123	12	48	13	-	505
<i>Poëphagus mutus baicalensis</i>	-	-	-	1	1	-	1	-	-	-	-	3
<i>Saiga tatarica borealis</i>	-	-	2	8	-	-	7	-	3	-	-	20
<i>Gazella guttursza</i>	-	-	1	60	22	2	118	21	46	2	-	272
<i>Gazella / Saiga</i>	-	1	9	21	8	-	49	3	18	5	-	114
<i>Capra sibirica</i>	6	27	140	121	47	18	170	22	63	11	2	627
<i>Ovis ammon</i>	1	15	48	27	12	3	32	10	6	1	-	155
<i>Capra / Ovis</i>	15	19	113	116	44	15	196	17	26	13	-	574
<i>Spirocerus kiakhtensis</i>	-	-	-	-	-	-	1	-	-	-	-	1
<i>Pisces</i>	-	2	6	5	3	-	-	5	-	-	-	21
<i>Amphibia</i>	-	-	2	2	-	-	3	-	1	-	-	8
<i>Aves</i>	7	49	194	133	75	15	137	12	55	5	-	682
Undeterminate fragments	1282	5152	14177	25167	18437	3127	41534	6243	29757	8221	405	153502
Total	1388	5605	15946	26864	19191	3288	43761	6533	30885	8483	418	162362

Table 6: Denisova cave, Eastern gallery. Faunal remains. d*: deformed part of layer 11 (after Vasil'ev et al. 2017)

3.1.2.5 *Human remains*

Denisova Cave has yielded numerous human remains that can be attributed either to Neanderthals or to Denisovans. The first remains were found in the 1984 excavation, in the Central chamber.

- Denisova 1 is a permanent incisor found in layer 12, and was ascribed first to a Neanderthal (Turner, 1990), then to a modern human (Shpakova and Derevianko, 2000; Shpakova, 2001), but it is actually a very worn incisor from a large bovid (Viola *et al.*, 2011).
- Denisova 2 is a worn deciduous molar found in layer 22.1, and is thus the earliest human fossil from Central Asia (Viola *et al.*, 2011). Its very strong wear made morphological comparisons impossible and prevented its attribution to a species, even if its size brings it closer to Neanderthals than modern humans (Slon *et al.*, 2017a). However, in a recent study, Slon *et al.* (2017b) ascribed it to the Denisovan group on the basis of DNA analysis.

Recently, a new specimen has been identified by collagen peptide mass fingerprinting, Denisova 16 in layer 9.1 (Douka *et al.*, 2019). However, the precise species could not be determined, and radiocarbon dating was not performed due to its small size.

In the Eastern gallery, four fossils have been described.

- Denisova 3 is a small fragment of a distal manual phalanx of a child – 6 to 7 years old – from layer 11.2, excavated in 2008. The morphology was undiagnostic, but the very good preservation of the nuclear and mitochondrial DNA allowed the identification of a new genetic sequence, that we now call Denisovan (Krause *et al.*, 2010; Reich *et al.*, 2010; Viola *et al.*, 2011).
- Denisova 8 is a very large fragmented upper third molar found at the interface between layers 11.4 and 12 in 2010, and the analysis of its nuclear and mitochondrial DNA sequence puts it in the Denisovan group (Sawyer *et al.*, 2015).
- Between those two Denisovan fossils, Denisova 5 is an adult toe phalanx found in layer 11.4 in 2008, morphologically falling in the ranges of variability of both Neanderthals and modern humans (Prüfer *et al.*, 2014). The very good preservation of the DNA allowed the complete reconstruction of the mitochondrial genome sequence of a Neanderthal.

- Denisova 9 is a distal hand phalanx found in layer 12.3; its morphology falls in the range of Near-Eastern and European Neandertals (Mednikova, 2013).

The interstratification between Denisovans and Neanderthals in the Eastern gallery is confirmed by a study on DNA on sediment (Slon *et al.*, 2017b), where Denisovan DNA was identified in layer 15 and Neanderthal DNA in layers 14 and 11.4 (Figure 29). Interestingly enough, no layer has yielded both DNAs. However, the recent discovery of Denisova 11 shows that interbreeding occurred between Denisovans and Neanderthals (Slon *et al.*, 2018).

- Denisova 11 is a splinter of a large long bone excavated in the lower part of layer 12 in the Eastern gallery, in 2012. Its morphology was undiagnostic, and it was analysed by collagen peptide mass fingerprinting, which identified it as a hominin. Its DNA sequence indicates that this is a young female individual, at least 13 years old, who is the offspring of a Neanderthal mother (its mitochondrial DNA corresponds to Neanderthals) and a Denisovan father.

The Eastern gallery hominins also include Denisova 6, a worn lower deciduous incisor found in layer 11.4, too small to be sampled for ancient DNA and thus indeterminate. Two more specimens have been identified using collagen peptide mass fingerprinting, Denisova 14 in layer 9.3 (indeterminate hominin) and Denisova 15 in layer 11.4 (Neanderthal). Both have been directly dated by AMS, Denisova 14 at $46,300 \pm 2,600$ BP, and Denisova 15 at $>50,200$ BP (Douka *et al.*, 2019).

In the South gallery, a single fossil has been published. Denisova 4 is a very large permanent upper molar excavated in layer 11.1 in 2000, and falls outside the Neanderthals and modern humans range. The size and morphology of its roots are also very different from Neanderthals and European Middle Pleistocene hominins (Reich *et al.*, 2010; Sawyer *et al.*, 2015). Its nuclear and mitochondrial DNA indicates that it belongs to a Denisovan (Sawyer *et al.*, *ibid*).

Denisova 13, a parietal fragment found during a section cleaning and attributed to layer 22, is described as hominin, but still undetermined (Viola *et al.*, 2019).

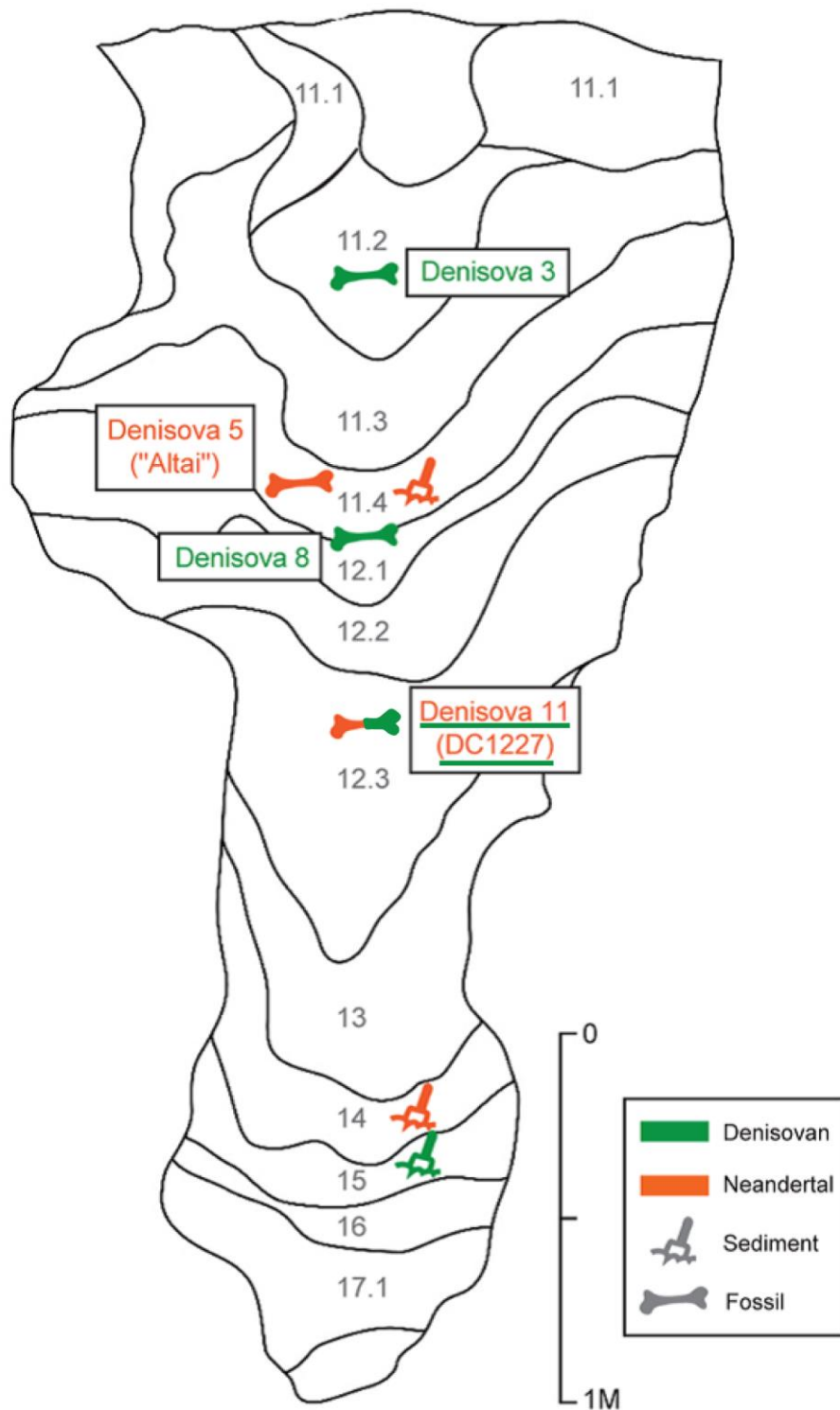


Figure 29: Denisova Cave, hominin DNA along the stratigraphy of the Eastern Gallery (modified after Slon et al., 2017b)

3.1.2.6 Lithic and bone industries

Different periods have been identified in the different sectors of the cave (Table 7).

	<i>Entrance zone</i>	<i>Central ch.</i>	<i>Eastern gallery</i>	<i>South gallery</i>
<i>Late UP</i>	5			
<i>Early UP</i>	6-7	9	9	9
<i>Transitional</i>	8	11	11	11
<i>MP</i>	9-10	12-22	12-17	

Table 7: Denisova cave. Summary of the lithic assemblage attributions (modified after Derevianko *et al.*, 2001)

3.1.2.6.1 Middle Palaeolithic

1.1.1.1.1.1 Entrance zone

The published information is based on material excavated in 1989 only (Derevianko *et al.*, 2001d; 2003). Layers 9 and 10 yielded respectively 569 and 833 artefacts. Levallois parallel reduction and radial reduction dominate the assemblage. A biface is reported in layer 10 (Derevianko *et al.*, 2003; fig. 82, 11). According to Zwyns (2012), who had access only to the drawing, the biface could be considered a core. We tend to agree with this interpretation: the artefacts seems organised in two faces, with the removal of a preferential pointed flake on one of the faces.

Blades are rare in layer 10, and their number increases in layer 9. The tool assemblage is rich in denticulates and notches, with an appearance of “Upper Palaeolithic tools” in layer 9 – mostly burins and endscrapers. According to the drawings in Derevianko *et al.* (2003; fig. 86, 2-4, 6, 8, 10), the endscrapers are actually side-scrappers, and the retouch on the burins look more like edge-damage for most of them. In the layer 10 sample studied by Goebel (1993), nearly half the tools are manufactured on Levallois products (6 Levallois flakes and 7 Levallois points). In layer 9, he describes a “unidirectional flat-faced blade core” (*ibid.*, fig. 6.37, K) that seems to be actually narrow-faced, and is similar to a burin-core (Zwyns, 2012). This burin-core and the blades that bear a bidirectional dorsal pattern may fit in the IUP variability (Zwyns, *ibid.*). However, the general assemblage of layers 10 and 9 can be described as Levallois Mousterian (Goebel, 1993) or Middle Palaeolithic with a Levallois component (Derevianko *et al.*, 2001; 2003).

1.1.1.1.1.2 Central chamber

The published information is based on excavations from 1984 and 1993-1995 (Derevianko *et al.*, 2001d; 2003).

Layer 22.2 yielded very few artefacts (n=7), one of them being a large flake with laminar removals on its edge (Derevianko *et al.*, 2003, fig. 56, 5). This seems to contrast with the rest

of the assemblage, consisting of one flake, 4 pieces of shatter, and one scraper that is compared to the Quina type. Layer 22.1 is richer (n=312), and 3 of the cores (n=10) are said to be Levallois. The Levallois products are 2 flakes, 2 fragments of blades and 5 points, and 6 of them present faceted *chapeau de gendarme* platforms. The rest of the assemblage mostly consists of flakes (n=114) and shatter (n=135); most of the tools (n=40) are manufactured on flakes (67.5%), and sidescrapers are the dominant type (n=13).

Layer 21 (n=293) is characterized by a production of short flakes on polyhedral and radial cores. The platforms are mostly plain or cortical, and most flakes have a natural back. Except for a chopper on a massive pebble, all the tools are manufactured on flakes. The toolkit is represented by scrapers, knives, denticulates and varied retouched flakes.

According to Derevianko *et al.* (2003), layers 22 and 21 represent an early stage of the Middle Palaeolithic, but layer 22 could also be attributed to a Late Acheulean. However, the presence of one bifacial form doesn't seem enough of an argument for an Acheulean attribution, in the absence of other typical large cutting tools like cleavers.

Layers 20 to 12 (n=7,545) represent the classic Middle Palaeolithic. The repartition of the material through the profile is very uneven, with only 17 artefacts in layer 18 and up to 2,500 artefacts in layer 12. As the techno-typological characteristics of the assemblages are quite homogenous, only the material from the most representative layers – 19, 14 and 12 – was published (Derevianko *et al.*, 2001d; 2003). They are characterised by a flake production with a diversity of reduction sequences dominated by parallel reduction patterns. Still, Levallois, radial and narrow-faced cores are also represented. The general industry is classified as non-Levallois, with low Levallois, laminar and facettage indexes. Points (n₁₉=12, n₁₄=11, n₁₂=13) dominate the Levallois products, but blades (n₁₉=8, n₁₄=6, n₁₂=9) and flakes (n₁₉=2, n₁₄=7, n₁₂=4) also occur. Most of the points have faceted *chapeau de gendarme* platforms. The most common retouched tools are sidescrapers, followed by denticulates. In layer 12, Zwyns (2012) notes the appearance of a few atypical artefacts, notably a possible burin-core on a thick side blade (Derevianko *et al.*, 2003; fig. 64, 6) and a triangular bidirectional Levallois core with removals on the narrow face (*ibid.*, fig. 64, 10). Those elements, which are more typical of IUP than Middle Palaeolithic, could indicate a change in the production system, or an intrusion from overlying assemblages.

The techno-typological features of layers 20-12 suggest an identification as a non-Levallois Mousterian with parallel and radial reduction strategies and numerous notches and denticulates, or “Denisova variant” of the Altai Middle Palaeolithic (Shunkov, 2005).

1.1.1.1.3 Eastern gallery

Layers 15 to 11.3 are associated with the Middle Palaeolithic (Kozlikin, 2017). The repartition of artefacts throughout the profile is uneven, from 10,801 in layer 14 to 986 in layer 13. Most of the other layers have yielded around 3,000-6,000 artefacts. The lower number of artefacts in layer 13 can be linked with a cold environment (MIS 6).

Layer 15 (n=3,913) is a flake-based assemblage, with radial (n=11) and Kombewa (n=11) cores. Most of the assemblage consists of shatter (n=2,364) and flakes (n=1,514). Two blades – or elongated blanks – are reported, but the Levallois reduction sequence is completely absent. The toolkit is dominated by indeterminate retouched flakes (n=22), denticulates (n=10) and scrapers (n=5).

Layer 14 (n=10,801) is similar to layer 15, with a predominance of flakes (n=4,201) and only 8 blades. In addition to radial (n=33) and Kombewa (n=36) cores, we can note the appearance of the parallel reduction sequence, with 4 cores. Only 123 tools have been identified, which constitutes 1% of the total assemblage. Denticulates (n=29) and scrapers (n=23) are the most numerous. There is no mention of any artefact linked to the Levallois reduction sequence in this layer.

Layer 13 (n=986) is a flake-based assemblage with radial (n=8) and Kombewa (n=2) cores. The toolkit is scarce (n=20), dominated by denticulates (n=5).

Those three layers present a very simple, flake-oriented production, seemingly quite expedient. According to Kozlikin (*ibid.*), layers 15 and 14 assemblages represent an early Middle Palaeolithic comparable to layers 22 and 21 of the Central chamber. Layer 13 is not included in this group because stratigraphic data link it to the end of the Tazovo period, but no techno-typological argument distinguishes it from the lower assemblages.

Layer 12 (n=6,738) is a flaked-based assemblage with Kombewa (n=28), radial (n=19), parallel (n=13), Levallois (n=8) and subprismatic (n=1) cores. Blades are more numerous (n=98), and three of the Levallois cores produced blades. The toolkit is dominated by scrapers (n=30) and denticulates (n=20), but new types appear: truncated flakes (n=3), truncated-faceted pieces (n=4) and Levallois products (n=10).

Layer 11.4 (n=4,104) is similar to layer 12, but only two Levallois cores have been identified, one for flake production and one for blade production. Levallois points are represented (n=11), as well as blades (n=42). The toolkit is dominated by scrapers (n=32), denticulates (n=20) and notches (n=16).

Layer 11.3 (n=5,498) presents the same characteristics than layer 11.4, with an increase of blades (n=141), and two subprismatic cores. The toolkit is still dominated by scrapers (n=35), notches (n=14) and denticulates (n=8), but endscrapers (n=7) and retouched blades (n=8) are also present. Zwyns (2012; fig.203) identified two burin-cores on thick blades (one cortical, one neo-crest), that are characteristic of the IUP.

These three layers seem to illustrate a flake-oriented production with a minor Levallois component – when considered together, layers 11.4 and 11.3 yield 62 Levallois products (Derevianko *et al.*, 2015). Originally, layer 11 was considered as a whole an Early Upper Palaeolithic layer, compared to the Central chamber layer 11 (Derevianko *et al.*, 2005; 2006; 2010a). Zwyns (2012) considers that a few elements are typical of the IUP – a volumetric blade core, a large unidirectional blade core (*ibid.*; fig. 202), at least two burin-cores on thick blades, bidirectional blades and Levallois-like convergent blanks (*ibid.*; fig.203). However, more recent investigations (Derevianko *et al.*, 2015) have shown that no UP markers like bone tools or ornaments were present in layers 11.3 and 11.4, contrary to layers 11.2 and 11.1; moreover, the lithic assemblage is more similar to layer 12 than to layers 11.2 and 11.1. According to Kozlikin (2017), layers 13-11.3 can be compared to layers 20-12 of the Central chamber, and are associated to a classic Middle Palaeolithic.

3.1.2.6.2 Upper Palaeolithic

1.1.1.1.1.4 Entrance zone

Layer 8 (n=1,310) is presented as transitional by Derevianko *et al.* (2001; 2003), but Mousterian by Goebel (1993). The reduction strategy is mostly illustrated by simple parallel flake cores with one platform (n=5) or two (n=1). Goebel identifies 7 Levallois cores, and two flat-faced blades cores; Derevianko *et al.* (*ibid.*), only 3 Levallois cores (and one of them is a flat-faced blade core; Derevianko *et al.*, 2003; fig.88, 5). Only 38 blades are recorded. The toolkit is dominated by scrapers (n=19) and denticulates/notches (n=15), but UP tools are also present, mostly retouched blades (n=15) and endscrapers (n=12).

Derevianko *et al.* (2001; 2003) note the decrease of Levallois features compared to lower layers, and estimate that the Mousterian and Upper Palaeolithic components coexist in the same

proportions. They suggest a gradual transition between Middle Palaeolithic and Upper Palaeolithic. Goebel (1993) considers that the Mousterian component is dominant, with an “unusual” admixture of UP tool types.

Layer 7 (n=537) is the first assemblage to yield traces of bladelet production, with a carinated core (Derevianko *et al.*, 2003; fig.92, 3) and a wedge-shaped core (*ibid.*; fig.92, 5). The only other core to be illustrated is a bidirectional flat-faced blade core with a posterior crest (*ibid.*; fig.93, 3). Goebel (1993) describes the toolkit as heterogeneous, but mainly Mousterian because of the scrapers and denticulates; however he mentions retouched bladelets, endscrapers and burins. The presence of the bladelet cores suggests a EUP attribution, as the blade core could be either IUP or EUP.

Layer 6 (n=679) is a blade-based assemblage with two cores: a volumetric blade core with a posterior crest (Derevianko *et al.*, *op.cit.*; fig.94, 7) and a narrow-face bladelet core (*ibid.*; fig.94, 8). Retouched bladelets, endscrapers on blades, 3 eggshell beads and 4 bone tools – including a bone needle – confirm the Upper Palaeolithic attribution.

Layer 5 (n=391) is the most blade and bladelet oriented production of Denisova Cave. The toolkit is dominated by UP tools, and 4 bone implements have been identified: a fragmented needle, a borer, a composite tool and a large thrusting tool. This assemblage can be attributed to a Late Upper Palaeolithic.

1.1.1.1.1.5 Central chamber

Layer 11 (n=2,508) is similar to layer 8 of the entrance zone, with a moderate amount of blades (n=139) and an equal proportion of Mousterian and UP tool types. Levallois products are present but rare. The cores display parallel and radial flaking, for the production of short flakes. However, we can note the introduction of bladelets, large uni- and bidirectional blades, as well as bifacial leaf-points (Derevianko *et al.*, 2003; fig.67, 3; fig. 69, 5, 7), bone tools (n=32) and ornaments (n=5). Thus, the reduction strategies and toolkit have Mousterian traits, but some artefacts are characteristic of IUP assemblages.

Layer 9 (n=1,513) yielded an increased number of blades and bladelets, with prismatic and radial cores. The toolkit is dominated by tools on blades, which is a definite UP trait, as well as two bifacial tools. Bone implements are also present (n=8), including needles and pendants. A geometric microlith is mentioned (Derevianko *et al.*, 1993a). The assemblage of layer 9 can be attributed to the EUP (Zwyns, 2012).

1.1.1.1.1.6 Eastern gallery

Layer 11.2 (n=3,365) yielded a limited number of blades (n=71), and a variety of reduction strategies: parallel flaking (n=12), radial (n=7), Levallois (n=2), subprismatic (n=1), narrow-faced (n=1) cores (Derevianko *et al.*, 2017; Kozlikin, 2017). The toolkit is dominated by scrapers (n=35) and denticulates (n=15), but there are also endscrapers (n=8), burins (n=5) and retouched blades (n=6). This is the first layer to yield bone tools, with a bone blade and a needle fragment, as well as stone (n=6) and bone (n=15) ornaments.

In layer 11.1 (n=1,001), only two cores have been identified, both Levallois (Derevianko *et al.*, 2017; fig.7, 1, 2). According to the drawings, one is unipolar convergent, and the other bipolar orthogonal. Five Levallois points are reported. Blades (n=38) can be convergent (*ibid.*; fig.7, 4, 5). The toolkit is dominated by scrapers (n=20), but two endscrapers and a denticulate are reported. One stone bracelet (Derevianko *et al.*, 2008a), 2 stone beads, 3 bone pendants and a bone ring have been identified.

The assemblages from layers 11.2 and 11.1 have been compared to layers 11 of the Central chamber and 8 & 7 of the Entrance zone (Kozlikin, 2017). Their industry presents a strong Middle Palaeolithic component, but the presence of tools like burins on blades and retouched blades brings it in the variability of the beginning of the Upper Palaeolithic in southern Siberia (Rybin, 2014; Derevianko *et al.*, 2017). Bone tools and ornaments suggests an Upper Palaeolithic attribution.

In layer 9 (n=2,002), blades are more numerous (n=134), and bladelets (n=3) are recorded for the first time. Radial (n=5), flat-faced (n=3), narrow-faced (n=1) and subprismatic (n=1) cores are present. The toolkit is dominated by scrapers (n=27) and Levallois points (n=5), but we notice the presence of a retouched blades (n=10), a backed bladelet, 4 endscrapers and 2 burins.

Kozlikin (2017) compares layer 9 to the Central chamber layer 9, and groups them with layers 5 and 6 of the Entrance zone when defining the Upper Palaeolithic industry of Denisova Cave.

3.2 THE OPEN-AIR SITES

3.2.1 Ust'-Karakol

3.2.1.1 *Location and history*

Ust'-Karakol (N 51°22'50'', E 84°41'20'' – 680 m asl) is located at the confluence of the Anuy and Karakol rivers, 1.8 km upstream from Denisova (Figure 19, Figure 30). Three geomorphological elements can be distinguished in the valley: the floodplain, the terrace (2 m above the floodplain), and the slope of the hill. The floodplain, 0.5 to 1 m above the river, extends to 150 m width. It contains alluvial clay deposits, over a layer of pebbles situated 14 m under the current bed of the Anuy River. The alluvial terrace dates back to the Upper Pleistocene and is covered by steppe herbs forming a meadow. The slope is first gentle (10 to 15°) for 200 m, then sharply increases (to 20 – 25°) at around 35 m above the river, where the steppe is replaced by a forest of birches and larches.

The site was discovered by A.P. Derevianko in 1984, and the first campaign took place in 1986 under the supervision of S.V. Markin (Derevianko *et al.*, 2003). The excavation (UK1-1) was located 9 m above the river level, and covered a surface of 120 m², with a depth of 4.95 m. Markin identified 10 lithological layers, 9 of which belong to the Pleistocene; three of the Pleistocene layers have yielded archaeological material.

From 1993 to 1997, A.V. Postnov directed a second campaign of excavation, opening a new sector (UK1-2) 5 m from the eastern border of UK1-1 (Slavinsky, 2007), 6 to 10 m above the river. UK1-2 covers a surface of 250 m², and the 6.5 m deep profile was separated in 20 lithological layers, 19 of which belonging to the Pleistocene.

From 1988 to 1990, another locus, UK2, was excavated (Maloletko & Panichev, 1990; Slavinsky, 2007), situated 50 m upslope from UK1-2. These two loci were later connected by a trench along the slope (Figure 31; Slavinsky, 2007; Zwyns, 2012), but neither UK2 nor the trench excavations have been published.



Figure 30: Ust'-Karakol 1-2 (photo J. Jaubert).

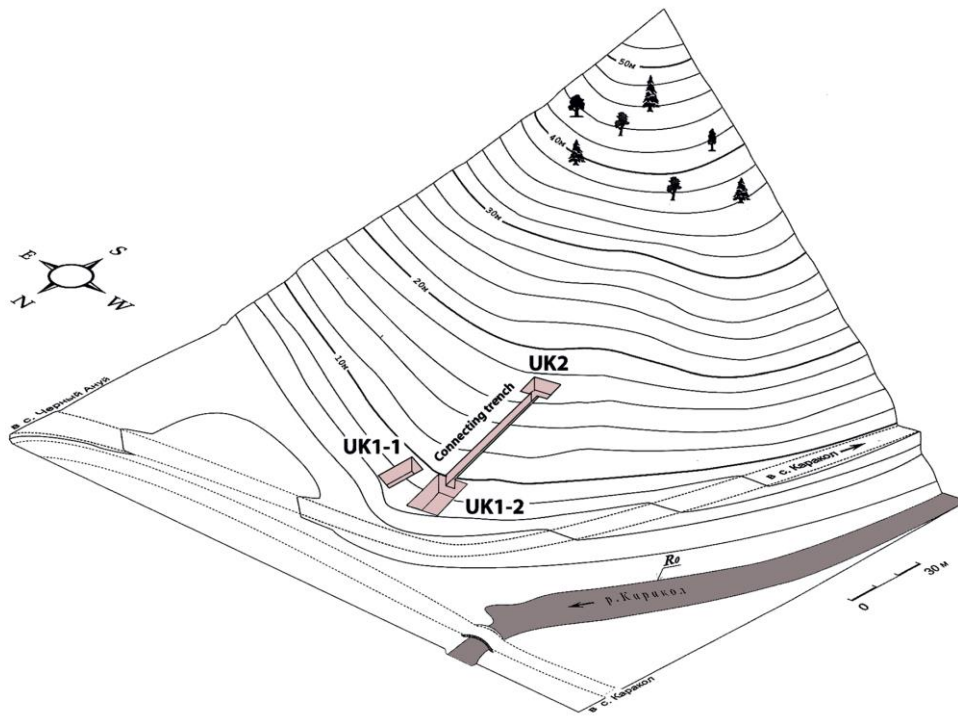


Figure 31: Ust'-Karakol, general reconstruction of the excavation areas (Zwyns, 2012)

3.2.1.2 Stratigraphy

3.2.1.2.1 UK1-1

Ten lithological layers have been distinguished on UK1-1 profile (Figure 32; Derevianko *et al.* 1987).

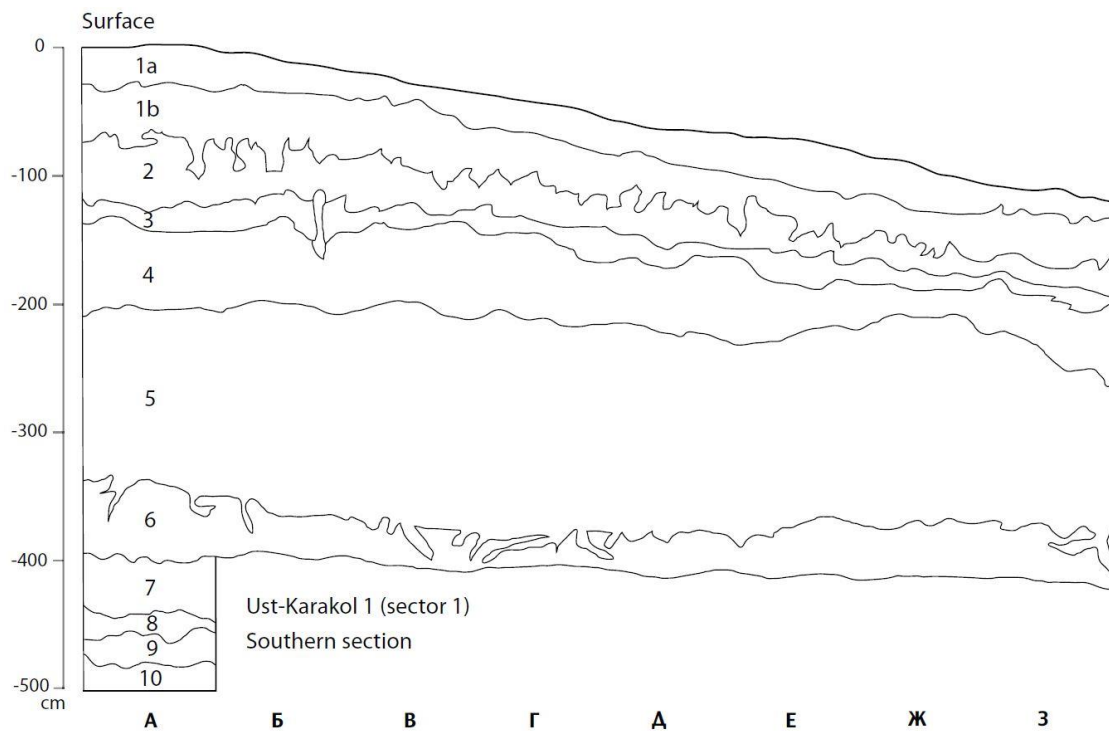


Figure 32: Ust'-Karakol 1-1, stratigraphic profile (Zwyns, 2012)

- Layer 1: modern humus, with some ceramics and bone fragments which constitute cultural horizon 1.
- Layer 2: light brown loam, with some debris (limestone, jasper, shales). Some artefacts and bones constitute cultural horizon 2.
- Layer 3: limestone blocks and pebbles, with a loamy filler.
- Layer 4: silty clay, mixed with remnants of humus bed.
- Layer 5: yellow-brown loam, with pebbles and gravel. Artefacts lay at the base (cultural horizon 3). This is the richest assemblage of the sector, and was first attributed to Early Upper Palaeolithic (Goebel, 1993), then distinguished in IUP and EUP sublayers (Slavinsky 2007; Zwyns, 2012).
- Layer 6: this is the deepest layer containing artefacts (cultural horizon 4). It consists of a homogeneous grey loam, with some limestone debris and frost cracks, filled by sediment from layer 5.
- Layer 7: limestone blocks with a filler of dark loam, presenting frost cracks.
- Layer 8: dark-grey loam
- Layer 9: grey clay with a few sandstone pebbles.
- Layer 10: pebbles and boulders, topped with clay and sand.

3.2.1.2.2 UK1-2

UK1-2 is divided in 20 lithological layers, nearly all of which have yielded archaeological material (Figure 33; Derevianko *et al.*, 2003). The first layers (1-3) compose the modern soil.

- Layer 1: light loams, rich in humus, with rare inclusions. Some vertical cracks are present. Its thickness ranges from 0.5 to 0.7 m.
- Layer 2: brown loess-like loam of porous structure, also presenting vertical cracks. Inclusions are a little more frequent (limestone, shale, hornfels, and quartz), with some pebbles. Thickness 0.15-0.2 m.
- Layer 3: white loess-like loam, with a higher number of brittle inclusions. Thickness 0.35-0.5 m.
- Layer 4: pebbles, blocks and gravel, with a loamy filler. The inclusions are nearly all limestone, and do not show a preferential orientation. Thickness 0.1-0.2 m.
- Layer 5: brown loam, with interlayers of darker and lighter brown, with a fine, porous structure. There are some lenses of a plastic blue-grey loam, as well as isolated vegetal coal detritus. On the eastern part of the profile, a lens of burned soil has been identified. The thickness of the layer ranges from 0.3 to 0.35 m.
- Layer 6: light-brown loess-like sediment, with inclusions of crushed stone, rare coals and, in vertical cracks, some humus. Thickness 0.15-0.25 m.
- Layer 7: gravel and crushed stone with some blocks, and a loamy filler. The maximal thickness is around 0.3 to 0.5 m, but it can be as thin as 0.05 m in some areas.

Layers 8 to 11 present quite homogeneous features: yellowish loess-like loam, with a fine grained structure with rare inclusions of small clastic material.

- Layer 8: brown to dark-brown loam, in some places replaced by light-brown, pale yellow loam; lenticular and layered texture, with a fine-grained, porous structure. A few cracks are filled by humus, and we can see a deformation of the layer due to slope processes on the eastern and western profiles. Most of the layer is 0.1 to 0.15 m thick, but it can be between 2 and 0.5 cm in the deformation.
- Layer 9: subdivided in three sublayers.
 - o Layer 9.1: light brown loess-like loam, with a porous structure and a lenticular texture, alternating lighter and darker sediment. Thickness 0.1-0.15.
 - o Layer 9.2: denser pale loam, with a compact structure. Thickness 0.1-0.12 m.

- Layer 9.3: pale red loam, with inclusions of hearth lenses, coals and small ferruginous spots. Thickness 0.25 to 0.3 m, except in the east, where it doesn't exceed 0.1 m.
- Layer 10: light brown, slightly grey loam, with an undefined texture and a fine-grained, porous structure. The thickness ranges from 0.2 to 0.3 m.
- Layer 11: this layer is subdivided in 3 sublayers.
 - Layer 11.1: light loam, uneven colour, with a porous structure and inclusions of small gravel and gruss. Thickness 0.2-0.25 m.
 - Layer 11.2: dense light-brown loam, 0.1 to 0.2 m thick on the northwestern part of the section; on the southern section, only pockets of sediments are visible.
 - Layer 11.3: loam of various colours, from light to dark grey and brown, with a dusty, fine-grained structure. This layer bears the traces of solifluction. Thickness 0.2 to 0.6 m.
- Layer 12: loam with dark brown and pale yellow lenses and white layers, as well as blocks and pebbles inclusions. This layer is separated in 3 sublayers, and its thickness doesn't exceed 0.35 m.
 - Layer 12.1: homogenous grey-brown loam.
 - Layer 12.2: horizon with a disturbed horizontal stratification.
 - Layer 12.3: layer with sub-horizontal stratification.
- Layer 13: dark brown loam with lenses of darker loam (maybe with humus). The layer is the thickest (0.45 m) on the south-western part.
- Layer 14: brown loam with lenses of dark, light and orange loam. The texture is layered and the structure fine-grained. There are sporadic inclusions of fine material. Thickness 0.25 to 0.3 m.
- Layer 15: dark-brown loam with lenses of darker and lighter loams, and a texture similar to layer 14. Thickness 0.2-0.3 m.
- Layer 16: red and dark loam, with a dense structure. Thickness 0.07-0.15 m.
- Layer 17: reddish-brown loam, including sporadic lenses of dark-brown and light-brown clays. The structure is very dense. Thickness 0.8-0.9 m.
- Layer 18: it is proposed that this layer was generated by hydromorphic floodplain soils. This layer is separated in two sublayers:
 - Layer 18.1: dark loam, with light loams spots and inclusion of pebbles and crushed stone. Thickness 0.2-0.35 m.

- Layer 18.2: dark grey loam, with lenses and interbeds of brown loam. The texture is fluid and layered, with some clastic material. Thickness 0.4-0.5 m.
- Layer 19: it consists of three types of sediments overlapping pebble deposits of different generations.
 - Layer 19.1: brown-green sandy loam with a porous structure. It lays on the first-generation alluvial bed (layer 20.1). Maximal thickness 0.2 m.
 - Layer 19.2: greenish sandy loam, with a loose structure, filling the “pockets” between large blocks and the pebbles of the second-generation alluvial bed (layer 20.2). Thickness 0.1-0.15 m.
 - Layer 19.3: green-brown loam, from nearly clay in the top part, to a sandy loam closer to the base of the layer. Thickness 0.7-0.8 m.
- Layer 20: pebbles and cobble deposit, distinguished in two levels (20.1 and 20.2), with a contact zone marked by erosion. Maximal thickness 1.8 m.

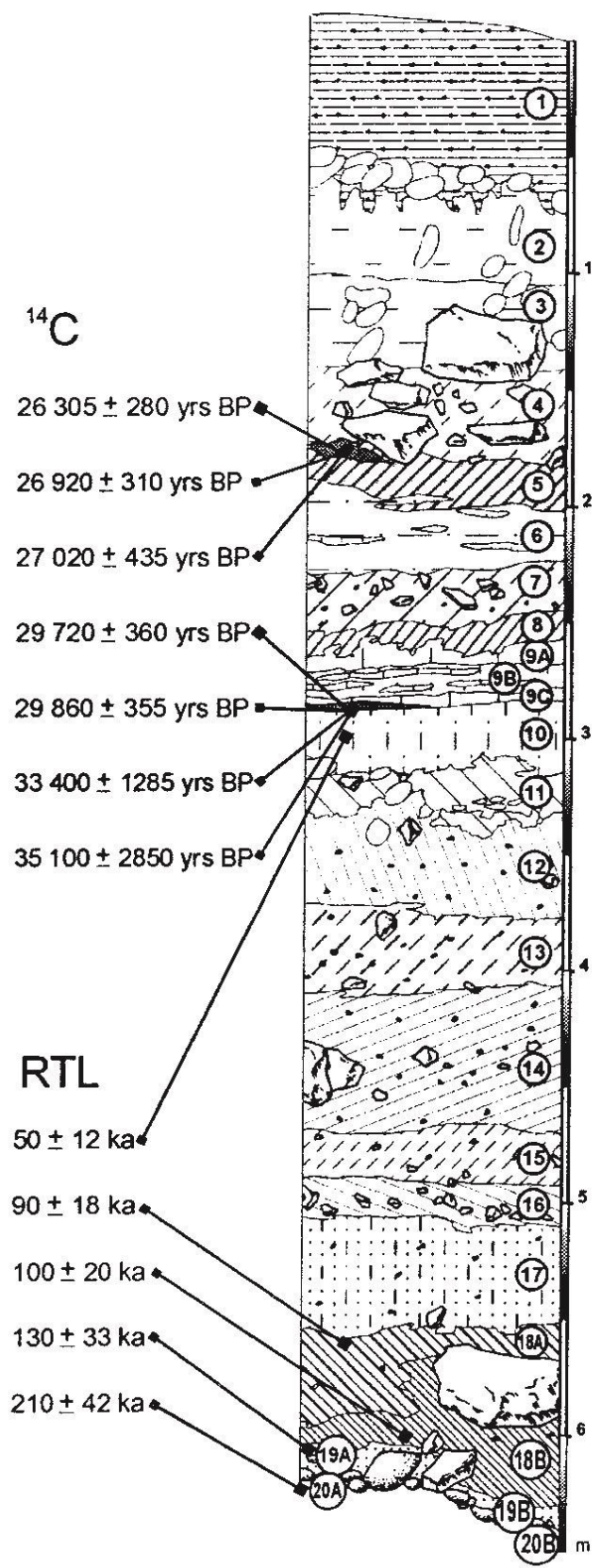


Figure 33: Ust'-Karakol 1-2, stratigraphic profile (Derevianko and Postnov, 2004)

3.2.1.3 Chronology

UK1-1 hearths, at the base of layer 5, yielded charcoal samples that were dated with the radiocarbon method. One combustion zone was dated to $31,410 \pm 1,160$ (SOAN-2515), and the other one $29,900 \pm 2,070$ ^{14}C BP uncalibrated (IGAN-1077). A bison bone from layer 2 was dated to $28,700 \pm 850$ ^{14}C BP uncalibrated (SOAN-2614) (Derevianko *et al.*, 1998a). Derevianko *et al.* (1990), attribute layer 2 to the Lipvosko-Novosolevo (end of MIS 3), layer 5 to the Karginian interstadial (MIS 3) and layer 6 to the Zyrian stadial (MIS 5a-d/4).

UK1-2 has yielded both thermo-luminescence (RTL) and radiocarbon dates (Figure 33; Derevianko *et al.* 2003). For the deepest layers, only RTL dating was available, the most ancient dates being 210 ± 42 ka (RTL-640) and 207 ± 41 ka (RTL-662), for respectively layer 20.1 and 20.2 – as we can see, the standard deviation is quite large. According to these dates, the alluvium deposit relates to the Tamarovo period, during the MIS 8. The overlying layer, 19.1, was dated at 133 ± 33 ka (RTL-661), which is consistent with the palynology and micro-mammal studies, concluding to a cold and moderately humid environment associated with the Tazovo period (MIS 6). Between layers 19 and 18, a break in sediment accumulation was identified, which would occur in the Kazantsevo interstadial (MIS 5e). The micromammal data indicates that the formation of the alluvial sediments of layer 18 corresponds to the cold humid phase at the beginning of the Ermakovian (MIS 5c). Microfaunal and palynological data of layers 17 to 14 indicate a dry and relatively warm climate (MIS 5a-5b). Layers 13 and 12 reflect the general deterioration of climatic conditions associated with MIS 4, when the steppe covers areas that were previously forested.

A break in sediment accumulation was again identified between layer 12 and layer 11, based on lithological and biostratigraphical data. The more recent layers have yielded radiocarbon dates, done by L.A. Orlov, from $35,100 \pm 2,850$ BP (layer 10) to $26,305 \pm 280$ BP (layer 5). A lens of burned sediment at the base of layer 9 has also yielded an RTL date of 50 ± 12 ka. This doesn't seem consistent with the ^{14}C results of layer 10 ($35,100 \pm 2,850$ BP) and layer 9 (from $33,400 \pm 1,285$ BP to $29,720 \pm 360$ BP). However, Derevianko *et al.* (2003) argued that, with the variations, the RTL date is not far from the oldest ^{14}C result for layer 9.

A paleomagnetic study carried out by Z.N. Gnibidenko established three excursions of the geomagnetic field (Derevianko *et al.*, *op. cit.*):

- Laschamp (44-42 ka) in layer 11,
- Mono (30-25 ka) in layer 5, and

- Gothenburg (13-11 ka) in layer 2.

Those paleomagnetic anomalies seem in adequation with the radiochronological results.

3.2.1.4 Faunal remains

Macrofaunal remains (n=356), mostly fragments of long bones (n = 319), have only been collected in UK1-2 (Derevianko *et al.*, 2003). 105 have been identified, belonging to 11 different species (Table 8). The bones are heavily covered in root etchings, which complicates the identification of cut-marks and carnivores traces. Only one bone, a metacarpus of *Capra sibirica* from layer 18, wears cut-marks (Figure 34). Although Wrinn (2010) mentions that Ust'-Karakol's faunal remains "clearly point to some defleshing and marrow processing of ungulates carcasses by hominins based on cut-marked and percussion-marked, cracked long bones", he doesn't provide the data of his zooarchaeological study in details, and no numbers are available.

<i>Species</i>	<i>Layer</i>						<i>Total</i>
	2	3-6	7-12	13-16	17	18	
<i>Canis lupus</i>						1	1
<i>Crocota spelaea</i>						1	1
<i>Equus przewalskii</i>	28	5	5	1		1	40
<i>Capreolus pygargus</i>		2				1	3
<i>Megaloceros giganteus</i>						1	1
<i>Cervus elaphus</i>	4			1	12		17
<i>Poephagus mutus</i>						5	5
<i>Bison priscus</i>		2	4	6	1	1	14
<i>Procapra gutturosa</i>	2						2
<i>Capra sibirica</i>	1		2			10	13
<i>Ovis ammon</i>	2	2	2		2		8
Total	37	11	13	8	15	21	105

Table 8: Mammal species from 1993-1997 excavations (Derevianko *et al.*, 2003)

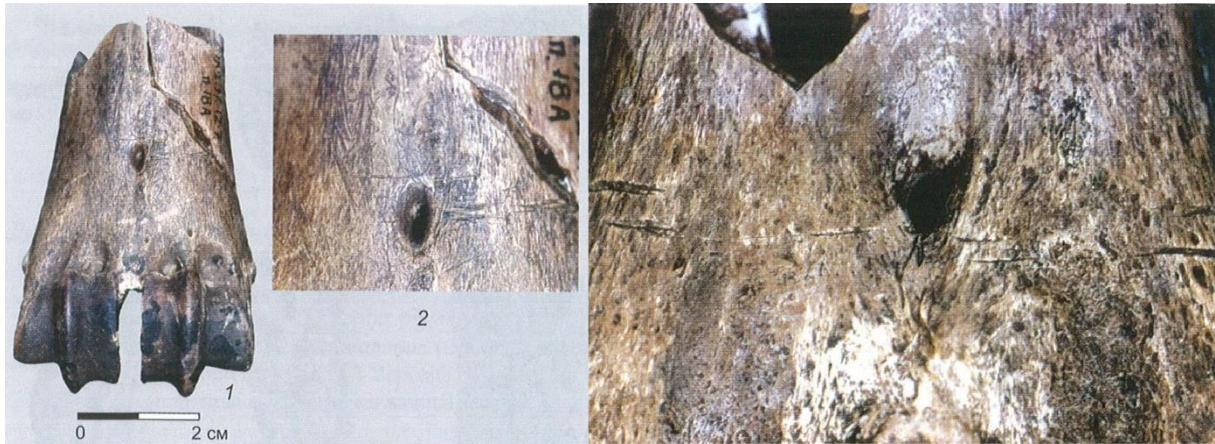


Figure 34: UK1-2. Metacarpus of *Capra siberica* (dorsal and palmar view) with cutmarks (Derevianko *et al.*, 2003)

More than 1700 microfaunal remains have been studied, the richest layer being layer 17 with 318 bones. 39 different species were identified, 36 of which are mammals, dominated by *Spermophilus* in the layers 19 to 11 and *Myospalax* for the upper layers.

3.2.1.5 Lithic industries

The raw materials used for the production of artefacts were identified as coming from the rivers Anuy and Karakol (Derevianko *et al.* 2003). They are very diverse, but dominated by sedimentary rocks (mostly aleurolite), effusive rocks and sandstones.

In UK1-1, cultural horizon 3 (in layer 5) has been identified as Early Upper Palaeolithic (Derevianko *et al.*, 1987), then subdivided into subhorizons (Slavinsky, 2007; Zwyns, 2012). In OH 5.5 and OH 5.4, the Initial Upper Palaeolithic is characterised by the production of large laminar blanks from asymmetrical, opposed platform cores (Zwyns, 2012). The thicker technical blades were then turned into burin-cores for the production of bladelets. Bifacial leaf-shaped artefacts were also identified in these layers (Derevianko & Markin, 1998; Zwyns *et al.*, 2012). In OH 5.3 and OH 5.1, the Early Upper Palaeolithic is defined by the presence of volumetric, unidirectional microblade cores, some of which are typological carinated endscrapers (Zwyns, 2012). However, the microblades are absent, which may be due to a lack of screening.

Different stages of Palaeolithic have been identified in UK1-2:

- Early Middle Palaeolithic, layer 19
- Middle Palaeolithic, layers 18-13
- Early Upper Palaeolithic, layers 11-8
- Middle Upper Palaeolithic, layer 5

- Final Upper Palaeolithic, layers 4-2

The Middle Palaeolithic is characterised by a high proportion of Levallois-related products, mostly blades and blade-like spalls. Tools are dominated by notches and denticulates (20.2%). The Early Upper Palaeolithic assemblage is dominated by a blade production from single and double platform prismatic cores, associated with a microblade production from wedge and cone shaped cores, as well as carinated endscrapers (Derevianko *et al.*, 2003).

3.2.1.6 Taphonomic studies

In UK1-1, Slavinsky (2007) realised a series of refits from cultural horizon 3 (layer 5). According to the results, the stratum could be subdivided in 5 sublayers, corresponding to 5 independent occupation horizons, OH5.1 to OH5.5. Transversal and longitudinal projections of the piece-plotted artefacts' altitudes by Zwyns (2012) support the subdivision in 5 independent assemblages separated by sterile horizons. Both studies distinguish two cultural traditions, Initial Upper Palaeolithic in OH5.5 and OH5.4, and Early Upper Palaeolithic for OH5.3 to OH5.1.

In UK1-2, Postnov (1999) realised a series of refits from layer 18. Most of the refits are very simple (two or three artefacts), some show the beginning of the reduction sequence, and one refit including 26 artefacts reconstructs a unidirectional convergent Levallois core and its products (Figure 35).

Belousova (2012) used refits and “raw material unit” method⁶ to check the integrity of the stratigraphy. Based on the results, she argued that layers 8 to 11 consist of only one short-term occupation. She also established that some artefacts retrieved in layer 11.2 and 11.1 come from layer 14 and 15, as in most parts of the site layers 12 and 13 are absent. Spatial and stratigraphic data suggest that after the deposit of layer 12, there was a partial exposure and destruction of layer 14, which led to the artefacts being located at the zone of contact between the layers, or mixed in the upper layers (Shunkov and Belousova, 2015). The post-depositional vertical redistribution of archaeological material could be due to a variety of factors: active slope processes, washout, bioturbation by small mammals, or cryoturbation.

⁶ Also called Transformation Analysis (TA) or Minimal Analytical Nodule Analysis (MANA)

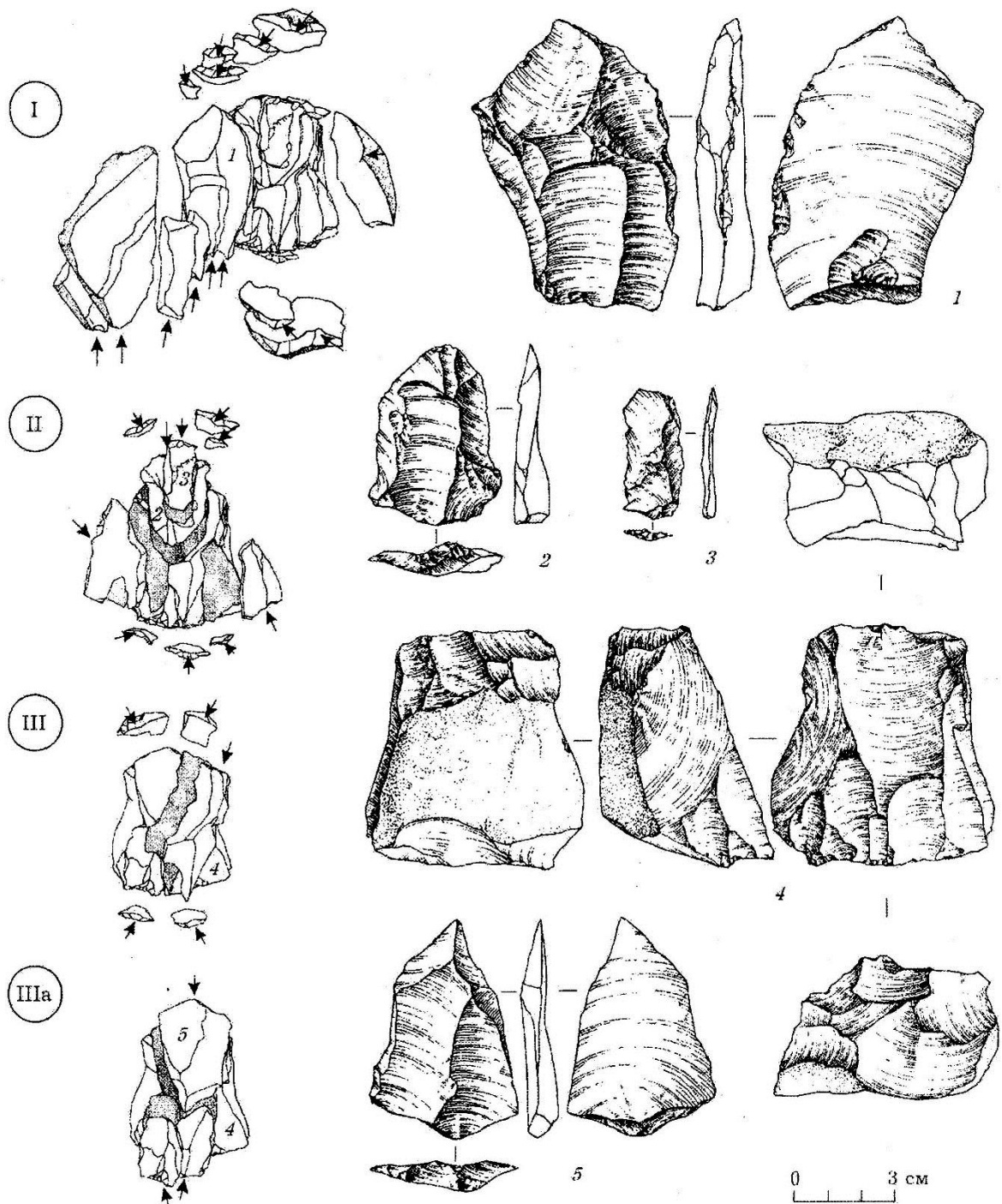


Figure 35: UK1-2. Refit of a Levallois core and a selection of associated artefacts (Postnov, 1999)

3.2.2 Kara-Bom

3.2.2.1 Location and history

Kara-Bom (N 50°43'; E 85°42') is located in the Upper Basin of the Ursul River in the Ongudaysky district of the Altai Republic (Figure 36), in the intermountain depression system of the Central Altai Mountains. Meaning "black rock" in Altai language, Kara-Bom (1120 m

asl) is situated at the foot of a schist cliff (Figure 37), next to a freshwater spring that was supposedly present in the occupation period (Derevianko and Rybin, 2003). The site offers an open view to the valley and is located next to a natural amphitheatre with a narrow pass which gives access to another valley. The natural trap created by these features could have been used by the Palaeolithic hunters using the site (*ibid.*).

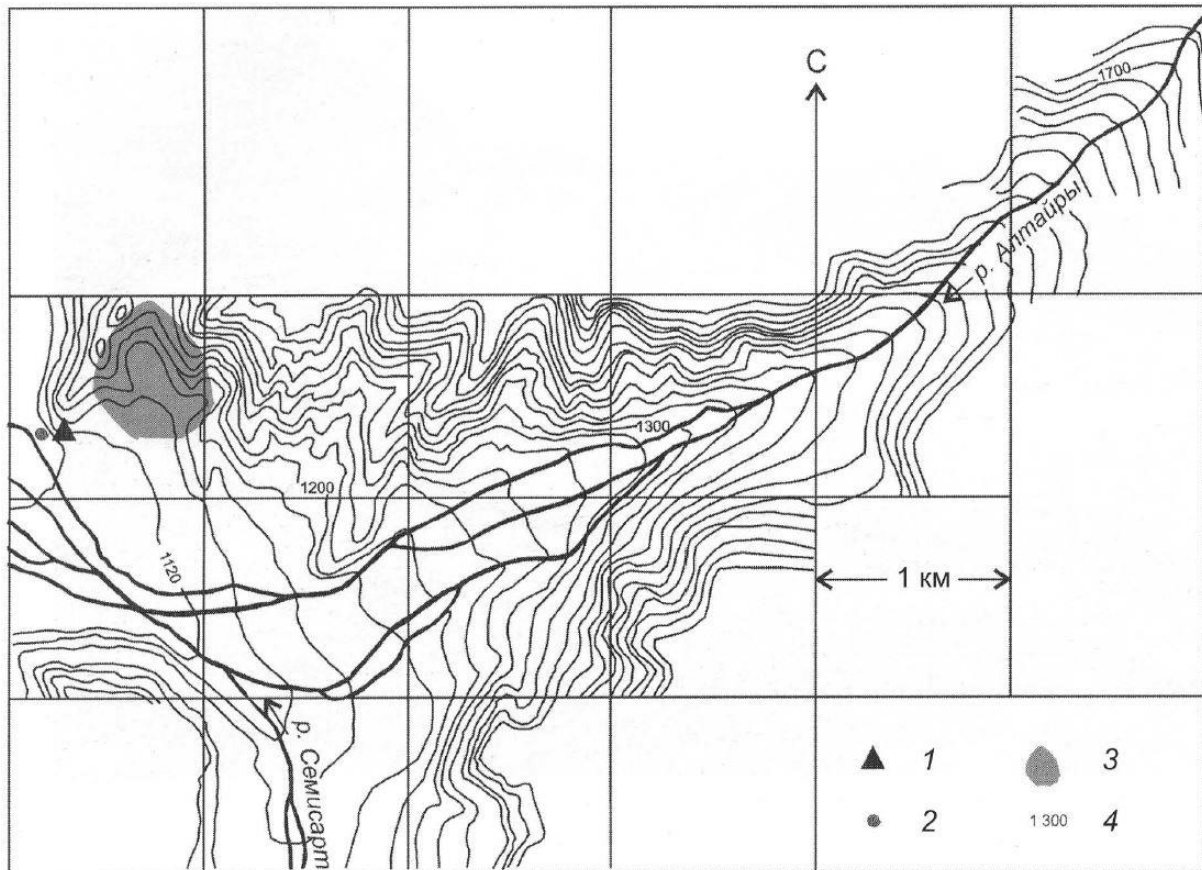


Figure 36: Topographic map of Kara-Bom area. 1: Kara-Bom site; 2: spring; 3: amphitheatre; 4: absolute elevation asl (Derevianko and Rybin, 2003)

Okladnikov directed the first campaign of excavation in 1980 in “Excavation Area 1” (Figure 38). The deposits were thought to be heavily disturbed by the water flow, thus the excavation was carried out in arbitrary layers up to 30 cm thick. However, after the discovery of a “Levallois-Mousterian” horizon, excavators started following the stratigraphic layers. This horizon was described as in “layer 3” of Okladnikov’s excavations, and has been designated as the “workshop”. It suggested an undisturbed deposition of artefacts in soft sandy loams with big plates of schist, and could be as thick as 1.6 m. The “workshop” was not totally excavated at the end of 1980, and the maximum depth attained corresponds to the top of the MP1 current level, at -411 cm (Okladnikov, 1983; Zwyns, 2012).



Figure 37: Kara-Bom (J. Jaubert).

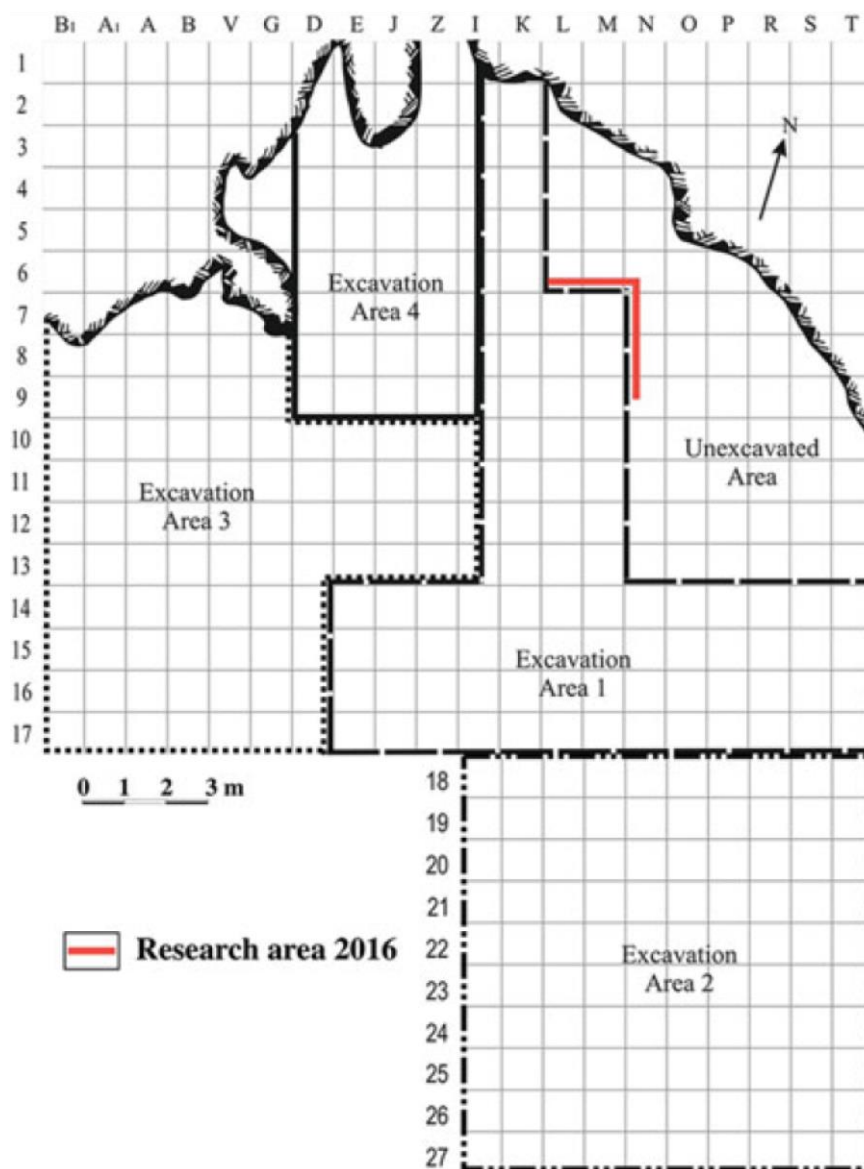


Figure 38: Kara-Bom, map of the excavation areas (Belousova et al., 2018)

The Altai Team of the Northern Complex Archaeological Expedition, directed by Derevianko and Petrin, resumed the excavation from 1987 to 1993, with a total extent of 300 m². The excavation of Area 1 revealed a hearth containing charcoal fragments, bones and artefacts in quadrants И-K/8-9, as well as bone ornaments and fragments of natural mineral pigments in adjacent quadrants Л-M/8-9, in the same stratigraphic level as Okladnikov’s “workshop”.

In 1991, Valery Petrin finished the excavation of Area 1. From 1990 to 1992 Areas 2 and 3 were excavated, but the sediments were identified as redeposited, except in the northern part of Area 2, where numerous hearths were identified (Derevianko and Rybin, *op. cit.*). In 1992-1993, investigations carried out in Area 4 allowed the establishment of a new stratigraphy, with

six archaeological layers attributed to the Upper Palaeolithic (Occupation Horizons – OH⁷ – 1 to 6) and two to the Middle Palaeolithic (MP Horizons 1 and 2) (Derevianko *et al.*, 1998d). Areas 1 and 4 were then correlated, and the “workshop” associated to OH5 and 6 of the new stratigraphy (Derevianko and Rybin, *op. cit.*).

A cleaning of the northern section (the only remaining part of the site) was carried out in 2016, to clarify the stratigraphy of the site and collect samples for dating (Belousova *et al.*, 2018). A hearth and Upper Palaeolithic material were excavated, including ochre and bone beads. The dating results are still to be published.

3.2.2.2 Stratigraphy

The 3.5 m profile has been separated into three lithological units (Derevianko *et al.*, 1998d):

- Unit 1 includes strata 1 to 8:
 - Stratum 1 corresponds to the modern soil, a brown sandy loam with sand and a minor admixture of humus.
 - Strata 2 to 4 seem to have been accumulated during the Sartan period (OIS 2), and are only found in the vicinity of the cliff, as they were washed out by erosion around 3 m from the wall. Stratum 2 consists of light brown loess-like sandy loam, with fine schist gruss; stratum 3 is a concentrate of coarse gruss with schist debris, and a light brown sandy loam filler; stratum 4 consists of brown sandy loam with a humic fraction in the uppermost part of the stratum. The first level of occupation, OH1, has been identified at the top of stratum 4.
 - Stratum 5 is subdivided into two substrata: both are constituted of brownish grey loam, but 5a yielded OH2, and 5b, containing less debris, yielded OH3.
 - Stratum 6 consists of grey coarse fragments, schist debris and a sandy loam filler. On the uppermost part of the layer, an admixture of humus was identified, maybe the trace of a buried soil in secondary position. OH4 is situated at the contact zone between stratum 6 and stratum 5b, OH5 in the central part of stratum 6, and OH6 in the lowermost part of the stratum.
 - Strata 7 and 8 do not contain any archaeological material. Stratum 7 consists of greenish grey sandy loam, with a significant fraction of sand and gravel,

⁷ The layers were later renamed UP 1 to 6 in later Russian publications. OH has been used in most of the English publications, so it is the designation we chose to keep here.

with spots of burnt sediment near the border with stratum 6; stratum 8 consists of bright brown sandy loam, and could represent a soil horizon.

- Unit 2 corresponds to stratum 9, and consists of brownish grey loessic loam. It is divided into three substrata: 9b yielded MP1 and 9c MP2. The Upper and Middle Palaeolithic horizons are thus separated by three sterile layers: 7, 8 and 9a.
- Unit 3 includes strata 10 and 11. They are composed of cryoturbated slumping deposits overlying the bedrock, with greenish silt containing loam of subaquatic origin. They do not contain any archaeological material.

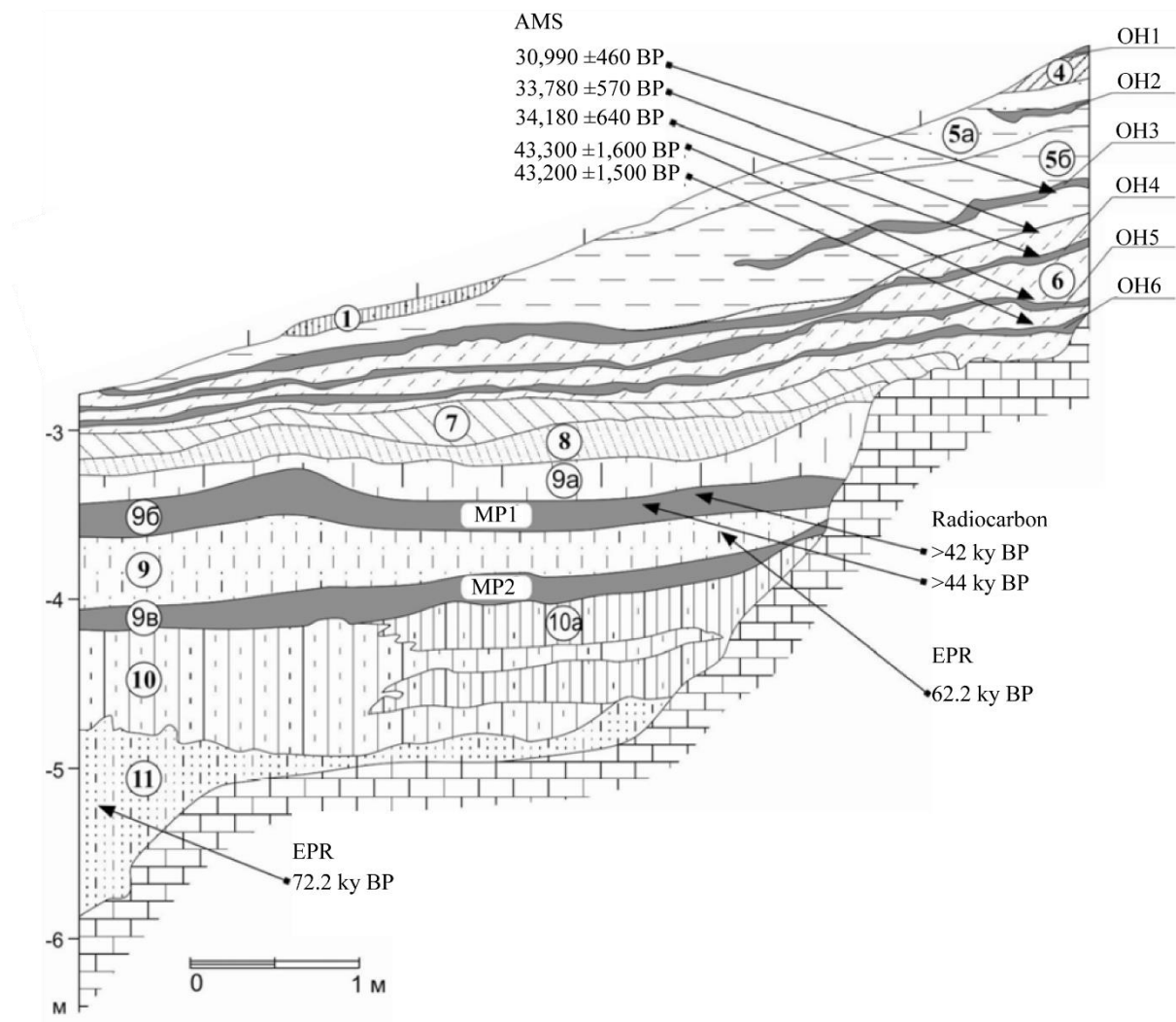


Figure 39: Kara-Bom. Stratigraphic profile on the line I (modified after Belousova and Rybin, 2013)

According to a recent refitting study, it is also worth noting that OH1 to 3 may belong to a single horizon, called UP1, and OH5 and 6 to another single horizon, UP2 (Belousova and Rybin, 2013).

3.2.2.3 Chronology

The first attempt to date the site was by conventional radiocarbon dating by the Institute of Geology of the Russian Academy of Science in Moscow, and yielded two dates, one on bone collagen from stratum 7 ($32,200 \pm 600$ BP – GIN-5934), the other on a charcoal from above the hearth of stratum 6, but with an unclear cultural association ($33,800 \pm 600$ BP – GIN-5935). Those dates were not considered reliable by the excavation team, as the samples could have been contaminated (Derevianko and Rybin, 2003).

In 1991, samples for AMS, conventional ^{14}C dating and EPR (Electro-Paramagnetic Resonance) were collected from a sequence of deposits in the H5 quadrant (Derevianko *et al.*, 1993c; 1998a; Goebel *et al.*, 1993; Derevianko and Rybin, 2003). In MP1, the ^{14}C dates obtained on collagen were infinite: > 42 ka BP (AA-8873) and > 44 ka BP (AA-8894). However, EPR dating in stratum 9 (below MP1) and stratum 11 (below MP2) yielded results of 62.2 ka and 72.2 ka respectively, which could provide a bracket for MP2. However, the sample used for stratum 9 is questioned (Derevianko *et al.*, 1993). OH6 and OH5 yielded AMS dates from wood charcoal, respectively $43,200 \pm 1,500$ BP (GX-17597) and $43,300 \pm 1,600$ BP (GX-17596). The OH5 sample was directly associated with a hearth. These results are very close to the limit of the method, and they could indicate a minimum age (Goebel *et al.*, 1993). A charcoal fragment from OH4, at the contact of strata 5 and 6, yielded an AMS date of $34,180 \pm 640$ BP (GX-17595), and another one from the uppermost part of stratum 6 yielded a date of $33,780 \pm 570$ BP (GX-17594). OH3 has yielded a date of $30,990 \pm 460$ BP (GX-17593). A last date was obtained on a charcoal from the contact zone of strata 5 and 4, $38,080 \pm 910$ BP (GX-17592). This charcoal was not associated with any archaeological material, and probably comes from a rodent's burrow (Goebel *et al.*, *op. cit.*).

3.2.2.4 Faunal remains

Few data have been published about the faunal remains of Kara-Bom, and the conservation of the bones was very poor. As for Ust'-Karakol, the bones can be weathered, display traces of bioturbation (root etching), and rounded or polished specimen may have been transported by water (Wrimm, 2010).

The mammal species are consistent throughout the sequence, dominated by mountain and steppe species (Derevianko *et al.*, 2000b), as *Equus* sp., *Bison* sp., *Capra sibirica* and others (Table 9).

<i>Occupation level</i>	<i>Identified species</i>
Middle Palaeolithic horizons 2 & 1	<i>Equus</i> sp. <i>Coelodonta antiquitatis</i> <i>Bison</i> sp. <i>Capra sibirica</i> <i>Mammuthus primigenus</i> <i>Panthera spelaea</i> - <i>Allactaga</i> sp. <i>Marmota baibacina</i>
Occupation horizons 6 & 5	<i>Equus</i> sp. <i>Bison</i> sp. <i>Capra sibirica</i> <i>Equus</i> cf. <i>hydruntinus</i> <i>Crocuta spelaea</i> - <i>Allactaga</i> sp. <i>Citellus</i> sp.
Occupation horizons 4 & 2	<i>Capra sibirica</i> <i>Equus</i> sp. <i>Bison</i> sp. - <i>Allactaga</i> sp. <i>Citellus</i> sp. <i>Arvicola terrestris</i> - <i>Avis</i>

Table 9: faunal representation in Kara-Bom, data from S.K. Vasiliev (in Derevianko et al., 2000)

Cutmarked and percussion marked cracked long bones of ungulates show some defleshing and marrow processing (Wrinn, 2010).

3.2.2.5 *Lithic industries*

Contrary to most sites of the Altai, Kara-Bom raw material is quite homogenous and consists of Devonian acid volcanic rocks, more precisely acidic aphyric cryptocrystalline effusive rock

(Kulik, 2014; Slavinsky *et al.*, 2016; 2019) – it had previously been described as chert (Goebel, 1993), aphyric acidulous effusives (Derevianko *et al.*, 2000b), cryptocrystalline silicate (Goebel, 2004) or metamorphic rock (Zwyns, 2012). The outcrops are situated in the nearby Aptyrga Mountain, the blocks are carried by water and found in alluvium of the Semistart and Altairy rivers (Goebel, 1993; Kulik *et al.*, 2003; Zwyns, 2012; Kulik, 2014). Their fine-grain texture and homogeneity, without inner cracks, makes them suitable for demanding methods, such as volumetric laminar (Derevianko *et al.*, 2000b; Zwyns, 2012) or Levallois.

The Middle Palaeolithic horizons, MP1 and MP2 (n=753), are dominated by the Levallois reduction sequence. According to Derevianko *et al.* (1998b), all the cores (n=23) are Levallois, most of them (n=16) displaying the scars of parallel reduction. As for the products, blades and points are numerous, with a Levallois index of 15.3 and a laminar index of 33 in MP2, and an increase of the blade component in MP1 with a laminar index of 46. It has been concluded that the reduction system varied through the process (Derevianko *et al.*, 2000): first, a recurrent unipolar parallel reduction, then a recurrent unipolar convergent technique, and a switch back to the recurrent unipolar parallel reduction at the end. The first stage produced large Levallois blades, guided by the preparation of a central ridge on the preform; up to three consecutive Levallois points could be obtained in the second stage; then shorter blades were produced in the last stage. The tool kit (n=152) is dominated by Levallois products (ILty MP2: 51.3; ILty MP1: 26.8), denticulated-notched tools (IVel. MP2: 32; IVel. MP1: 52), Mousterian tools (II MP2: 32; II MP1: 17) and Upper Palaeolithic tools (III MP2: 16; III MP1: 21). In 2012, N. Zwyns studied a sample of 34 artefacts from MP1 (Zwyns, 2012), and concluded that there was a flake production from flat-faced cores, with a radial or bidirectional mode, and a probably sub-volumetric blade production (with the presence of some crested elements, and thick side blades).

The first Upper Palaeolithic horizons, OH6 and OH5 (n=1472), often viewed together because of their techno-typological similarities⁸, are characterised by a parallel-flaking blade production. The laminar index is 55.5 for OH6 and 61.9 for OH5 (Derevianko *et al.*, 1998b). Tools (n=224) are mostly made on blades (*e.g.* 70.6% of tools in OH6). Upper Palaeolithic type tools (index 38.9) and notched-denticulated (index 28) are the most common, while Mousterian-Levallois tools have an index of 9.8. Though the Levallois points are still present, they are more elongated, with a unidirectional scar pattern. Endscrapers on blades, multifaceted burins and

⁸ They may constitute a single occupation, UP2 (Belousova and Rybin, 2013)

points shaped on blades didn't previously exist in MP2 and MP1. The burins are made out of exhausted cores, *débordant* flakes and lateral spalls. Wedge-shaped microblade cores have been identified, which would make Kara-Bom the earliest dated occurrence of this technology in northern Asia (Derevianko *et al.*, 2000). OH6 and OH5 material was described as a transitional technology, shifting from the Levallois to the prismatic reduction (Derevianko *et al.* 1998b, 2000; Derevianko and Rybin, 2003). However, in his review of the material, Zwyns (2012; Zwyns *et al.*, 2012) concludes that OH6 and OH5 can't be considered as transitional but are consistent with an Initial Upper Palaeolithic attribution (*sensu* Kuhn *et al.*, 1999; Kuhn and Zwyns, 2014), with a reduction alternating between a broad and a narrow face of the core, following a sub-volumetric approach, producing blades, convergent blades and crested elements. He also noted the use of burin-core technology to produce bladelets, where the thickest blades (*débordant*, crested or backed blades) were snapped in fragments (Slavinsky *et al.*, 2019), then turned into cores using the edge of the blank as a flaking surface (Zwyns, 2012; Zwyns *et al.*, 2012).

The last Upper Palaeolithic horizons, OH4 to 1 (n=404), show the same primary features of core reduction than OH6 and OH5, but the size of products decreases, and microbladelets are more numerous; faceted and trimmed platforms are scarce (Derevianko *et al.*, 1998; Derevianko *et al.*, 2000). Parallel bidirectional flaking is more present than in the lower layers (26% for OH4 to 1, 19.6% for OH6 & 5). No trace of Levallois-type reduction has been documented. The tools are mostly represented by the notched-denticulated (35.1) and the Upper Palaeolithic type categories (32.3).

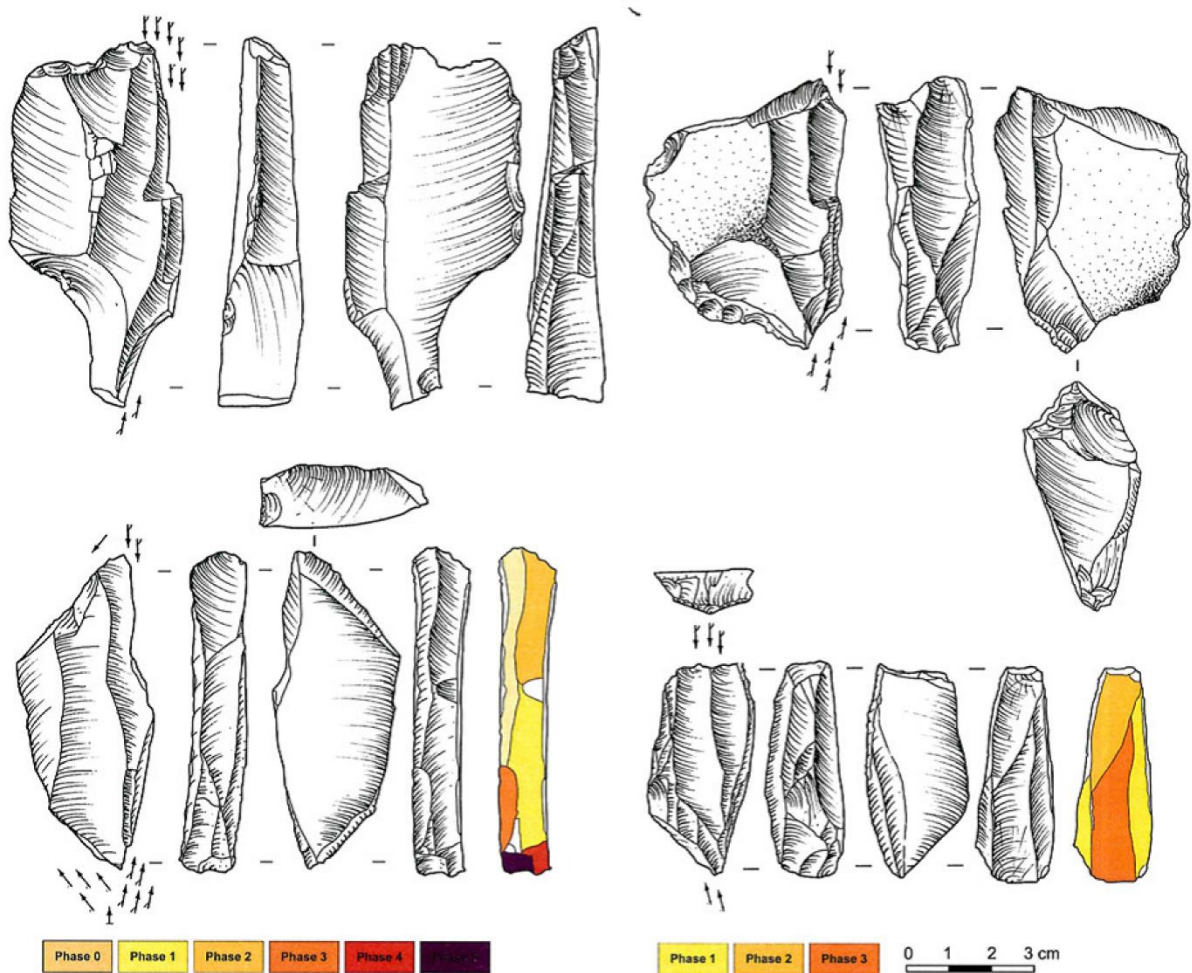


Figure 40: Kara-Bom. Burin cores from OH 5 and 6 (Zwyns *et al.*, 2012)

3.2.2.6 Taphonomic studies

A first series of refits allowed the reconstruction of two reductions sequences, one from MP2 and the other from OH4 (Slavinsky and Rybin, 2007). The MP2 refit includes 37 artefacts, scattered over an area of 6 m², displaying a unipolar convergent Levallois mode, with a production of atypical points (Figure 41). The other refit combines 9 elements from OH4 (n=4), OH5 (“in the periphery”, downslope; n=3) and Okladnikov’s workshop (n=2). The OH5 material comes from a part of the section where the archaeological layers are stretched and their distinction was difficult (Derevianko *et al.*, 1998d; Derevianko and Rybin, 2003). The refit displays a unidirectional blade production from a subprismatic core (Figure 42).

To assess the integrity of OH6 and OH5 assemblages, Zwyns (2012; Zwyns *et al.*, 2012) used breakage refits on broken blades and short sequence refits. Half of the refits occur in OH5 (n=8), and the few refits between levels (OH4/OH5 – n=1 – and OH5/OH6 – n=3) do not seem to show an important vertical movement, as they occur downslope, where the layers are very close to each other. However, in another refitting study, the authors estimate that OH5 and OH6

belong to the same horizon, named UP2 (Belousova and Rybin, 2013; Slavinsky *et al.*, 2016). Two types of reductions sequences were identified: a production of large blades from subprismatic bidirectional cores, and a production of bladelets and small blades from uni- and bidirectional narrow-faced cores (“burin-cores”). The same study groups OH1 to 3 in a single horizon, UP1, characterised by a subprismatic bidirectional reduction of blade cores similar to UP2, but also a subprismatic unidirectional method that is unique to UP1.

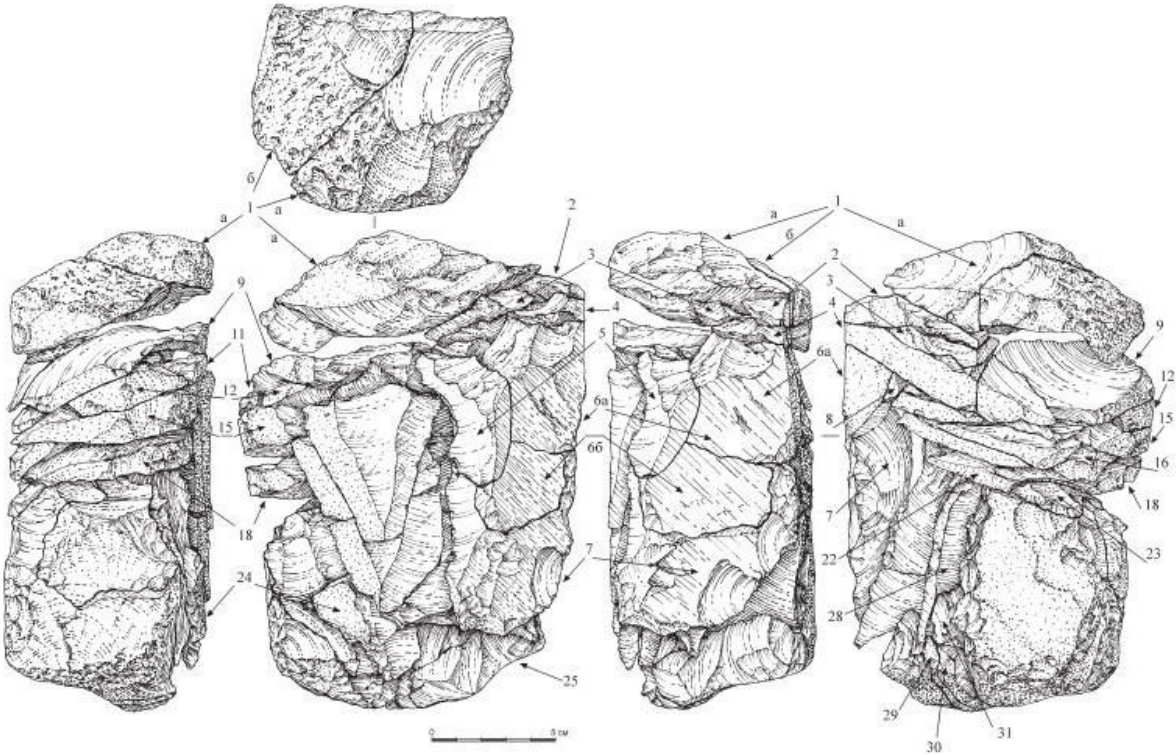


Figure 41: Kara-Bom. Refit of a Levallois core from MP2 (Slavinsky and Rybin, 2007)

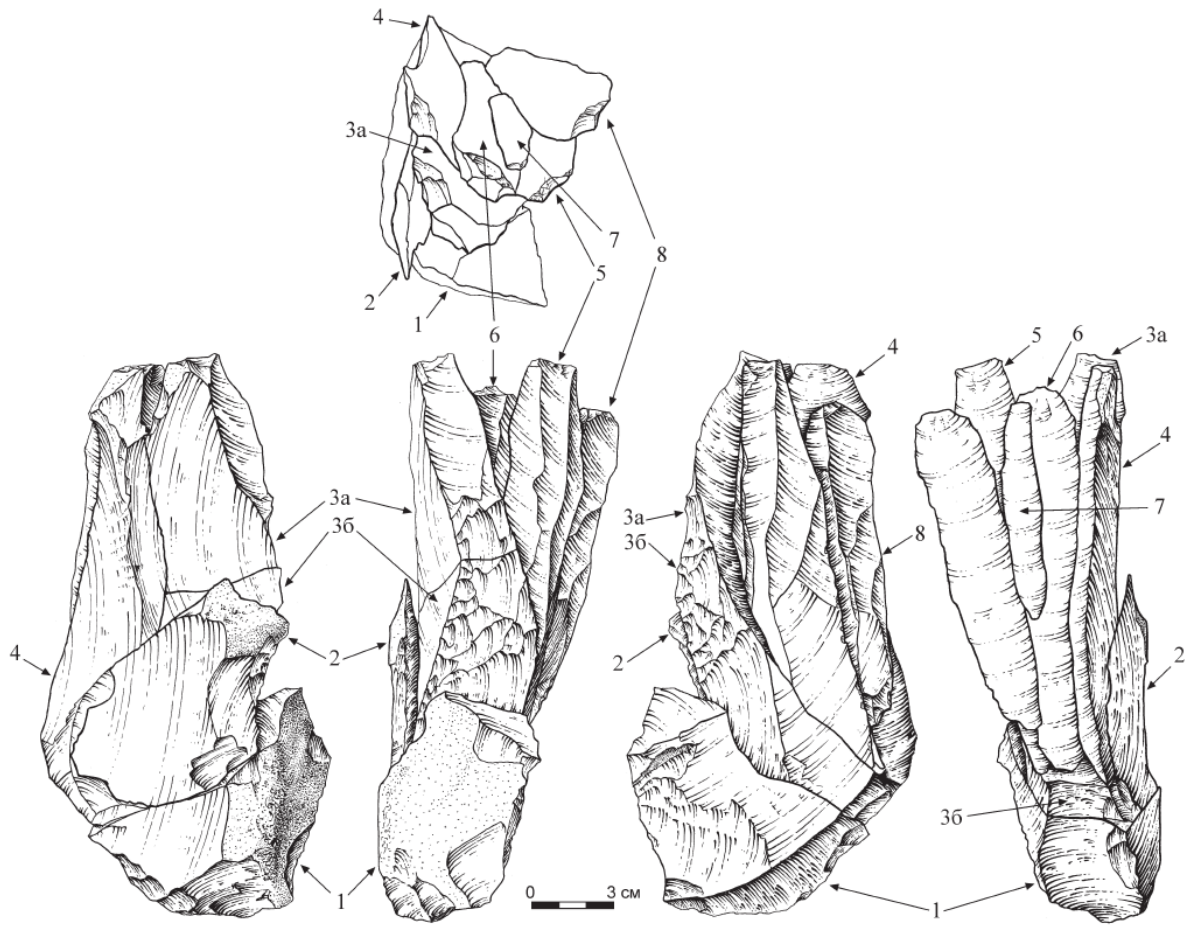


Figure 42: Kara-Bom. Refit of a blade core from OH5 (Slavinsky and Rybin, 2007)

4 Lithic analyses and results

4.1 UST'-KANSKAYA

4.1.1 Raw materials

The raw material identification for artefacts from the 1999 to 2003 excavations had been done by N.A. Kulik; we completed the study for the most recent material. We identified a wide diversity of raw materials: porphyritic and aphyritic igneous rocks, sandstone, chert, jasperoids, gritstones, tuff, schist, quartz, quartzite, aleurolite, dyke, etc. However, most of these materials can be collected in the same place, the Charysh River (Rudenko, 1961; Kulik and Postnov, 2001), and present the same petrophysical and clastic qualities (Kulik and Postnov, *op. cit.*). This is due to the geological history of this area: the Charysh-Teretkinsky fault induced a uniform transformation of the diverse rocks that were present. So, if different in genesis, they are similar in general chemistry, acquiring a close mineral composition and a fine-grain structure well adapted to knapping activities.

When comparing the types of reduction sequences, we can see that the great majority of the raw materials were knapped according to methods requiring a high degree of predetermination (including Levallois, volumetric blade and bladelet reduction sequences) as well as more expedient methods (Figure 43). Only the quartz and schist were not used for highly demanding methods, which can be explained by their flaking properties.

When comparing how each material has been worked, we can distinguish 4 groups of raw materials:

- The first group, consisting only in the jasperoids, has been selected at 70% for reduction sequences requiring a high degree of predetermination (HDP).
- The second group consists of raw material that have been selected at more than 40% for HDP methods: sandstone, chert, aleurolite, dyke and gritstone.
- The third group gathers raw materials that show no specific scheme of selection: porphyric igneous rock, aphyric igneous rock, tuff and rhyolite.
- Quartz and schist have been selected for expedient methods.

Thus, even if nearly all of the different materials present a similar structure and knapping qualities, and were used for high and low predetermination methods, we could nevertheless identify different types of selections.

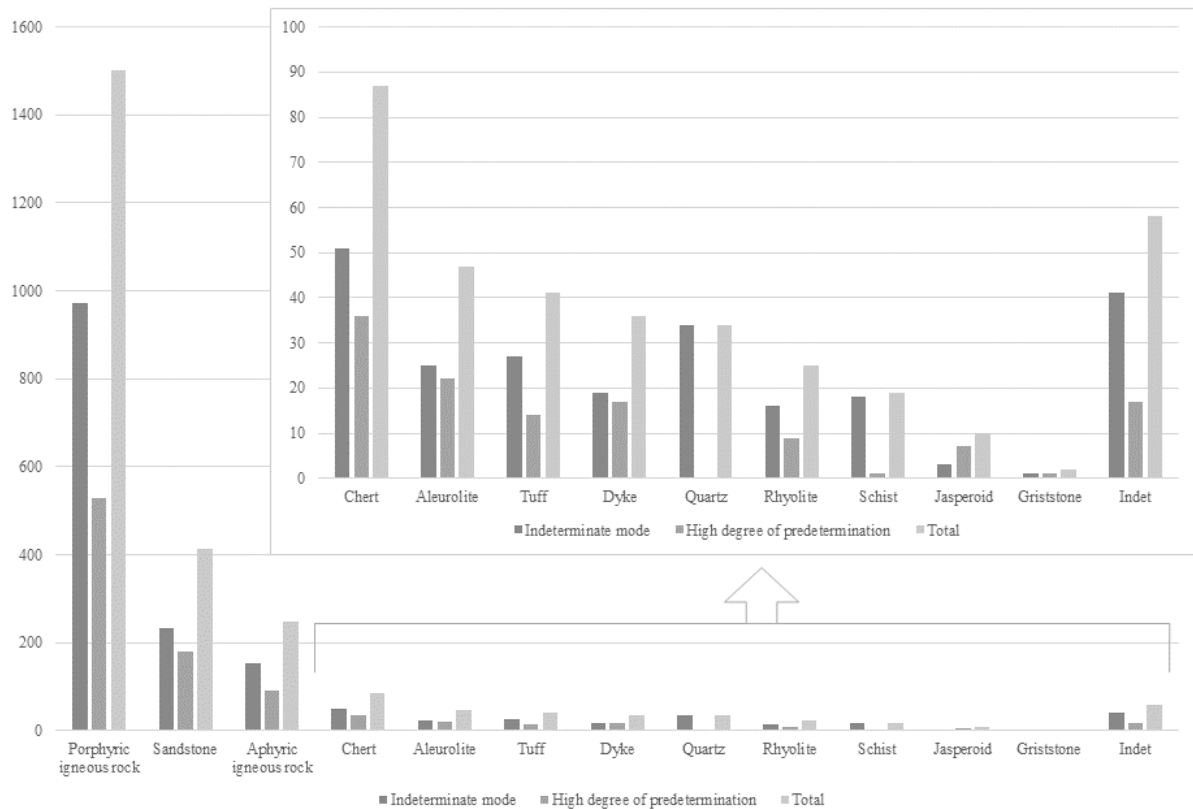


Figure 43: Ust'-Kanskaya. Raw materials distribution according to the identified type of reduction.

4.1.2 Technological study

During the second phase of excavation (1999 – 2007), more than 40 m² were excavated and entirely screened (wet sieving with 0.5 and 0.1 cm meshes, then dry sieving with meshes from 5 to 0.5 mm), yielding a total of 3051 lithic artefacts, spanning all the 10 layers. The layers display a much contrasted abundance of archaeological remains (Table 10), with half of the total in layer 5, by far the most profuse level of the site. These differences in sample sizes has

LAYER	1	2	3	4	5	6	7	8	9	10	Total
Cores		1	18	10	42	6	4	3	1		85
<i>Levallois</i>			2		7	2	1	1	1		14
Flakes	15	172	588	251	1040	166	81	80	26	13	2432
100% cortex		4	5	6	16	1	1				33
>50% cortex	1	18	27	21	95	15	7	5	3		192
< 50% cortex	4	42	131	70	258	28	18	23	5	2	581
<i>Levallois flakes and points</i>	1	6	58	20	74	17	4	11	3	2	196
<i>Blades</i>	3	40	242	64	154	31	15	34	3	2	588
Pebble tools					3						3
Debris and fragments		13	61	61	325	41	11	11	6	2	531
Total	15	186	667	322	1410	213	96	94	33	15	3051

Table 10: Ust-Kanskaya. Repartition of the artefacts.

induced the notion that the modes of occupation of the cave varied in time: very occasional for layers 1, 9 and 10; moderately intense for layers 2-3 and 6-8; extremely intense for layers 5 and 4 (Postnov, 2008).

4.1.2.1 Layer 10

4.1.2.1.1 Reduction sequences

No core was found in this layer.

4.1.2.1.2 Production

The production (n=13) is dominated by flakes (n=11), with the presence of two laminar blanks. Most of the products don't have residual cortex (n=11).

The Levallois production is composed of a Levallois blade and two Levallois flakes (Figure 44). Another blade has been identified but it consists only of a mesial fragment, making it impossible to assess if it belongs to a Levallois reduction sequence, though it seems likely.

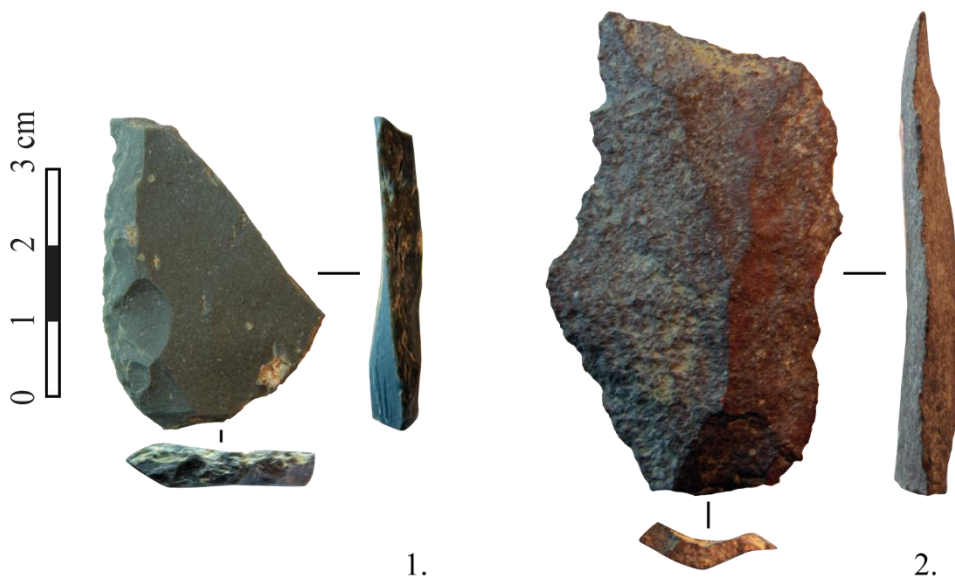


Figure 44: Ust'-Kanskaya, layer 10. Fragmented, retouched Levallois product (1), Levallois laminar blank (2).

- Breakage

Most of the products are broken, with only 4 complete artefacts (Table 11).

	Blades	Flakes	Total
<i>Mesio-distal</i>		2	2
<i>Mesial</i>	1	1	2
<i>Mesio-proximal</i>		3	3
<i>Proximal</i>		2	2
<i>Complete</i>	1	3	4
<i>Total</i>	2	11	13

Table 11: Ust'-Kanskaya, layer 10. Breakage.

- Sizes

Only 4 products are complete, thus it is not possible to observe any trend on artefacts' lengths in layer 10. A laminar blank is 60.5 mm long, and the three complete flakes are 30.3, 24 and 17 mm long. The average flake is 24.3 mm wide and 6.3 mm thick (Figure 45). The two laminar blanks are 34.2 and 22.2 mm wide, and 8.2 and 5 mm thick. The two Levallois flakes are 42 and 28.1 mm wide and 11.9 and 6.8 mm thick.

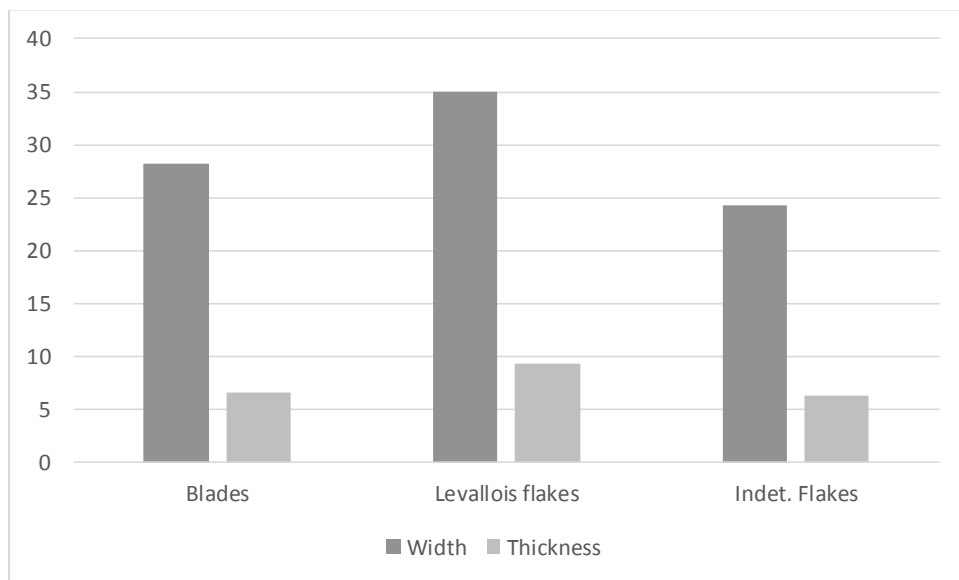


Figure 45: Ust'-Kanskaya, layer 10. Mean measurements of the products.

- Dorsal scar patterns

Most of the products wear scars that indicate a unidirectional parallel reduction (Table 12). As we can see, all the Levallois products were obtained through this method.

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Unidirectional parallel</i>	3	1	2	6
<i>Bidirectional parallel</i>			1	1
<i>Centripetal</i>			2	2
<i>Indet</i>			4	4
<i>Total</i>	3	1	9	13

Table 12: Ust'-Kanskaya, layer 10. Dorsal scar pattern.

- Platform preparation

Most of the products have a plain platform (Table 13); the only prepared platforms are a dihedral one, for an indeterminate flake, and a faceted, for a Levallois product.

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Plain</i>	2		3	5
<i>Dihedral</i>			1	1
<i>Facetted</i>	1			1
<i>Broken</i>			2	2
<i>ND</i>		1	2	3
<i>Total</i>	22	27	28	80

Table 13: Ust'-Kanskaya, layer 10. Platform preparation.

- Morphologies

Most of the products have a quadrangular shape (Table 14), a straight profile (Table 15), and a triangular or trapezoidal cross-section (Table 16). The convex profile observed on some low predetermined products is due to a pronounced bulb (Table 15).

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Quadrangular</i>	2	1	3	6
<i>Triangular</i>	1		1	2
<i>Semi-circular</i>			3	3
<i>Indet.</i>			2	2
<i>Total</i>	3	1	9	13

Table 14: Ust'-Kanskaya, layer 10. Product shape.

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Straight</i>	3	1	3	7
<i>Concave</i>			1	1
<i>Convex</i>			4	4
<i>Indet.</i>			1	1
<i>Total</i>	3	1	9	13

Table 15: Ust'-Kanskaya, layer 10. Product profile.

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Triangular</i>	2		4	6
<i>Trapezoidal</i>		1	3	4
<i>Semi-circular</i>			2	2
<i>Rectangular</i>	1			1
<i>Total</i>	3	1	9	13

Table 16: Ust'-Kanskaya, layer 10. Product cross-section.

4.1.2.1.3 Transformed products

Three elements have been retouched, all scrapers. The retouch is always direct, continuous and scaled, with a long extent on the support. The supports are heavily fragmented. Two of them were obtained through indeterminate reduction sequences, and the other one is a fragmented Levallois product (Figure 44, 1).

	<i>Nb</i>
<i>Scraper (simple)</i>	3
<i>Total</i>	3

Table 17: Ust'-Kanskaya, layer 10. Types of tools.

4.1.2.2 Layer 9

4.1.2.2.1 Reduction sequences

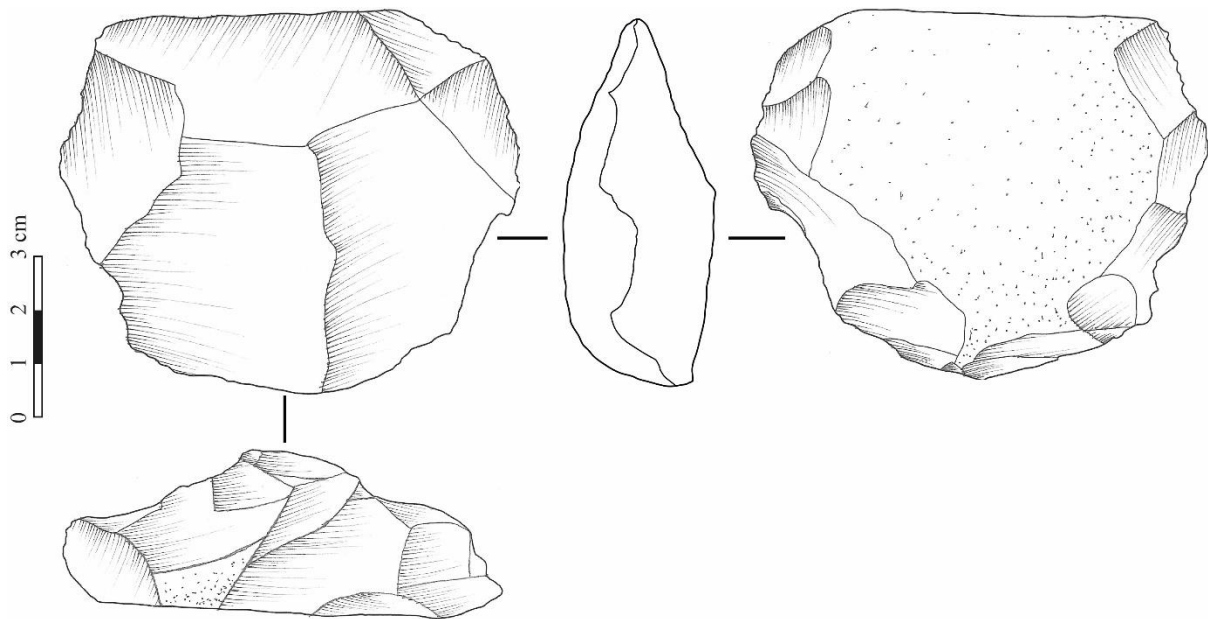


Figure 46: *Ust'-Kanskaya, layer 9. UK06.8/31.482.9 (drawing J. Galfi).*

One core has been identified in this layer (Figure 46). The remaining cortex indicates that it was manufactured out of a pebble. It opposes two hierarchized surfaces, one as a flaking surface, and the other as a prepared striking platform. The latter is mainly cortical, and prepared by a series of centripetal removals around the periphery. The removals on the flaking surface are centripetal and invasive. This core can be classified as recurrent centripetal Levallois.

4.1.2.2.2 Production

The production (n=26) is dominated by flakes (n=23), with a sporadic presence of blades (n=3). As for layer 10, the products have generally no cortex (n=18), but 5 are less than 25% covered and 3 more than 75% covered.

The Levallois production is composed of two Levallois flakes, and one Levallois point. Two blades fragments are too partial to be attributed for sure to a Levallois reduction sequence, though it would seem likely. Another third blade fragment could also be linked to the Levallois concept, but its triangular section may also indicate a volumetric type of reduction.

- Breakage

The fragmentation is a lot less intense than for other layers, with only 7 fragments, including the three blades (Table 18).

	Blades	Flakes	Total
<i>Distal</i>		2	2
<i>Mesio-distal</i>		1	1
<i>Mesial</i>	1	1	2
<i>Proximal</i>	2		2
<i>Complete</i>		19	19
<i>Total</i>	3	23	26

Table 18: Ust'-Kansaya, layer 9. Breakage.

- Size

The average flake is 30 x 27 x 8 mm (Figure 47). The two Levallois flakes measure 36 x 34 x 7 mm and 39 x 54 x 9 mm, while the Levallois point is longer and proportionately narrower, at 57 x 34 x 7 mm. As the three laminar blanks are broken, no information is available on their lengths. They measure 38 x 13 mm, 27 x 15 mm and 23 x 7 mm.

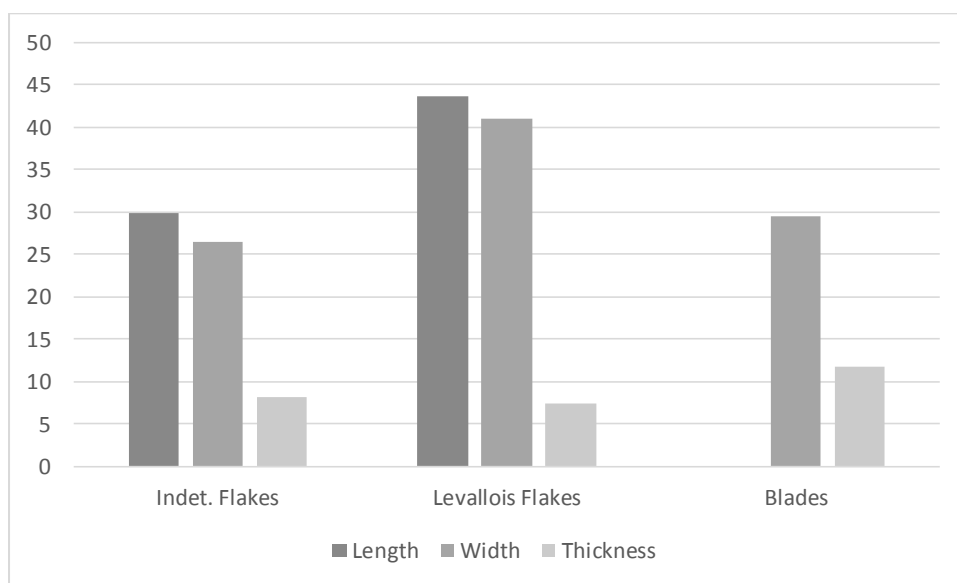


Figure 47: Ust'-Kanskaya, layer 9. Mean measurements of the products.

- Dorsal scar patterns

Most of the artefacts are unidirectional parallel, but the Levallois products are also convergent (Table 19).

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Unidirectional parallel</i>	1	3	4	8
<i>Unidirectional convergent</i>	2			2
<i>Bidirectional parallel</i>			1	1
<i>Bidirectional orthogonal</i>			2	2
<i>Multidirectional</i>			3	3
<i>Indet</i>			10	10
<i>Total</i>	3	3	20	26

Table 19: Ust'-Kanskaya, layer 9. Dorsal scar patterns.

- Platform preparation

Platforms are mostly unprepared, except for blades and Levallois products, where they are faceted and dihedral (Table 20).

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Plain</i>			11	11
<i>Dihedral</i>		1	1	2
<i>Facetted</i>	3	1		4
<i>Punctual</i>			2	2
<i>Cortical</i>			1	1
<i>Missing</i>			1	1
<i>ND</i>		1	4	5
<i>Total</i>	3	3	20	26

Table 20: Ust'-Kanskaya, layer 9. Platform preparation.

- Morphologies

The products have a quadrangular or triangular shape (Table 21), with a straight profile (Table 22) and mostly a triangular cross-section (Table 23), except the Levallois products that all have a trapezoidal cross-section.

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Quadrangular</i>	2	2	9	13
<i>Triangular</i>	1	1	7	9
<i>Oval</i>			1	1
<i>Semi-circular</i>			2	2
<i>Indet.</i>			1	1
<i>Total</i>	3	3	20	26

Table 21: Ust'-Kanskaya, layer 9. Product shape.

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Straight</i>	1	2	9	12
<i>Concave</i>	1		4	5
<i>Convex</i>	1	1	5	7
<i>Sinuuous</i>			1	1
<i>Indet.</i>			1	1
<i>Total</i>	3	3	20	26

Table 22: Ust'-Kanskaya, layer 9. Product profile.

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Triangular</i>		1	12	13
<i>Trapezoidal</i>	3	2	2	7
<i>Semi-circular</i>			6	6
<i>Total</i>	3	3	20	26

Table 23: Ust'-Kanskaya, layer 9. Product cross-section.

4.1.2.2.3 Transformed products

	<i>Nb</i>
<i>Scraper (simple)</i>	1
<i>Indet.</i>	1
<i>Total</i>	2

Table 24: Ust'-Kanskaya, layer 9. Types of tools.

Only two products have been retouched; the support of the first one is a Levallois flake, and the other is an indeterminate quartz flake. Both have a continuous, direct, semi-abrupt, scaled retouch. For the Levallois flake, the retouch is only on the mesial part of the blank, on the left

side, and its extent is marginal. It doesn't correspond to a precise typological category. As for the quartz, it presents a total, long retouch on its right side, creating a sidescraper.

4.1.2.3 Layer 8

4.1.2.3.1 Reduction sequences

This layer has yielded three cores (Table 25). They each illustrate a different type of reduction sequence.

<i>Method</i>	<i>Mode</i>	<i>Matrix</i>	<i>Nb</i>
<i>Levallois</i>	Centripetal	Indet	1
<i>Blade core?</i>	Unidirectional parallel	Indet	1
<i>Low predetermination</i>	1 FS	Pebble	1
<i>Total</i>			3

Table 25: Ust'-Kanskaya, layer 8. Cores.

One of them illustrates a low predetermination reduction sequence with 14 centripetal removals on one face. The two other cores are described below.

- UK05.8/30.617.8

No cortex remains on this core, but it is likely that it was produced on a block (Figure 48, 4). It displays a single flaking surface on the broad side of the core blank. The back is shaped by big flake removals, and the platform is mainly shaped by a big invasive flake, with two other convergent removals around it. We can see that the ridge at the intersection of these removals was selected as striking point, resulting in dihedral platforms on the predetermined products. The flaking surface illustrates a sequence of 9 removals, mostly laminar blanks. The last removals, on the external edge, are hinged.

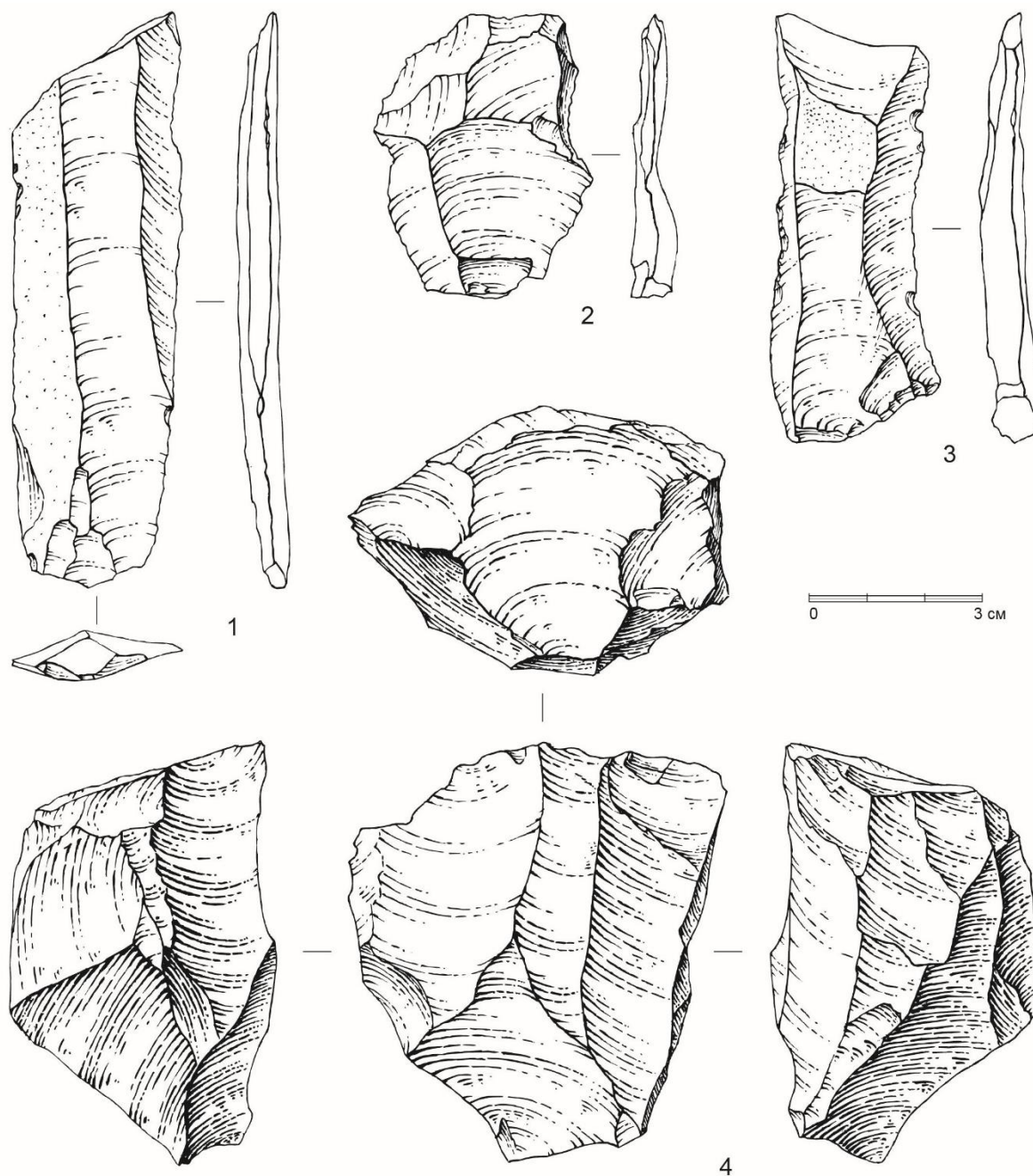


Figure 48: Ust'-Kanskaya, layer 8. Laminar blanks (1, 3), Levallois flake (2), volumetric blade core (4) (from Postnov, 2006).

- UK05.8/30.571.8

This extremely reduced core has no remaining cortex, but its back consists mainly of a frost spall negative (Figure 49). It opposes two hierarchized surfaces. The platform is prepared by a series of centripetal, secant removals. The flaking surface illustrates a sequence of 6 centripetal invasive removals. The last try at flaking resulted in a hinged scar because the surface was too flat. This core can be identified as a centripetal recurrent Levallois core.

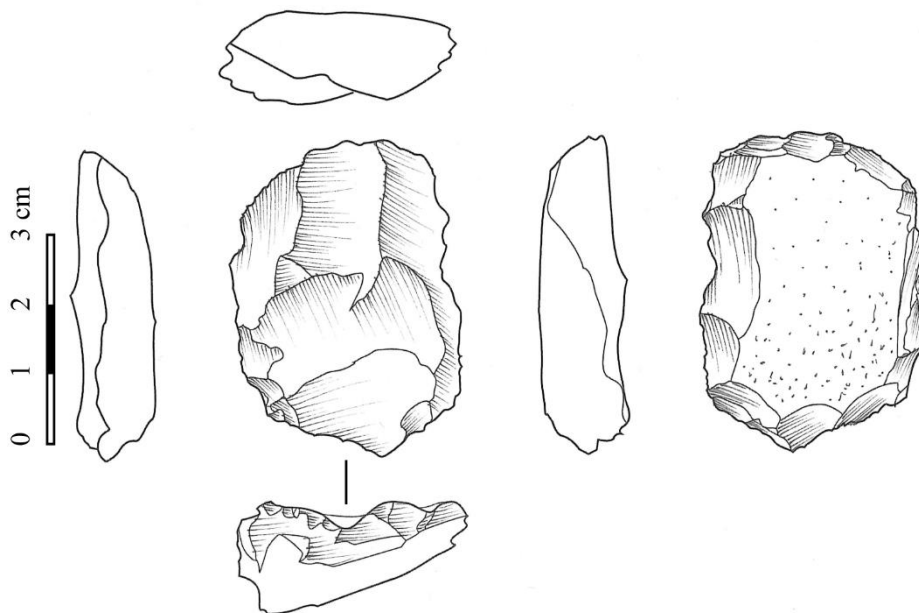


Figure 49: Ust'-Kanskaya, layer 8. UK05.8/30.571.8 (outlines C. Lesage; shading J. Galfi).

4.1.2.3.2 Production

The production (n=80) is dominated by flakes (n=47) with a notable number of blades (n=33; Figure 48, 1). Most of the products have no residual cortex (n=52).

The Levallois production is composed of four Levallois blades, eight Levallois flakes (Figure 48, 2 and 3; Figure 51), and three Levallois points (Figure 51). In addition, we identified seven *débordant* flakes that are part of the Levallois reduction sequence.

- Breakage

The assemblage is heavily fragmented, with only 39 complete artefacts (Table 26). The blades and laminar blanks are a lot more fragmented than the flakes, due to their more fragile shape.

	Blades	Flakes	Total
<i>Distal</i>	3	4	7
<i>Mesio-distal</i>	4		4
<i>Mesial</i>	6	2	8
<i>Mesio-proximal</i>	8	7	15
<i>Proximal</i>	4	3	7
<i>Complete</i>	9	30	39
<i>Total</i>	34	46	80

Table 26: Ust'-Kanskaya, layer 8. Breakage.

- Size

Mean measurements of blades are 72 x 32 x 11 mm; Levallois flakes are 46 x 38 x 10 mm; indeterminate flakes are 49 x 38 x 12 mm (Figure 50).

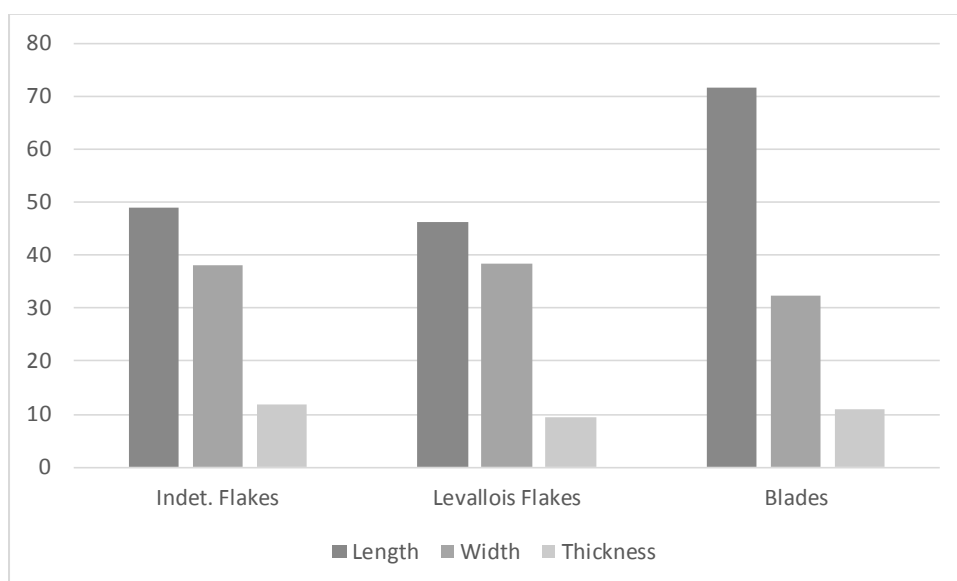


Figure 50: Ust'-Kanskaya, layer 8. Mean measurements of the products.

- Dorsal scars patterns

A majority of the products display scars consistent with a parallel reduction, mostly unidirectional (Table 27). Levallois products are also unidirectional convergent.

	Levallois	Volumetric laminar	Blades (ind.)	Indet./low predet.	Total
<i>Unidirectional parallel</i>	6	3	15	7	31
<i>Unidirectional convergent</i>	7			1	8
<i>Bidirectional parallel</i>	4		7	1	12
<i>Bidirectional orthogonal</i>	3		1		4
<i>Centripetal</i>	2				2
<i>Multidirectional</i>			2	7	9
<i>Cortical</i>				1	1
<i>Indet</i>			2	11	13
Total	22	3	27	28	80

Table 27: Ust'-Kanskaya, layer 8. Dorsal scars patterns.



Figure 51: Ust'-Kanskaya, layer 8. Levallois point (1) and elongated point (3), Levallois flakes (2, 4).

- Platform preparation

Platforms are generally plain, but different types of preparation have been identified (Table 28). Approximately half of the Levallois products have a faceted platform.

	Levallois	Volumetric laminar	Blades (ind.)	Indet./low predet.	Total
<i>Plain</i>	9	2	5	14	30
<i>Dihedral</i>	2		3	1	6
<i>Facetted</i>	10		3	2	15
<i>Punctual</i>		1	1		2
<i>Cortical</i>	1		1	3	5
<i>Broken</i>			1	1	2
<i>ND</i>			13	7	20
<i>Total</i>	22	3	27	28	80

Table 28: Ust'-Kanskaya, layer 8. Platform preparation.

- Morphologies

The production mainly consists in quadrangular blanks (n=54), although triangular shapes were also sought after (n=19), especially for Levallois products (Table 29). Most of the products have a straight profile, but some of the longer blades can be more curved (Table 30). Cross-sections are mainly triangular, showing that the removals were detached following one main ridge (Table 31), but nearly half of the Levallois products have a trapezoidal cross-section.

	Levallois	Volumetric laminar	Blades (ind.)	Indet./low predet.	Total
<i>Quadrangular</i>	10	3	25	16	54
<i>Triangular</i>	9		2	8	19
<i>Oval</i>	2				2
<i>Semi-circular</i>	1			4	5
<i>Total</i>	22	3	27	28	80

Table 29: Ust'-Kanskaya, layer 8. Product shape.

	Levallois	Volumetric laminar	Blades (ind.)	Indet./low predet.	Total
<i>Straight</i>	17	3	16	18	54
<i>Concave</i>	4		9	4	17
<i>Convex</i>	1		1	4	6
<i>Sinuuous</i>			1	2	3
<i>Total</i>	22	3	27	28	80

Table 30: Ust'-Kanskaya, layer 8. Product profile.

	Levallois	Volumetric laminar	Blades (ind.)	Indet./low predet.	Total
<i>Triangular</i>	11	1	18	18	48
<i>Trapezoidal</i>	10	2	9	7	28
<i>Semi-circular</i>	1				1
<i>Rectangular</i>				2	2
<i>Indet.</i>				1	1
<i>Total</i>	22	3	27	28	80

Table 31: Ust'-Kanskaya, layer 8. Product cross-section.

4.1.2.3.3 Transformed products

Thirteen products have been retouched. The toolkit is quite varied, but dominated by retouched blades (Table 32).

	<i>Nb</i>
<i>Scraper (simple)</i>	1
<i>Mousterian point</i>	1
<i>Retouched blade</i>	4
<i>Notch</i>	1
<i>Denticulate</i>	1
<i>Backed knife</i>	1
<i>Truncated blade</i>	1
<i>Partially retouched flake</i>	2
<i>Indet.</i>	1
<i>Total</i>	13

Table 32: Ust'-Kanskaya, layer 8. Types of tools.

The Mousterian point was manufactured on a Levallois flake, and the notch on a debordant flake that was a by-product of the Levallois reduction sequence. The supports of the other tools are indeterminate flakes.

The retouch is mainly direct, continuous and scaled, and is located on the whole side (n=7), or on the distal (n=5) or proximal part (n=1). Its extent is mainly marginal (n=7), but can be long (n=4), invasive (n=1), or short (n=1).

4.1.2.4 Layer 7

4.1.2.4.1 Reduction sequences

Four cores have been identified in this layer (Table 33).

<i>Method</i>	<i>Mode</i>	<i>Matrix</i>	<i>Nb</i>
<i>Levallois</i>	Centripetal	Pebble	1
<i>Radial</i>	Centripetal	Flake	1
<i>Low Predetermination</i>	1 FS	Pebble	1
	2 FS	Indet	1
<i>Total</i>			4

Table 33: Ust'-Kanskaya, layer 7. Cores.

Two of them illustrate low predetermination sequences; one is unifacial, with three unidirectional parallel removals; the other one opposes two non-hierarchized surfaces, which present two bidirectional removals on one side, and one removal on the other side. The two others are described below.

- UK04.8/31.284.7

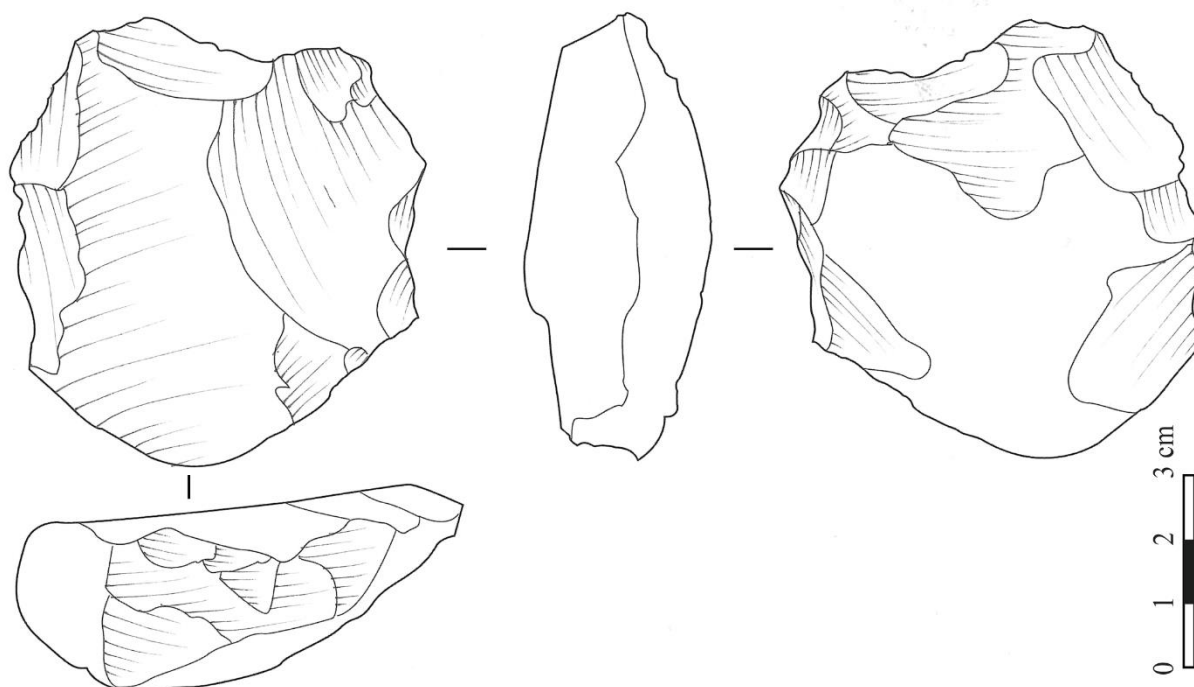


Figure 52: Ust'-Kanskaya, layer 7. UK04.8/31.284.7 (drawing J. Galfi).

This core is produced on a pebble (Figure 52). It opposes two hierarchized surfaces, one as a striking platform and the other one as a flaking surface. The striking platform, mainly cortical, is prepared by a series of secant, radial removals around the periphery. The removals

corresponding to the last preferential negative show a thorough preparation of the striking platform by faceting. The flaking surface illustrates a sequence of 6 centripetal removals. This core can be classified as a recurrent centripetal Levallois core.

- UK04.8/31.288.7

This core is produced on a slab blank (Figure 53). It opposes two hierarchized surfaces. The striking platform is mainly cortical, and prepared by a series of secant, radial removals around the periphery, most of them hinged. The flaking surface is the ventral face of the slab blank. It illustrates a sequence of numerous secant and subparallel centripetal removals, some of which are hinged. As these removals are not invasive, and leave an important part of the natural surface of the blank, this core cannot be classified as Levallois, although it may have been the initial intent of the knapper. It can be described as a moderately predetermined radial core.

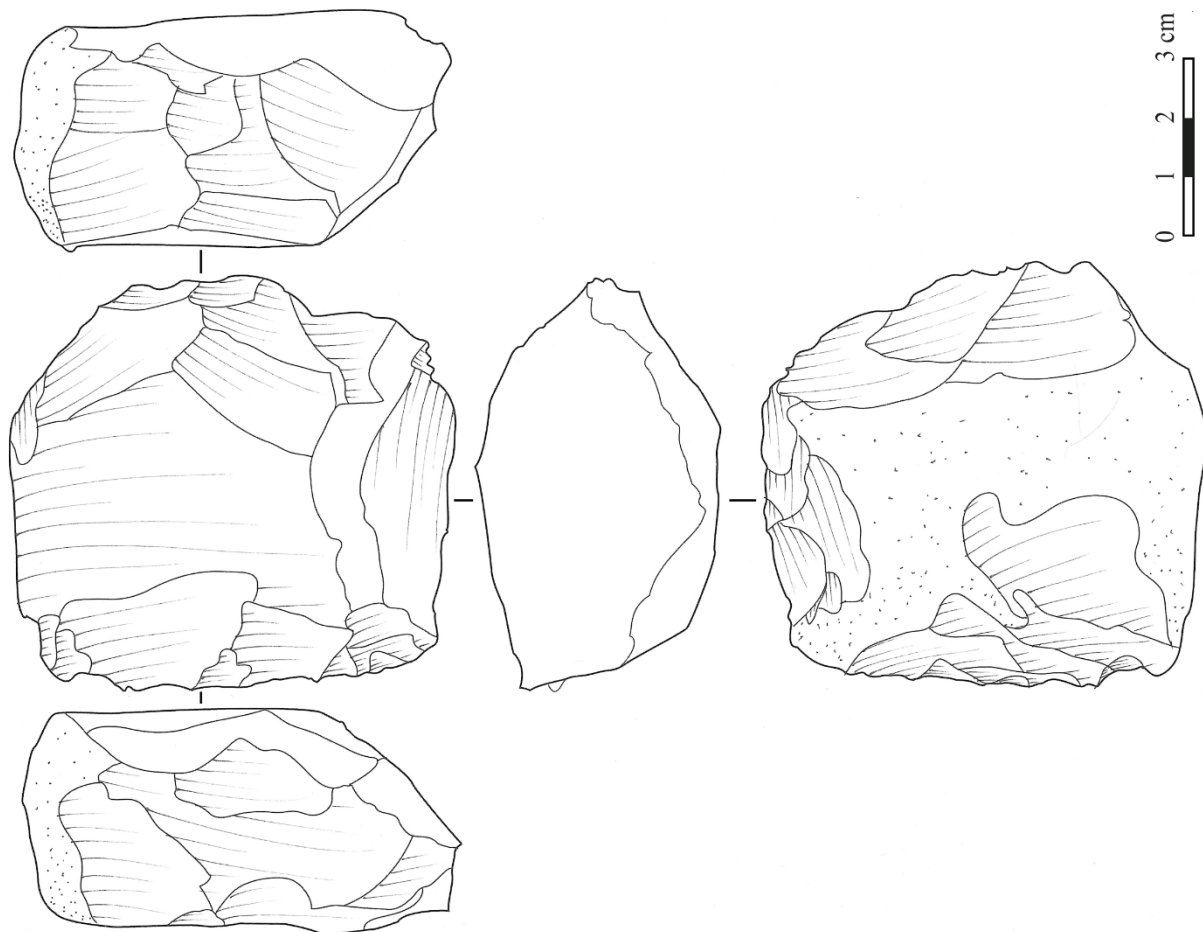


Figure 53: Ust'-Kanskaya, layer 7. UK04.8/31.288.7 (drawing J. Galfi).

4.1.2.4.2 Production

The production (n=81) is dominated by flakes (n=66), with an incidental presence of blades (n=15). Most of the artefacts do not display residual cortex (n=55).

The Levallois production is composed of one Levallois blade, two Levallois flakes and two Levallois points (Figure 54). Three *débordant* flakes are also linked to the Levallois reduction sequence.

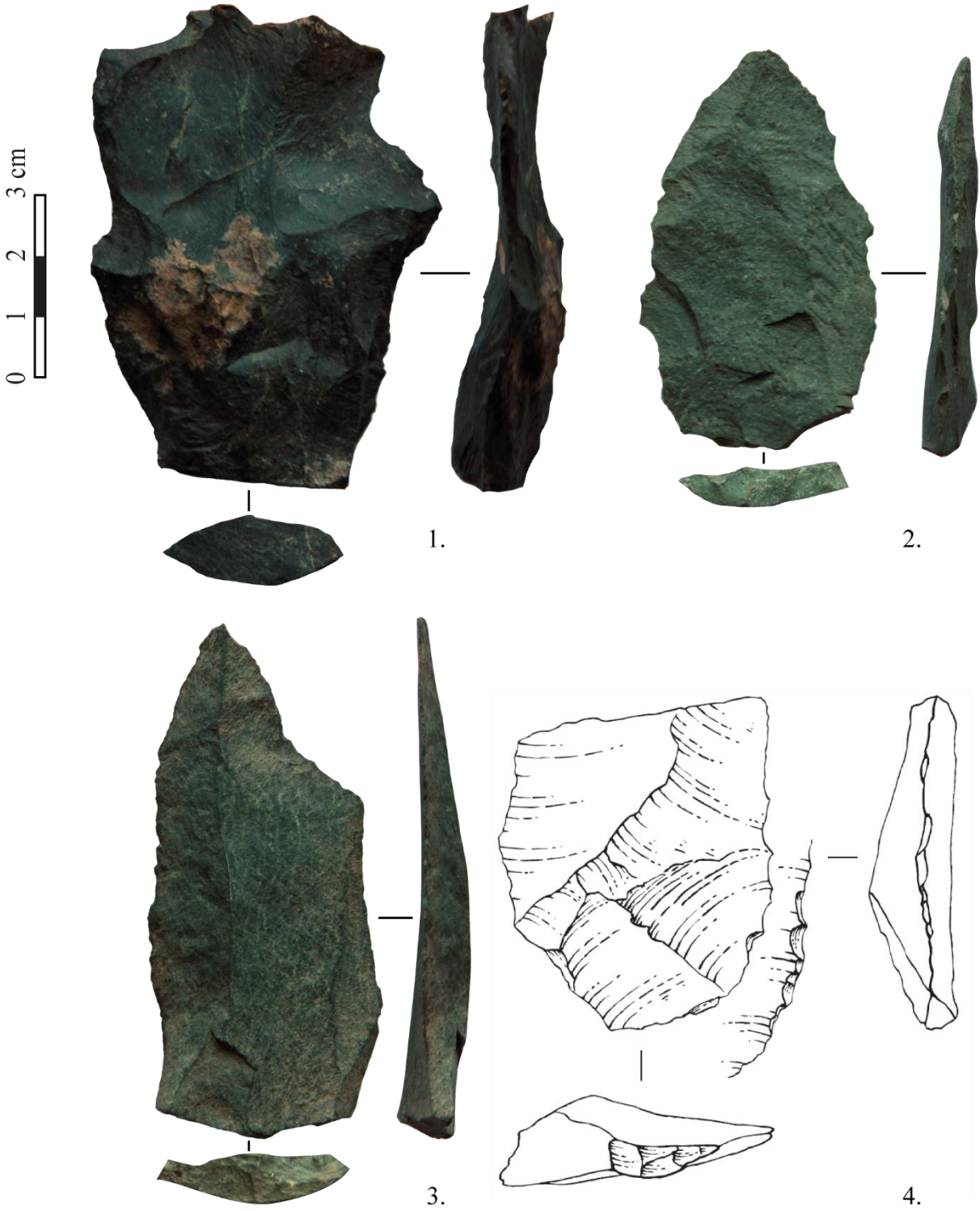


Figure 54: Ust'-Kanskaya, layer 7. Levallois flakes (1, 2), blade (3) and oblique *débordant* flake (4; from Postnov, 2006).

- Breakage

About half the assemblage is complete, but nearly all the blades are fragmented (Table 34).

	Blades	Flakes	Total
<i>Distal</i>		9	9
<i>Mesial</i>	6	3	9
<i>Mesio-proximal</i>	3	7	10
<i>Proximal</i>	4	5	9
<i>Complete</i>	2	41	43
<i>Indet.</i>		1	1
<i>Total</i>	15	66	81

Table 34: Ust'-Kanskaya, layer 7. Breakage.

- Size

As only two blades are complete, it is not possible to observe any trends on their lengths. One blade measures 84 x 36 x 9 mm and the other one 44 x 15 x 11 mm. Mean measurements of the indeterminate flakes are 39 x 31 x 9 mm, and 60 x 43 x 12 mm for the Levallois products (Figure 55). As we can see, the Levallois artefacts are larger than the other types of products for every dimension.

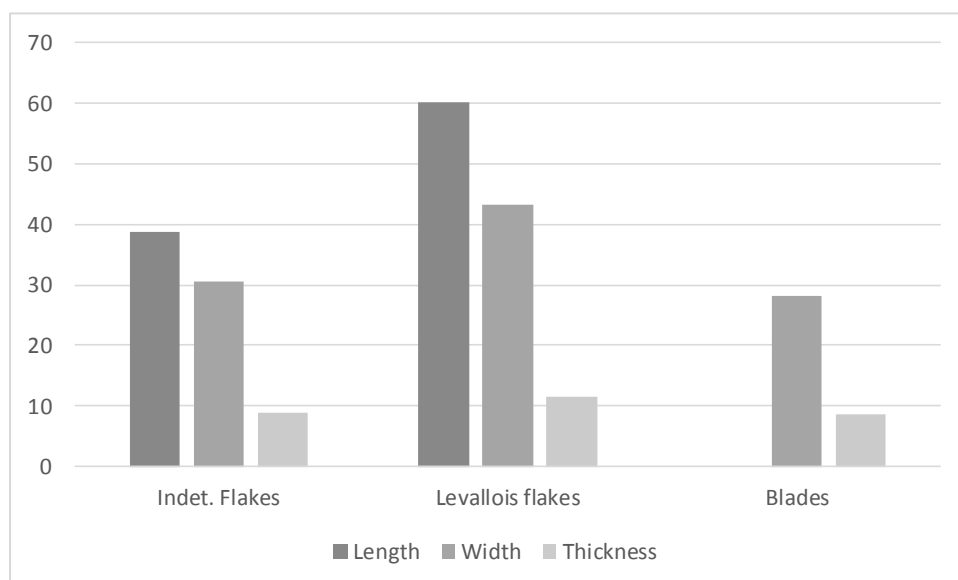


Figure 55: Ust'-Kanskaya, layer 7. Mean measurements of the products.

- Dorsal scar pattern

The indeterminate blades and flakes are mainly unidirectional parallel, and the Levallois products mainly unidirectional convergent (Table 35).

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Unidirectional parallel</i>	1	11	26	38
<i>Unidirectional convergent</i>	3		2	5
<i>Bidirectional parallel</i>	1	1	5	7
<i>Bidirectional orthogonal</i>		1	5	6
<i>Centripetal</i>			5	5
<i>Multidirectional</i>			9	9
<i>Cortical/Natural</i>			5	5
<i>Indet</i>		1	5	6
<i>Total</i>	5	14	62	81

Table 35: Ust'-Kanskaya, layer 7. Dorsal scar pattern.

- Platform preparation

Platforms are generally unprepared, except for Levallois products for which they are faceted (Table 36). The blades platforms present a variety of preparations, faceted, dihedral or punctual, as well as some unprepared plain or cortical platforms.

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Plain</i>	1	3	30	34
<i>Dihedral</i>		1	5	6
<i>Faceted</i>	4	2	3	9
<i>Punctual</i>		1	4	5
<i>Cortical</i>		1	2	3
<i>Broken</i>			2	2
<i>ND</i>		6	16	22
<i>Total</i>	5	14	62	81

Table 36: Ust'-Kanskaya, layer 7. Platform preparation.

- Morphologies

Most of the products are quadrangular, with a straight profile and a triangular cross-section (Table 37, Table 38, Table 39). However, the Levallois products are mainly triangular with a trapezoidal cross-section.

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Quadrangular</i>	2	13	27	42
<i>Triangular</i>	3	1	20	24
<i>Oval</i>			4	4
<i>Semi-circular</i>			9	9
<i>Indet.</i>			2	2
<i>Total</i>	5	14	62	81

Table 37: Ust'-Kanskaya, layer 7. Product shape.

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Straight</i>	3	13	37	53
<i>Concave</i>	2	1	13	16
<i>Convex</i>			8	8
<i>Sinuuous</i>			2	2
<i>Indet.</i>			2	2
<i>Total</i>	5	14	62	81

Table 38: Ust'-Kanskaya, layer 7. Product profile.

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Triangular</i>	1	12	36	49
<i>Trapezoidal</i>	4	2	17	23
<i>Rectangular</i>			7	7
<i>Indet.</i>			2	2
<i>Total</i>	5	14	62	81

Table 39: Ust'-Kanskaya, layer 7. Product cross-section.

4.1.2.4.3 Transformed products

Nine artefacts have been retouched. Most of them do not define a particular type of tool (two retouched blades, a partially retouched flake, and two indeterminate tools; Table 40).

	<i>Nb</i>
<i>Scraper (simple)</i>	1
<i>Mousterian point</i>	1
<i>Retouched blade</i>	2
<i>Notch</i>	1
<i>Burin</i>	1
<i>Partially retouched flake</i>	1
<i>Indet.</i>	2
<i>Total</i>	9

Table 40: *Ust'-Kanskaya, layer 7. Types of tools.*

The scraper and the two indeterminate tools are manufactured on quartz slabs, while the other tools are on indeterminate flakes of aphyric igneous material. The retouch is always scaled, direct and continuous, mostly semi-abrupt with a long extent (n=4), but also low-angle with a marginal extent (n=3) and abrupt with a short extent (n=1).

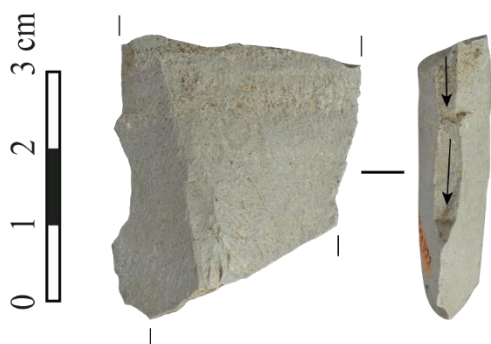


Figure 56: *Ust'-Kanskaya, layer 7. Burin.*

The burin (Figure 56) was produced on a mesial fragment of blade, the distal fracture surface used as a striking platform. The scars of three unidirectional burin spalls can be observed on its left side.

4.1.2.5 Layer 6

4.1.2.5.1 Reduction sequences

This layer has yielded six cores (Table 41). Three of them illustrate low predetermination sequences; one is a fragment of unifacial core, with 10 multidirectional removals; one is bifacial, with three centripetal removals on one side, and one invasive removal on the other side; the last one presents two surfaces, one mainly cortical with 4 removals, and the other one more extensively flaked.

<i>Method</i>	<i>Mode</i>	<i>Matrix</i>	<i>Nb</i>
<i>Levallois</i>	Centripetal	Flake	1
		Indet	1
<i>Discoid</i>	Bifacial	Pebble	1
<i>Low Predetermination</i>	1 FS	Pebble	1
	2 FS	Pebble	2
<i>Total</i>			6

Table 41: Ust'-Kanskaya, layer 6. Cores.

The three other cores are described below.

- UK05.8/30.529.6b

This core is produced on a pebble. It opposes two pyramidal non-hierarchized surfaces. One surface bears the traces of at least 12 centripetal and cordal removals, the other one of 5 centripetal removals. The platforms don't seem prepared. The reduction seems to have taken place alternatively on the two faces, in a Discoid type of sequence. We can define this core as a bifacial Discoid with an alternate discontinuous reduction.

- UK02.10/29.18.6a

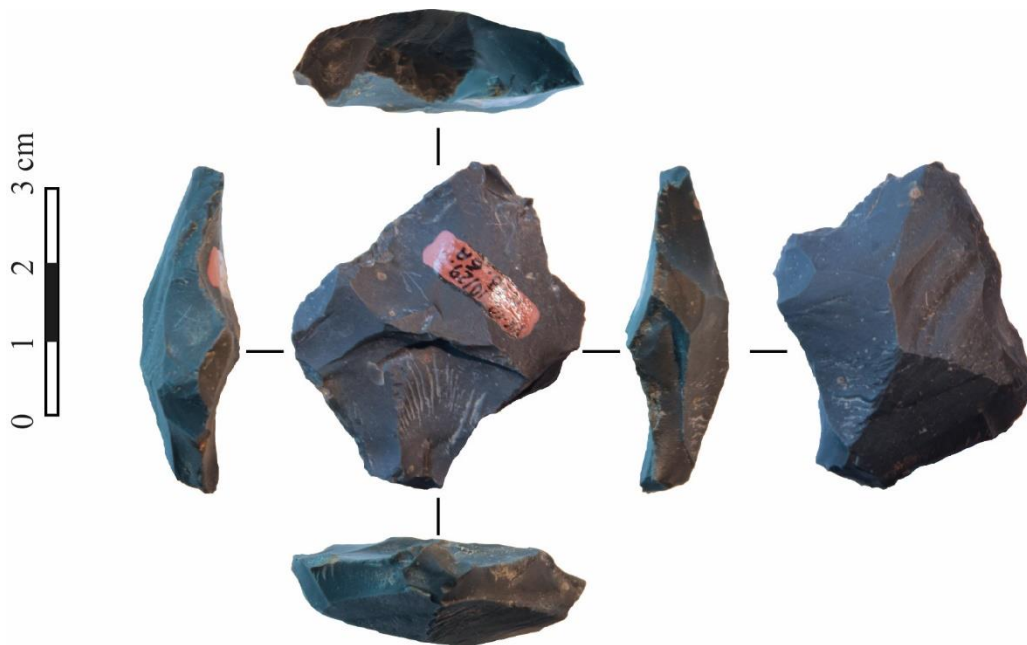


Figure 57: Ust'-Kanskaya, layer 6. UK02.10/29.18.6a.

This extremely reduced core, produced on an unidentified matrix but potentially a flake, opposes two hierarchized surfaces. The flaking surface is organized according to a centripetal reduction, with at least 5 removals. The striking platform is prepared by a series of secant, radial

removals along the periphery. This core can be classified as a recurrent centripetal Levallois core.

- UK99.9/30.228.6b

This core was produced on a flake; it opposes two hierarchized surfaces, the flaking surface on the dorsal surface of the flake, and the striking platform on the ventral surface of the flake. The scars of 9 centripetal removals can be seen on the flaking surface, and 7 other centripetal, more secant removals can be identified on the striking platform. This core can also be classified as a recurrent centripetal Levallois core.

4.1.2.5.2 Production

The production (n=166) is dominated by flakes (n=135), with the presence of some blades (n=31). Most of the artefacts do not have any residual cortex (n=122).

The Levallois production is composed of two Levallois blades, twelve Levallois flakes, and five Levallois points (Figure 58). A *débordant* flake is also identified as being part of the Levallois reduction sequence.

- Breakage

A little more than half the assemblage is complete, but less than a quarter of the blades (Table 42).

	Blades	Flakes	Total
<i>Distal</i>	2	10	12
<i>Mesio-distal</i>	1	3	4
<i>Mesial</i>	6	12	18
<i>Mesio-proximal</i>	7	11	18
<i>Proximal</i>	8	14	22
<i>Complete</i>	7	83	90
<i>Fragment</i>		2	2
<i>Total</i>	31	135	166

Table 42: Ust'-Kanskaya, layer 6. Breakage.

- Size

The Levallois flakes are on average the widest and thinnest type of products, with mean measurements amounting to 51 x 39 x 8 mm, while blades are logically the longest (65 x 26 x 8 mm; Figure 59). The indeterminate flakes average 45 x 34 x 10 mm.



Figure 58: Ust'-Kanskaya, layer 6. Levallois points (2, 3, 4), elongated point (6), and Levallois flakes (1, 5).

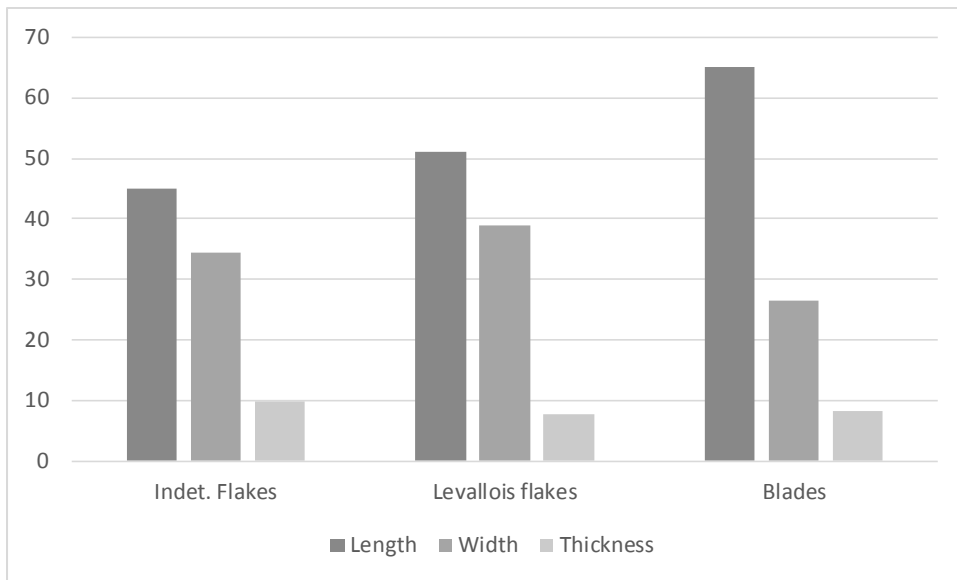


Figure 59: Ust'-Kanskaya, layer 6. Mean measurements of the products.

- Dorsal scar pattern

The Levallois products wear scars with various organizations, but most of them are unidirectional convergent (Table 43). The only blade that could be linked with a volumetric reduction is unidirectional convergent, although the indeterminate blades are mainly unidirectional parallel.

	Levallois	Volumetric laminar	Blades (ind.)	Indet./low predet.	Total
<i>Unidirectional parallel</i>	2		22	42	66
<i>Unidirectional convergent</i>	8	1		4	13
<i>Bidirectional parallel</i>	1		2	5	8
<i>Bidirectional orthogonal</i>	4		3	11	18
<i>Centripetal</i>	3			4	7
<i>Multidirectional</i>	2			23	25
<i>Cordal</i>				4	4
<i>Cortical</i>				6	6
<i>Indet</i>			1	18	19
Total	20	1	28	117	166

Table 43: Ust'-Kanskaya, layer 6. Dorsal scar pattern.

- Platform preparation

About half the products present a plain platform (Table 44). Out of the 19 blades that present a proximal part, 11 have an unprepared platform (9 plain, 2 cortical), and 4 are faceted. The

Levallois products have both dihedral and faceted platforms (n=7), and a minority of plain platforms (n=5).

	Levallois	Volumetric laminar	Blades (ind.)	Indet./low predet.	Total
<i>Plain</i>	5		9	63	77
<i>Dihedral</i>	7		2	7	16
<i>Faceted</i>	7		4	1	12
<i>Punctual</i>			1	3	4
<i>Cortical</i>			2	10	12
<i>Missing</i>				2	2
<i>Broken</i>			1	6	7
<i>ND</i>	1	1	9	25	36
<i>Total</i>	20	1	28	117	166

Table 44: Ust'-Kanskaya, layer 6. Platform preparation.

- Morphologies

It seems that the typical sought-after product is quadrangular (Table 45), with a straight profile (Table 46), and a triangular cross-section (Table 47). However, we can note that, contrary to all the other types of artefacts, the Levallois products have mainly a trapezoidal cross-section, indicating the search for two guide-ridges in this reduction sequence.

	Levallois	Volumetric laminar	Blades (ind.)	Indet./low predet.	Total
<i>Quadrangular</i>	12		22	64	98
<i>Triangular</i>	7	1	6	44	58
<i>Oval</i>	1			4	5
<i>Semi-circular</i>				4	4
<i>Indet.</i>				1	1
<i>Total</i>	20	1	28	117	166

Table 45: Ust'-Kanskaya, layer 6. Product shape.

	Levallois	Volumetric laminar	Blades (ind.)	Indet./low predet.	Total
<i>Straight</i>	11	1	20	79	111
<i>Concave</i>	7		8	21	36
<i>Convex</i>	2			15	17
<i>Sinuuous</i>				2	2
<i>Total</i>	20	1	28	117	166

Table 46: Ust'-Kanskaya, layer 6. Product profile.

	Levallois	Volumetric laminar	Blades (ind.)	Indet./low predet.	Total
<i>Triangular</i>	5		17	67	89
<i>Trapezoidal</i>	15	1	11	32	59
<i>Semi-circular</i>				6	6
<i>Rectangular</i>				12	12
<i>Total</i>	20	1	28	117	166

Table 47: Ust'-Kanskaya, layer 6. Product cross-section.

4.1.2.5.3 Transformed products

Twenty-one supports have been retouched (12.7 %; Table 48). Scrapers dominate the assemblage (n=6), followed by partially retouched flakes (n=5) and retouched blades (n=4).

	<i>Nb</i>
<i>Scraper</i>	6
<i>Simple</i>	3
<i>Double</i>	3
<i>Mousterian point</i>	2
<i>Retouched blade</i>	4
<i>Denticulate</i>	2
<i>Backed knife</i>	1
<i>Truncated flake</i>	1
<i>Partially retouched flake</i>	5
<i>Total</i>	21

Table 48: Ust'-Kanskaya, layer 6. Types of tools.

One of the Mousterian points is manufactured on a Levallois point, and two pseudo-Levallois points have been retouched, one into a scraper and the other one on a partially retouched flake. The other tools supports are indeterminate flakes.

4.1.2.6 Layer 5

This assemblage is by far the richest, with about half of the total artefacts (n=1410).

4.1.2.6.1 Reduction sequences

Forty-two cores have been identified in this layer (Table 49). Most of them (n=32) belong to low predetermination methods, with one to three flaking surfaces (Figure 61). They were usually abandoned after a few removals, and not pursued until exhaustion.

<i>Method</i>	<i>Mode</i>	<i>Matrix</i>	<i>Nb</i>
<i>Levallois</i>	Centripetal	Nodule	2
		Indet	1
	Preferential	Pebble	1
		Indet	1
	Indet	Flake	1
<i>Levallois?</i>	Unidirectional parallel	Pebble	1
<i>Lamellar</i>	Unidirectional parallel	Flake	1
<i>Discoid</i>	Bifacial	Pebble	1
		Indet.	1
<i>Low Predetermination</i>	1 FS	Nodule	1
		Pebble	12
	2 FS	Nodule	4
		Pebble	7
		Flake	2
	3 FS	Indet.	3
		Nodule	1
		Pebble	1
		Flake	1
<i>Total</i>			42

Table 49: Ust'-Kanskaya, layer 5. Cores.

Two cores are flaked according to a bifacial Discoid method, in an alternate discontinuous mode. They were both flaked until exhaustion; on one of them, the overhang was used as a guide-ridge to produce the last three flakes.

One lamellar core has been produced on a fragment of a thick blank and not intensively reduced (Figure 61). It is unidirectional, and its last product, at the expense of the dorsal surface, was a pointed bladelet with a width of 11 mm.

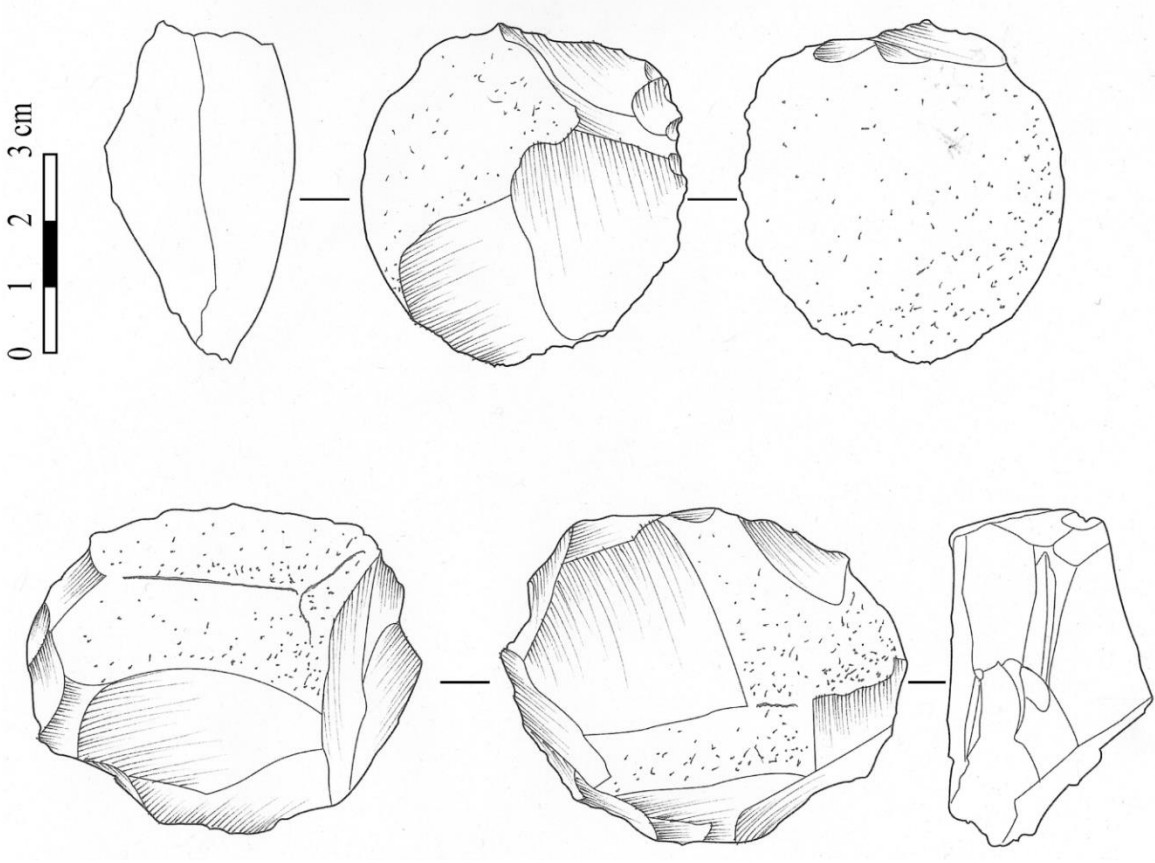


Figure 60: Ust'-Kanskaya, layer 5. Low predetermination cores (drawings J. Galfi).

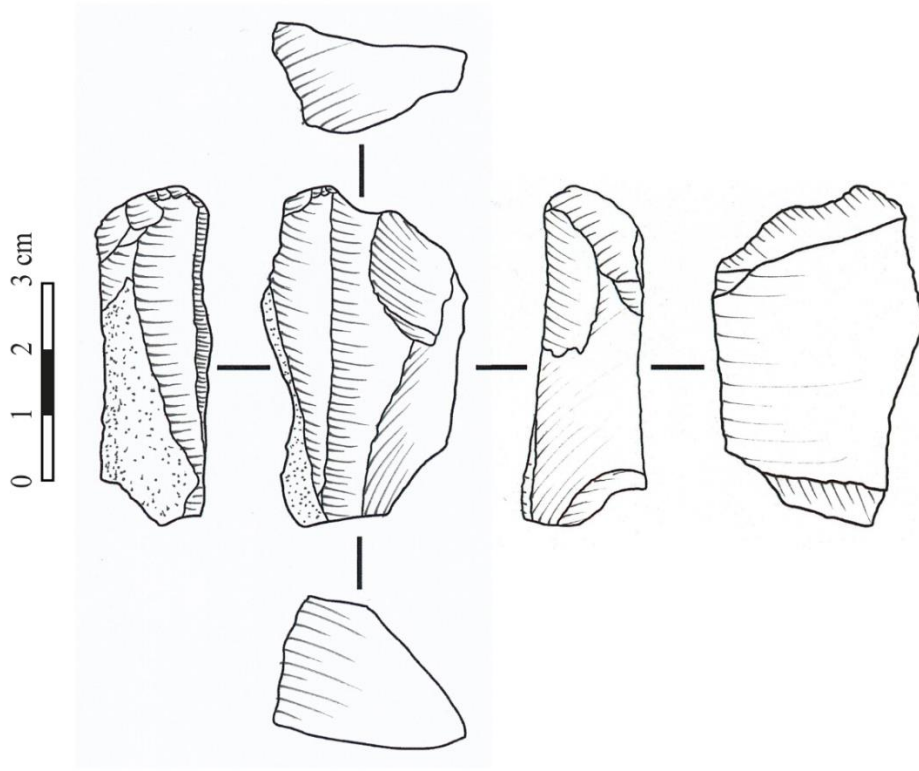


Figure 61: Ust'-Kanskaya, layer 5. Lamellar core.

The Levallois reduction

Two different raw materials were used for the Levallois cores, porphyritic igneous rock (n = 4) and sandstone (n = 3), mainly blocks and pebbles – only one core made out of a flake. They are quite small in size, on average 61 x 55 x 24 mm, and were heavily reduced. Three of them display the characteristics of a recurrent centripetal mode at the end of their exploitation, and two correspond to the preferential mode. The core that display the features of a unidirectional parallel reduction does not answer fully to the criteria commonly used for the Levallois concept.

- UK06.8/32.471.5d

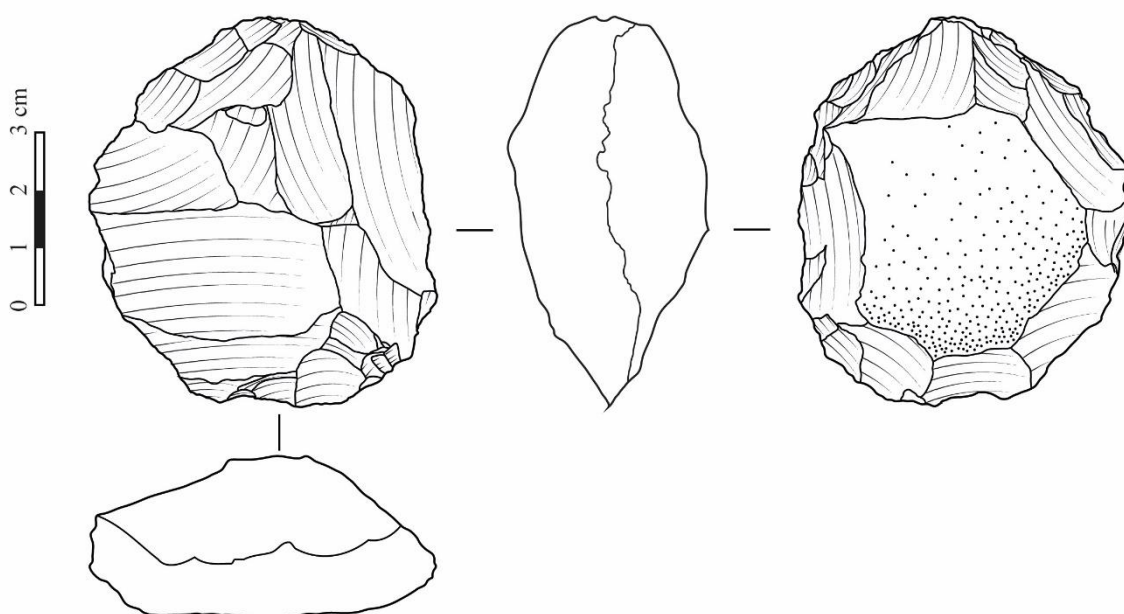


Figure 62: *Ust'-Kanskaya, layer 5. UK06.8/32.471.5d.*

This core is produced on a nodule of raw material (Figure 62). It opposes two hierarchical surfaces. The striking platform, mainly cortical, is prepared by a series of secant, radial removals around the periphery. Some smaller removals, mostly hinged, correspond the preparation of the platform of the last dorsal removal. The flaking surface illustrates a series of secant and subparallel centripetal removals. A double patina can be noted, indicating that three removals of the flaking surface and two removals on the flaking surface were produced in a second phase.

- UK00.8/31.262.5c

This core opposes two hierarchical surfaces (Figure 63); the striking platform is prepared by a series of radial removals, many of which are hinged. The flaking surface illustrates a series of more than 10 centripetal removals.

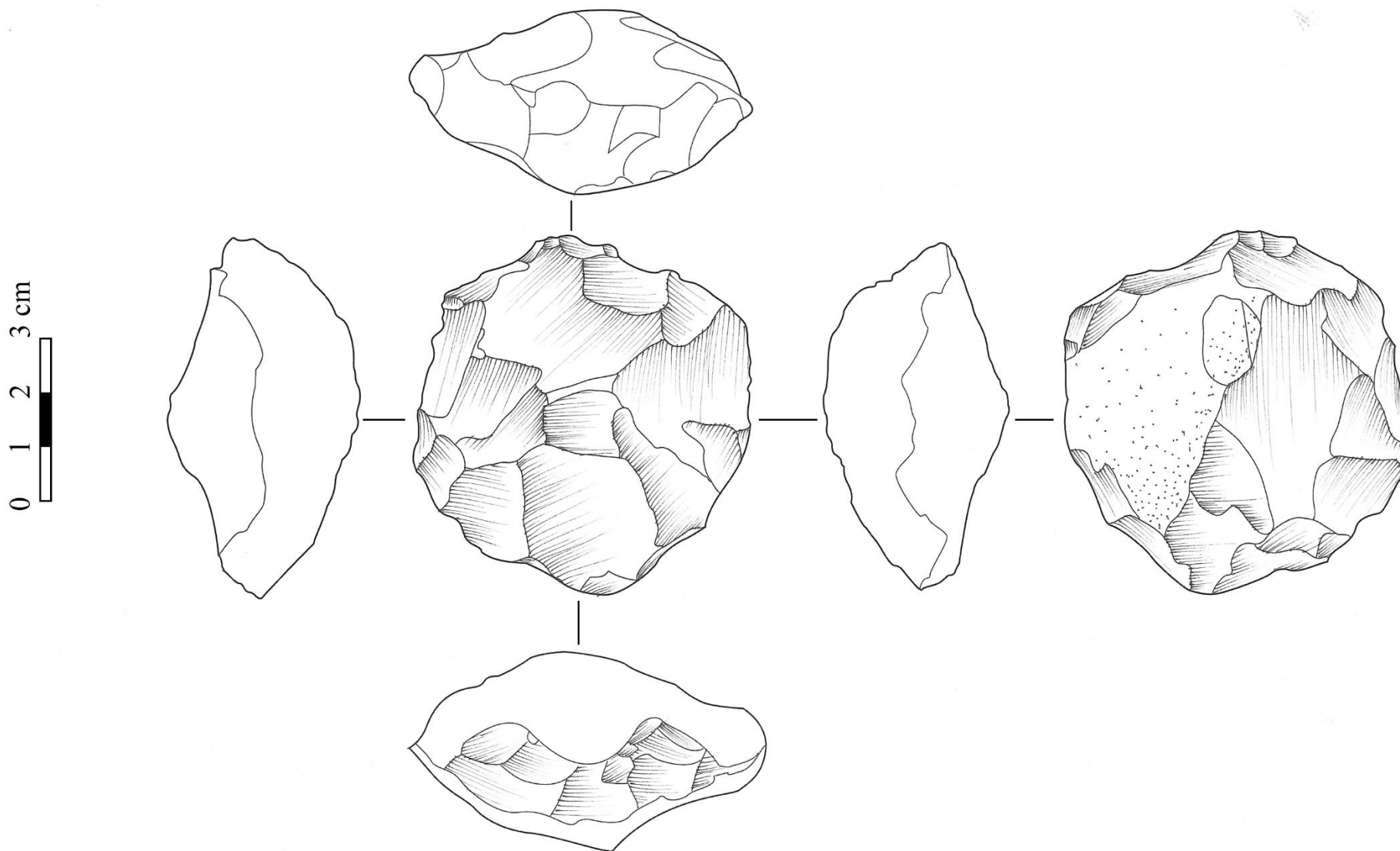


Figure 63: Ust'-Kanskaya, layer 5. UK00.8/31.262.5c (outlines C. Lesage; shading J. Galfi)

- UK06.8/32.681.5b

This core was produced on a pebble (Figure 64). It is organised in three surfaces. The back is shaped by an invasive removal and split surface from the fracture of the pebble. The striking platform is a narrow face, shaped by a series of small, hinged removals. The flaking surface displays an organization of the lateral convexities: on one side by a longitudinal removal, and on the other side by a series of short, transversal removals. Due to the fracture, no information is available on the distal convexity. An invasive, preferential blank was produced at the centre of the flaking surface.

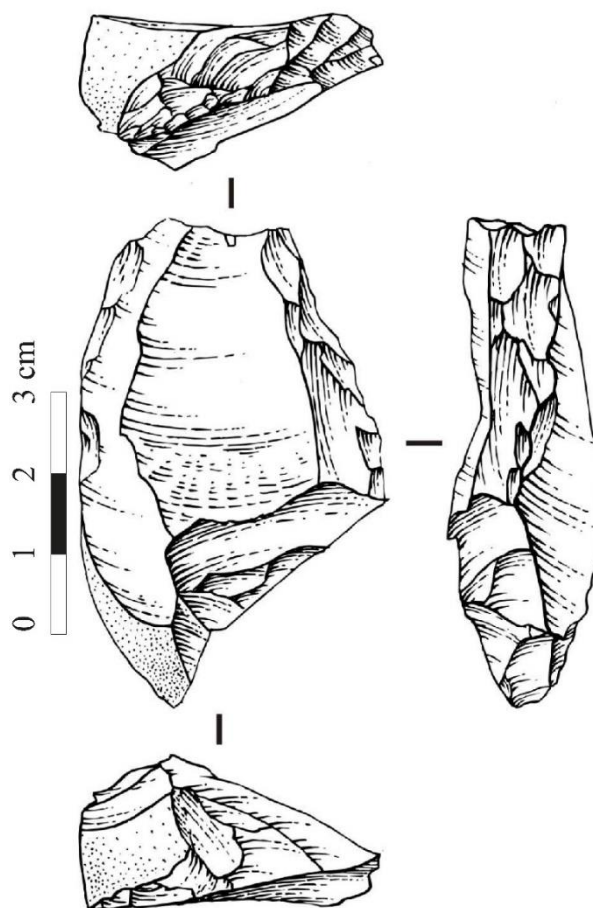


Figure 64: Ust'-Kanskaya, layer 5. UK06.8/32.681.5b (from Postnov, 2006)

- UK07.8/31.486.5e

This core opposes two hierarchical surfaces (Figure 65). The striking platform is prepared by a series of secant, radial removals. A series of smaller, hinged removals correspond to the faceting of the butt prior to the removal of the preferential flake on the flaking surface. The flaking surface bears the traces of 5 removals: 4 of them were used to shape the convexities of the surface, for the removal of the 5th one, the preferential Levallois flake.

- UK07.9/32.447.5e

This is a fragment of core, where we can identify two opposed, hierarchical surfaces (Figure 66). The striking platform is prepared by a series of unipolar parallel removals. On the flaking surface, the scars of two invasive, centripetal flakes, can be identified, as well as a series of smaller, more secant removals, maybe for a reorganization of the lateral convexity. This core is too fragmented to determine its reduction mode, but it seems it could be recurrent centripetal.

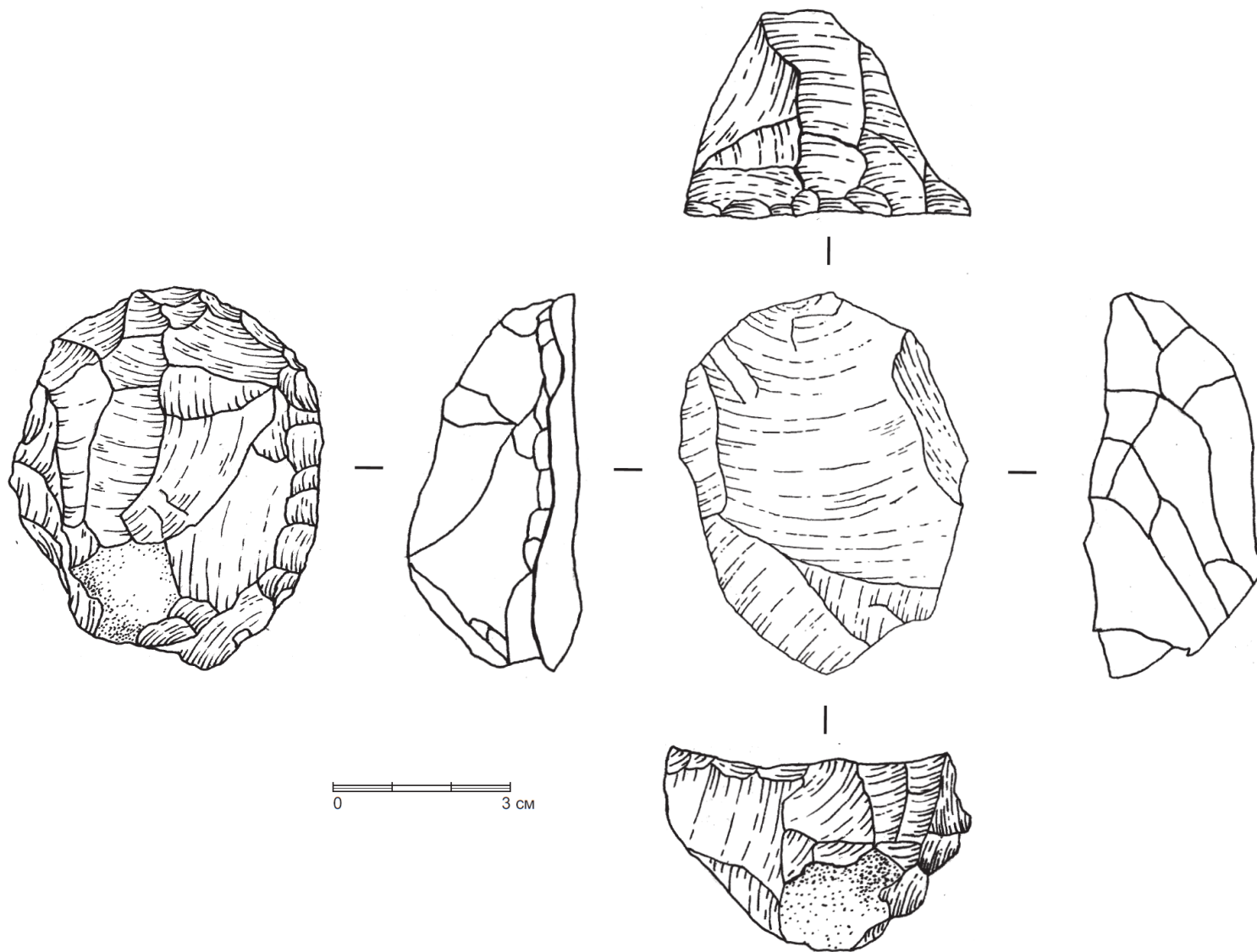


Figure 65: Ust'-Kanskaya, layer 5. UK07.8/31.486.5e (from Postnov, 2008).

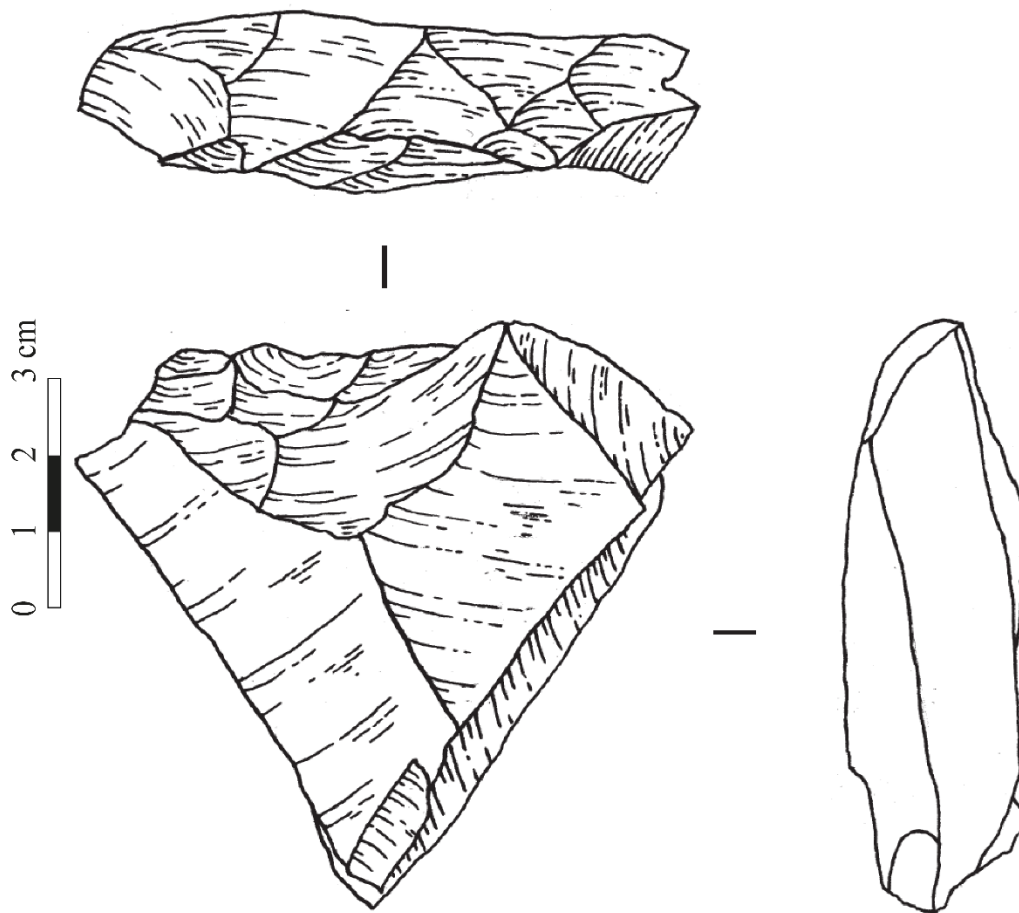


Figure 66: Ust'-Kanskaya, layer 5. UK07.9/32.447.5e (from Postnov, 2008).

4.1.2.6.2 Production

The production (n=1040) is dominated by flakes (n=886), with blades (n=151) and very exceptional bladelets (n=3). Most of the artefacts do not bear residual cortex (n=671).

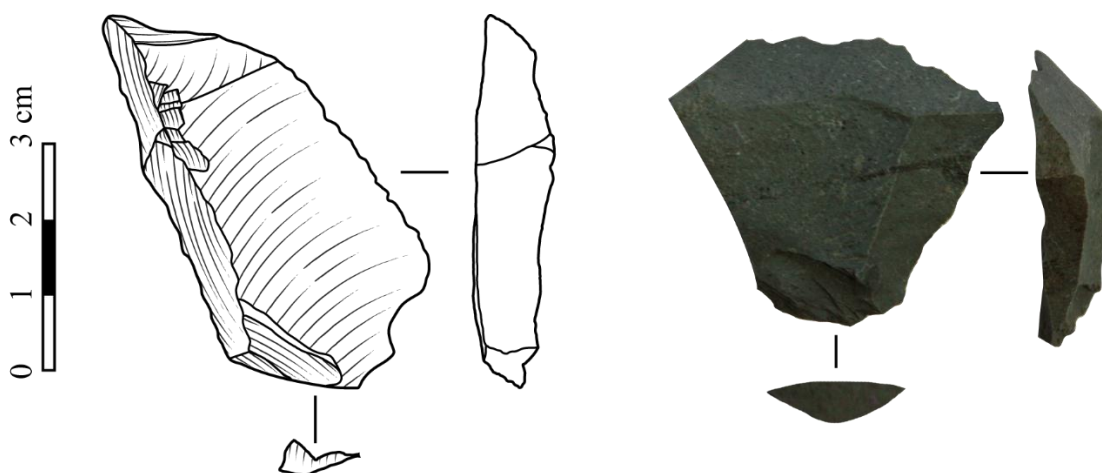


Figure 67: Ust'-Kanskaya, layer 5. Débordant flakes.

The Levallois production is composed of six Levallois blades, fifty Levallois flakes and twenty-four Levallois points (Figure 69). In addition, five débordant flakes and six maintenance flakes have been identified as part of the Levallois reduction sequence (Figure 67).

- Breakage

About half the assemblage is complete (n=570); the blades present a higher fragmentation rate than the flakes, with only a third of them complete (Table 50).

	Blades	Flakes	Total
<i>Distal</i>	20	98	118
<i>Mesio-distal</i>	6	21	27
<i>Mesial</i>	26	48	74
<i>Mesio-proximal</i>	18	96	114
<i>Proximal</i>	35	72	107
<i>Complete</i>	48	522	570
<i>Fragment</i>	1	27	28
<i>Indet.</i>		2	2
<i>Total</i>	154	886	1040

Table 50: Ust'-Kanskaya, layer 5. Breakage.

- Size

The average flake is 43 x 33 x 10 mm; blades are the longest, narrowest and thinnest type of product (on average 62 x 26 x 8 mm; Figure 68). The Levallois flakes and points average at 55 x 40 x 8 mm.

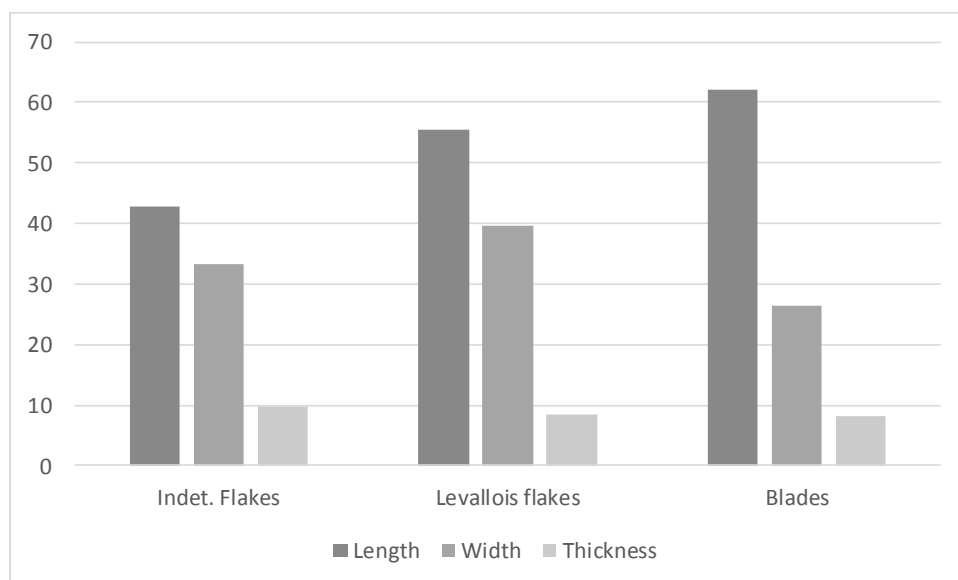


Figure 68: Ust'-Kanskaya, layer 5. Mean measurements of the products.

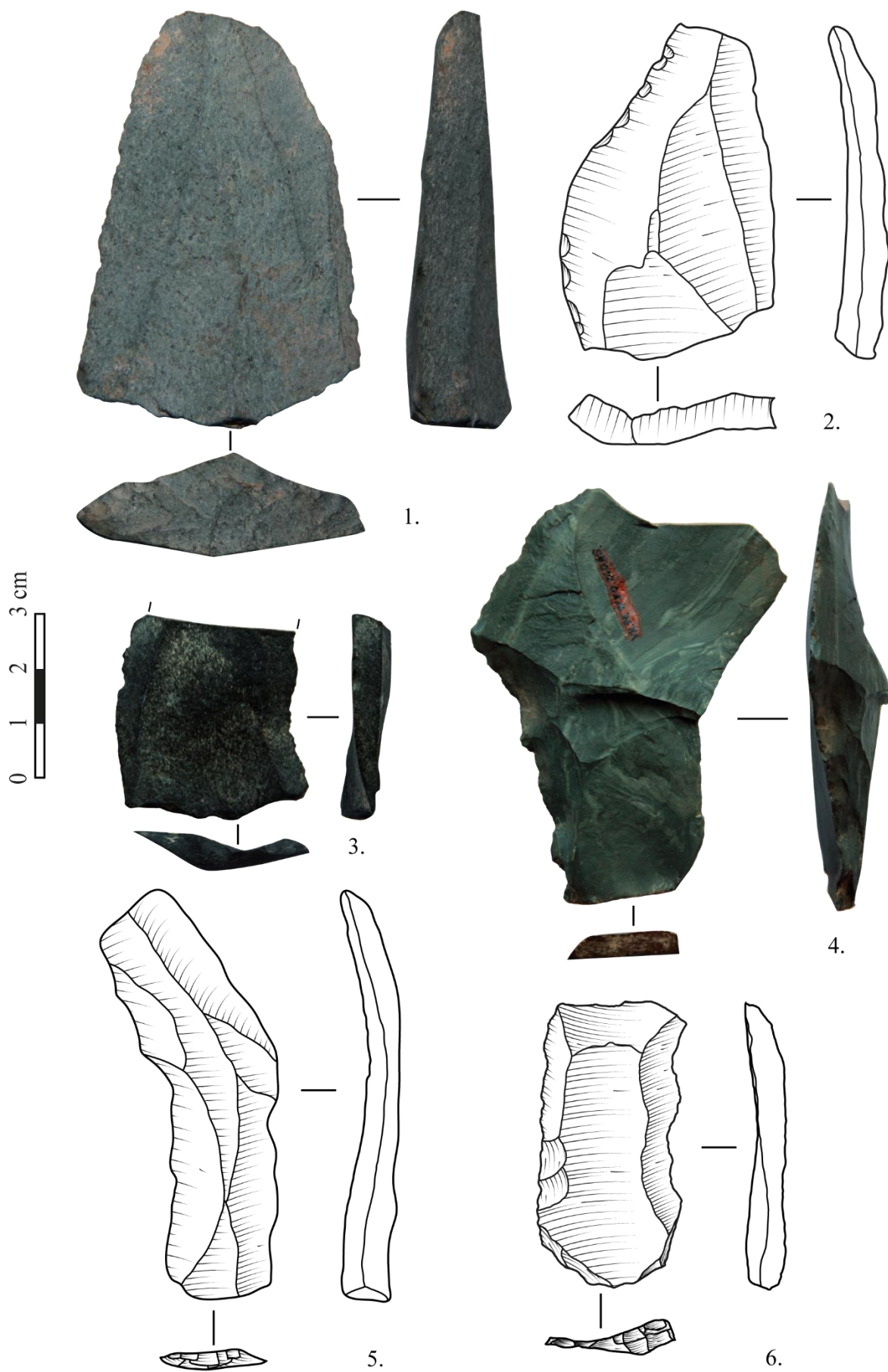


Figure 69: Ust'-Kanskaya, layer 5. Levallois points (1, 2), Levallois flakes (4, 6), Levallois blades (3, 5).

- Dorsal scar pattern

The Levallois and laminar blanks are mostly unidirectional – for the Levallois blanks, half of them are parallel, the other half convergent (Table 51). All three bladelets have been obtained through a unidirectional parallel method.

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Unidirectional parallel</i>	33	2	99	3	323	460
<i>Unidirectional convergent</i>	32		5		34	71
<i>Bidirectional parallel</i>	4		19		54	77
<i>Bidirectional orthogonal</i>	7		12		133	152
<i>Centripetal</i>	12				27	39
<i>Multidirectional</i>			2		107	109
<i>Cordal</i>	1				26	27
<i>Cortical</i>			1		46	47
<i>Indet</i>	2		2		54	58
Total	91	2	140	3	804	1040

Table 51: Ust'-Kanskaya, layer 5. Dorsal scar pattern.

- Platform preparation

With most of the artefacts presenting plain butts, Levallois blanks stand out with a majority of faceted platforms (Table 52).

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Plain</i>	28	1	49	1	403	482
<i>Dihedral</i>	9		6		20	35
<i>Facetted</i>	42		22		20	84
<i>Punctual</i>	1		6		38	45
<i>Cortical</i>	1		2		90	93
<i>Missing</i>	3				7	10
<i>Broken</i>	1		6		22	29
<i>ND</i>	6	1	49	2	199	257
<i>Indet.</i>					5	5
Total	91	2	140	3	804	1040

Table 52: Ust'-Kanskaya, layer 5. Platform preparation.

- Morphologies

The average product has a quadrangular shape (Table 53) – although triangular blanks are common amongst Levallois products – and a straight profile (Table 54). Cross-sections are mainly triangular (Table 55). However, more than two-thirds of the Levallois products have a trapezoidal cross-section.

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Quadrangular</i>	52	2	116	2	586	758
<i>Triangular</i>	33		22	1	165	221
<i>Oval</i>	4		1		12	17
<i>Circular</i>					3	3
<i>Semi-circular</i>	2		1		36	39
<i>Indet.</i>					2	2
<i>Total</i>	91	2	140	3	804	1040

Table 53: Ust'-Kanskaya, layer 5. Product shape.

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Straight</i>	72	2	114	2	590	780
<i>Concave</i>	18		18	1	107	144
<i>Convex</i>			2		81	83
<i>Sinuuous</i>			6		21	27
<i>Indet.</i>	1				5	6
<i>Total</i>	91	2	140	3	804	1040

Table 54: Ust'-Kanskaya, layer 5. Product profile.

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Triangular</i>	23	2	82	3	436	546
<i>Trapezoidal</i>	65		54		277	396
<i>Semi-circular</i>	2		2		46	50
<i>Rectangular</i>			2		36	38
<i>Indet.</i>	1				9	10
<i>Total</i>	91	2	140	3	804	1040

Table 55: Ust'-Kanskaya, layer 5. Product cross-section.

4.1.2.6.3 Transformed products

The transformed products represent 13% of the blanks (n=137). Most of them are on undifferentiated blanks, but some of the Levallois products and blades were selected as well (n=43). Simple lateral scrapers are by far the most common retouched tool (Table 56). The tools rarely show more than one episode of retouch, which is continuous, scaled, semi-abrupt, rectilinear, and varies in extent from marginal to invasive (Figure 70).

We can also note the presence of three pebble tools, where few removals on one of the narrow extremities of a pebble shaped a functional edge (chopping-tool).

	<i>Nb</i>	
<i>Scraper</i>	77	56.2%
<i>Simple</i>	63	
<i>Double</i>	12	
<i>Triple</i>	1	
<i>Quadruple</i>	1	
<i>Mousterian point</i>	12	8.8%
<i>Retouched blade</i>	19	13.9%
<i>Retouched bladelet</i>	1	0.7%
<i>Notch</i>	6	4.4%
<i>Denticulate</i>	4	2.9%
<i>Backed Knife</i>	3	2.2%
<i>Burin</i>	2	1.5%
<i>Perforator</i>	2	1.5%
<i>Truncated flake</i>	1	0.7%
<i>Bifacial tool</i>	1	0.7%
<i>Indet</i>	9	6.6%
<i>Total</i>	137	100%

Table 56: Ust'-Kanskaya, layer 5. Types of tools.

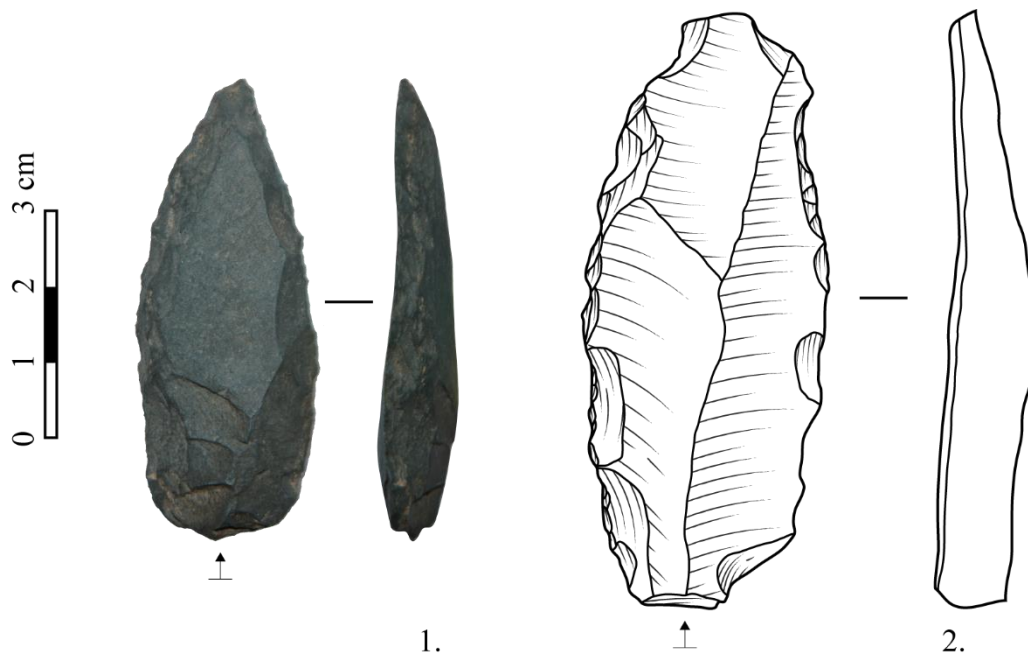


Figure 70: Ust'-Kanskaya, layer 5. Mousterian point (1), retouched blade (2).

4.1.2.7 Layer 4

4.1.2.7.1 Reduction sequences

Out of the ten cores identified in this assemblage, none illustrate a highly predetermined scheme (Table 57). They were usually abandoned after a few removals, and not pursued until exhaustion.

<i>Method</i>	<i>Mode</i>	<i>Matrix</i>	<i>Nb</i>
<i>Discoid</i>	Bifacial	Nodule	1
<i>Low Predetermination</i>	1 FS	Pebble	4
		Indet.	1
	2 FS	Nodule	1
		Indet.	1
	3 FS	Pebble	1
	4 FS	Indet	1
<i>Total</i>			10

Table 57: Ust'-Kanskaya, layer 4. Cores.

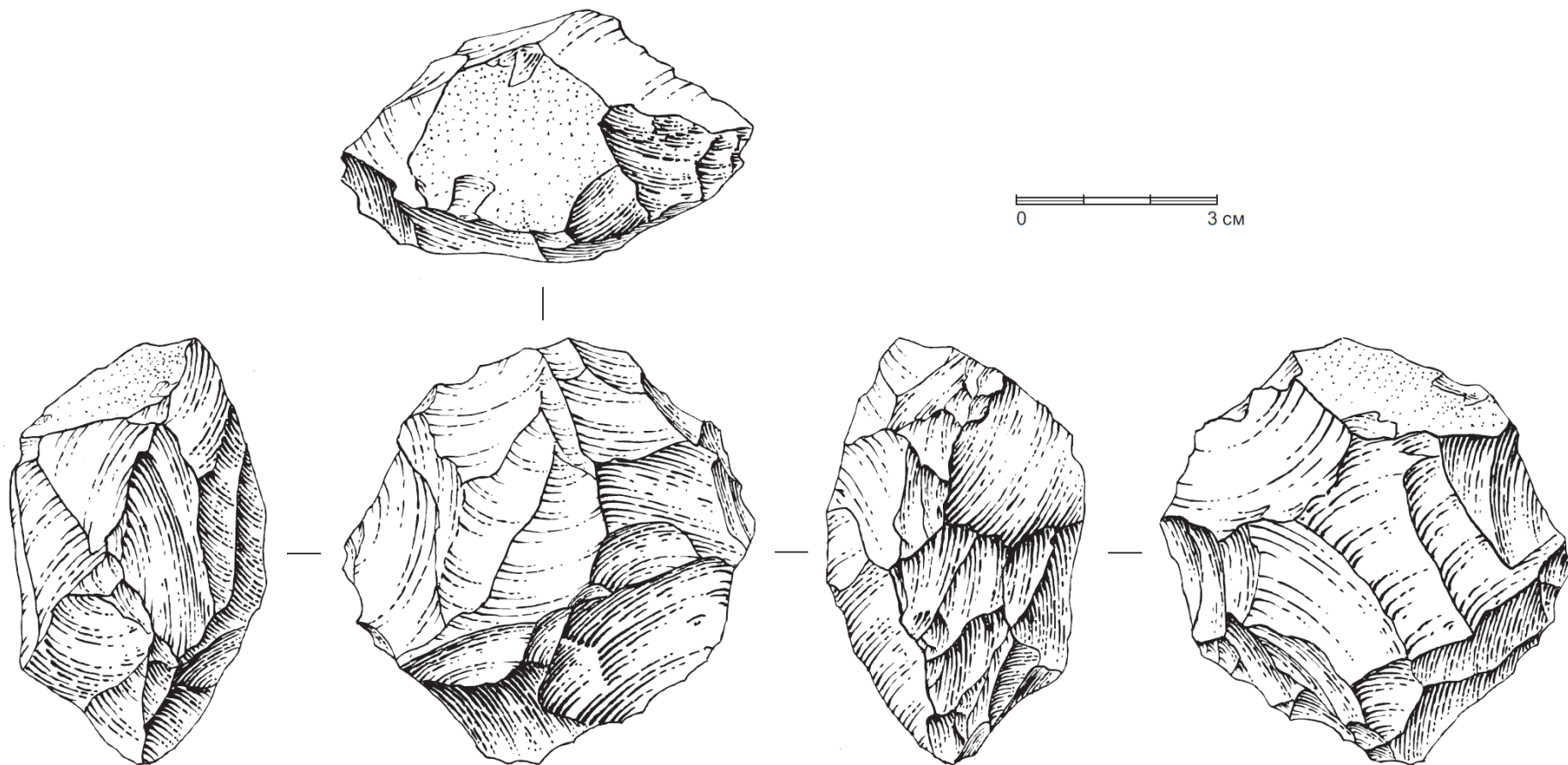


Figure 71: Ust'-Kanskaya, layer 4. Discoïd core (from Postnov, 2006).

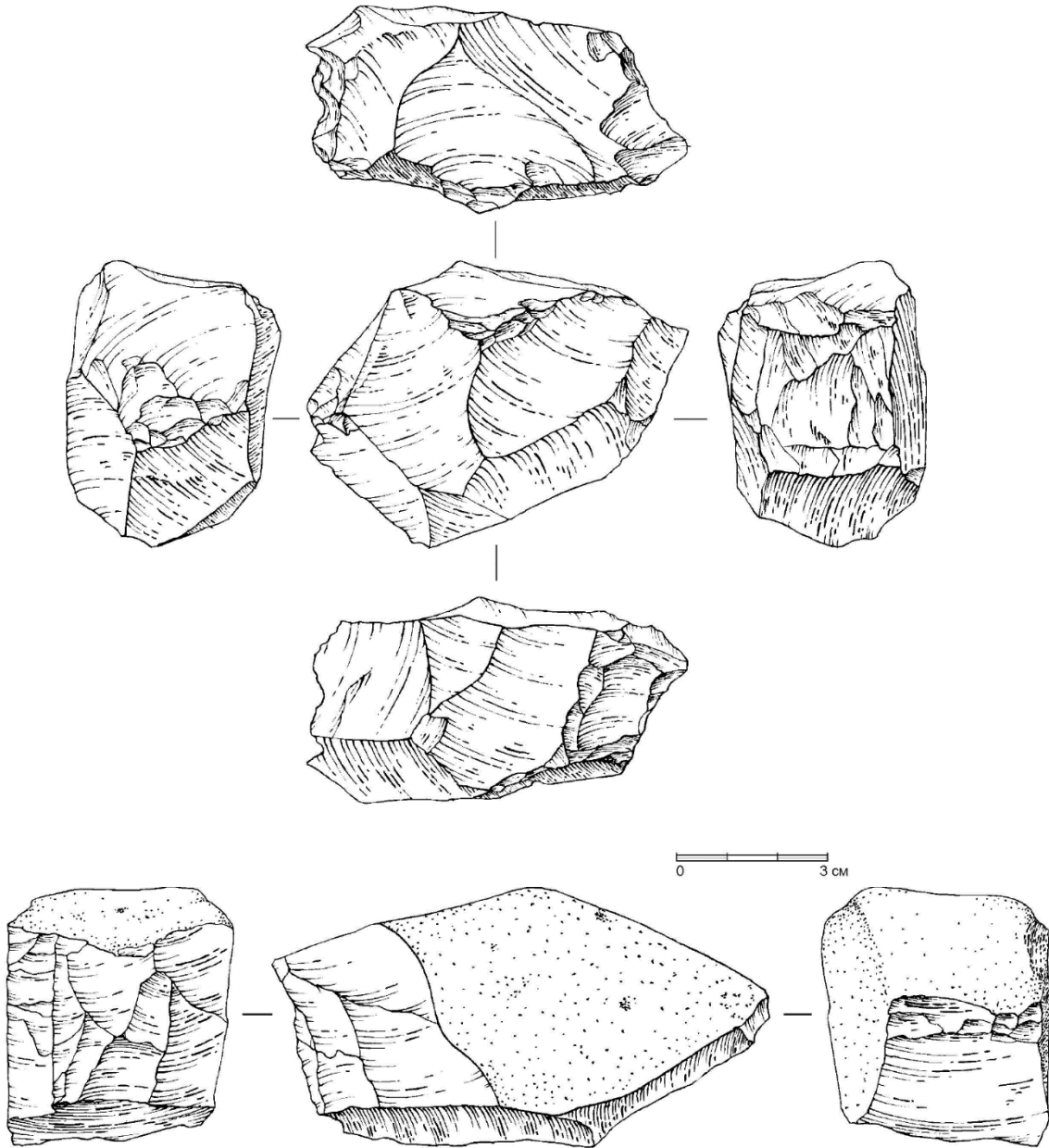


Figure 72: Ust'-Kanskaya, layer 4. Low predermination cores (from Postnov, 2005).

4.1.2.7.2 Production

The production (n=251) is dominated by flakes, with blades (n=65) and occasional bladelets (n=4). Most of the artefacts do not bear residual cortex (n=154), or less than a quarter of the dorsal surface is covered (n=46).

The Levallois production is composed of two Levallois blades, eight Levallois flakes and twelve Levallois points (Figure 73, Figure 74).

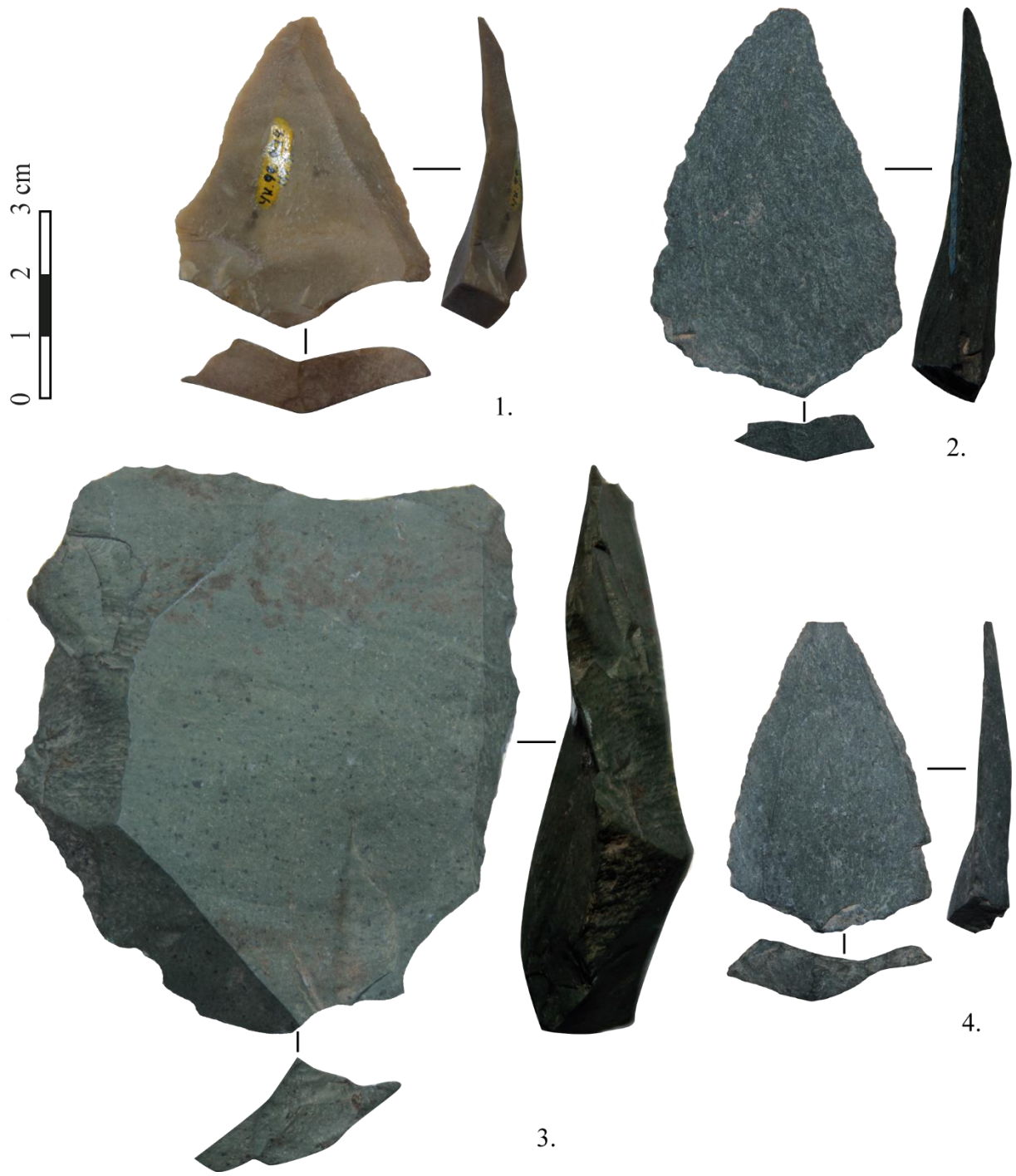


Figure 73: Ust'-Kanskaya, layer 4. Levallois points (1, 2, 4), Levallois flake (3).



Figure 74: Ust'-Kanskaya, layer 4. Levallois flake (1), blade (2).

- Breakage

Less than half the assemblage is complete (n=107), with only 16% for the blades (Table 58).

	Blades	Flakes	Total
<i>Distal</i>	3	21	24
<i>Mesio-distal</i>	7	11	18
<i>Mesial</i>	14	6	20
<i>Mesio-proximal</i>	17	21	38
<i>Proximal</i>	17	20	37
<i>Complete</i>	11	96	107
<i>Fragment</i>		7	7
<i>Total</i>	69	182	251

Table 58: Ust'-Kanskaya, layer 4. Breakage.

- Size

The average flake is 46 x 34 x 11 mm (Figure 75), while a Levallois flake is taller, wider and thinner (55 x 36 x 8 mm). Blades are the tallest, with mean measurements of 59 x 27 x 8 mm.

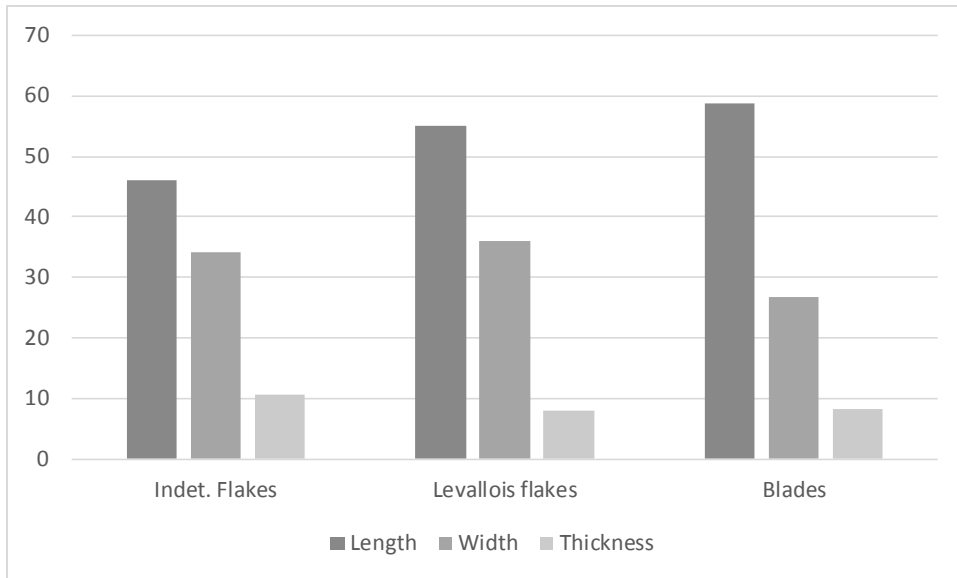


Figure 75: Ust'-Kanskaya, layer 4. Mean measurements of the products.

- Dorsal scar pattern

More than half the products present a unidirectional parallel pattern (Table 59); however the Levallois blanks are mainly convergent, which is consistent with the fact that they are mostly points.

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Unidirectional parallel</i>	7	4	41	4	74	130
<i>Unidirectional convergent</i>	13	1	5		14	33
<i>Bidirectional parallel</i>		2	6		11	19
<i>Bidirectional orthogonal</i>			1		21	22
<i>Centripetal</i>	2				7	9
<i>Multidirectional</i>			1		15	16
<i>Cordal</i>					6	6
<i>Cortical</i>		1	1		8	10
<i>Indet.</i>					6	6
Total	22	8	55	4	162	251

Table 59: Ust'-Kanskaya, layer 4. Dorsal scar pattern.

- Platform preparation

Most of the platforms are unprepared, although half of the Levallois products present faceted or dihedral platforms (Table 60).

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Plain</i>	8	3	21	1	84	117
<i>Dihedral</i>	4		1		4	9
<i>Facetted</i>	8		6		6	20
<i>Punctual</i>			1	2	2	5
<i>Cortical</i>		1	4		13	18
<i>Broken</i>	1	1	1		8	11
<i>ND</i>	1	3	21	1	45	71
<i>Total</i>	22	8	55	4	162	251

Table 60: Ust'-Kanskaya, layer 4. Platform preparation.

- Morphologies

The artefacts are mostly quadrangular, with a straight profile and either a triangular or trapezoidal cross-section (Table 61, Table 62, and Table 63).

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Quadrangular</i>	12	5	45	4	97	163
<i>Triangular</i>	10	3	10		62	85
<i>Oval</i>					1	1
<i>Semi-circular</i>					2	2
<i>Total</i>	2	8	55	4	162	251

Table 61: Ust'-Kanskaya, layer 4. Product shape.

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Straight</i>	18	7	51	3	132	211
<i>Concave</i>	4	1	4	1	18	28
<i>Convex</i>					10	10
<i>Sinuuous</i>					2	2
<i>Total</i>	22	8	55	4	162	251

Table 62: Ust'-Kanskaya, layer 4. Product profile.

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Triangular</i>	2	3	25	3	82	115
<i>Trapezoidal</i>	21	3	29	1	58	112
<i>Semi-circular</i>		1	1		7	9
<i>Rectangular</i>		1			13	14
<i>Indet.</i>					1	1
<i>Total</i>	23	8	55	4	162	251

Table 63: Ust'-Kanskaya, layer 4. Product cross-section.

4.1.2.7.3 Transformed products

The transformed products represent 14% of the blanks (n=34). The supports are mostly undifferentiated, with the exception of 7 retouched blades, and a partially retouched Levallois point. The burins are not manufactured on blades, but on two indeterminate flakes and a *débordant* flake. Denticulate are the most common tool type (Table 64), followed by retouched blades and scrapers.

The tools rarely show more than one episode of retouch, which is mostly total, direct, continuous, scaled, semi-abrupt or acute, and long or marginal.

	<i>Nb</i>
<i>Scraper</i>	6
<i>Simple</i>	2
<i>Double</i>	4
<i>Retouched blade</i>	7
<i>Notch</i>	2
<i>Denticulate</i>	9
<i>Backed Knife</i>	1
<i>Burin</i>	3
<i>Partially retouched flake</i>	6
<i>Indet.</i>	2
<i>Total</i>	36

Table 64: Ust'-Kanskaya, layer 4. Types of tools.

4.1.2.8 Layer 3

4.1.2.8.1 Reduction sequences

Eighteen cores have been identified in this layer (Table 65). They are mainly manufactured on pebbles. Most of them (n=14) belong to low predetermination methods, with one to three flaking surfaces.

<i>Method</i>	<i>Mode</i>	<i>Matrix</i>	<i>Nb</i>
<i>Levallois</i>	Unidirectional parallel	Pebble	1
		Flake	1
<i>Blade core?</i>	Bidirectional parallel?	Indet	1
<i>Lamellar</i>	Unidirectional parallel	Pebble	1
<i>Low Predetermination</i>	1 FS	Pebble	3
		Flake	1
		Indet	1
	2 FS	Nodule	2
		Pebble	4
		Flake	1
		Indet.	1
3 FS	Nodule	1	
<i>Total</i>			18

Table 65: Ust'-Kanskaya, layer 3. Cores.

The bladelet core is bidirectional (Figure 76): a short sequence of at least two removals was carried out at the intersection of the dorsal and ventral surface of a fragmented flake, before attempting to switch platforms, which resulted only in two short hinged removals.

We found a fragment of a probable bidirectional laminar volumetric core. Unfortunately its state of conservation does not allow us to precise the reduction process used.

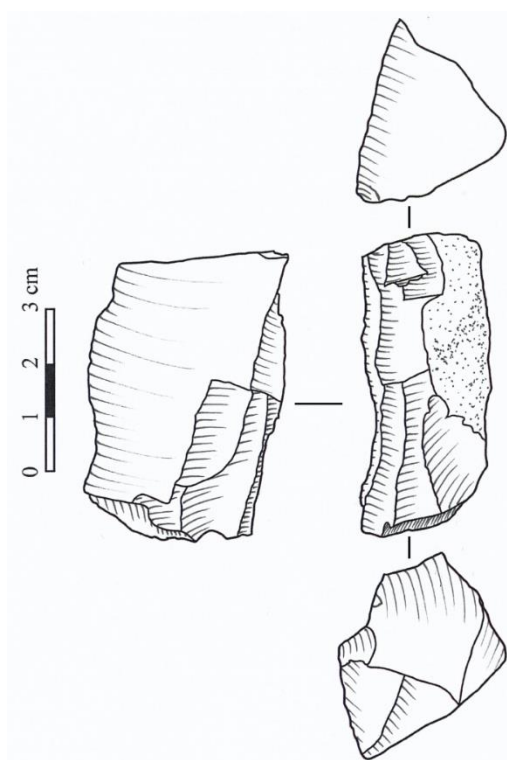


Figure 76: Ust'-Kanskaya, layer 3. Lamellar core.

The Levallois reduction

The Levallois cores, made out of dyke and sandstone, are unidirectional recurrent parallel. At the stage when the cores have been discarded, the scars indicate that the intended products were short blades or rectangular flakes. It is highly plausible that in the earlier stages of reduction, these cores were used to produce longer blades consistent with the archaeological record.

- UK99.7/30.23.3c

This core was produced on a pebble (Figure 77). It opposes two hierarchical surfaces. The negatives on the striking platform show that it was used as a flaking surface earlier in the sequence, for the removal of elongated blanks. Short flakes were then removed orthogonally, with a more secant angle, to shape the surface as a striking platform. On the flaking surface, we can distinguish the unidirectional removals of at least four predetermined, elongated flakes, the fifth being hinged.

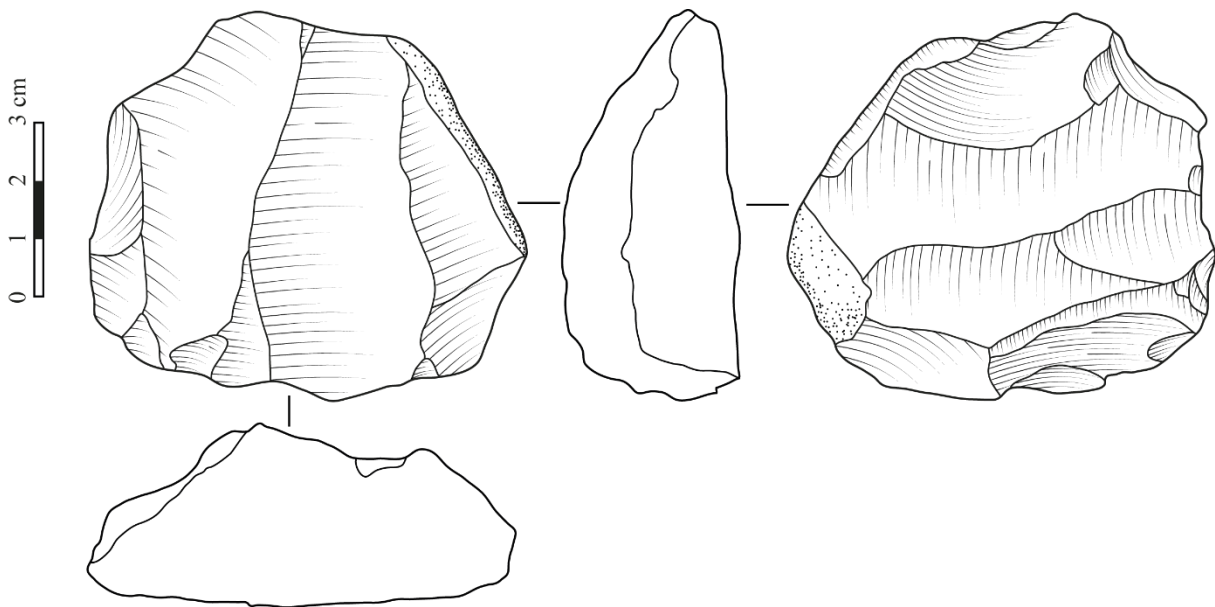


Figure 77: Ust'-Kanskaya, layer 3. UK99.7/30.23.3c.

- UK99.9/30.48.3d

This core was produced on a flake. It opposes two hierarchical surfaces. The striking platform, on the ventral surface of the original flake, was prepared by a series of cordal and centripetal, secant removals. The flaking surface illustrates first a series of unidirectional removals, to shape the lateral convexity, then a series of orthogonal, unidirectional removals, which are the sought-after products.

4.1.2.8.2 Production

The production (n=588) is dominated by flakes (n=337), but blades are numerous (n=242). Some bladelets have also been identified (n=9). Most of the artefacts do not bear residual cortex (n=423), or less than a quarter of the dorsal surface is covered (n=91).



Figure 78: Ust'-Kanskaya, layer 3. Levallois points.

The Levallois production is composed of eighteen Levallois flakes and forty Levallois points, as well as one maintenance flake (Figure 78, Figure 79). If no blade can undoubtedly be linked

to the Levallois reduction sequence, most of them (n=174) could be produced either by a Levallois or a volumetric method.

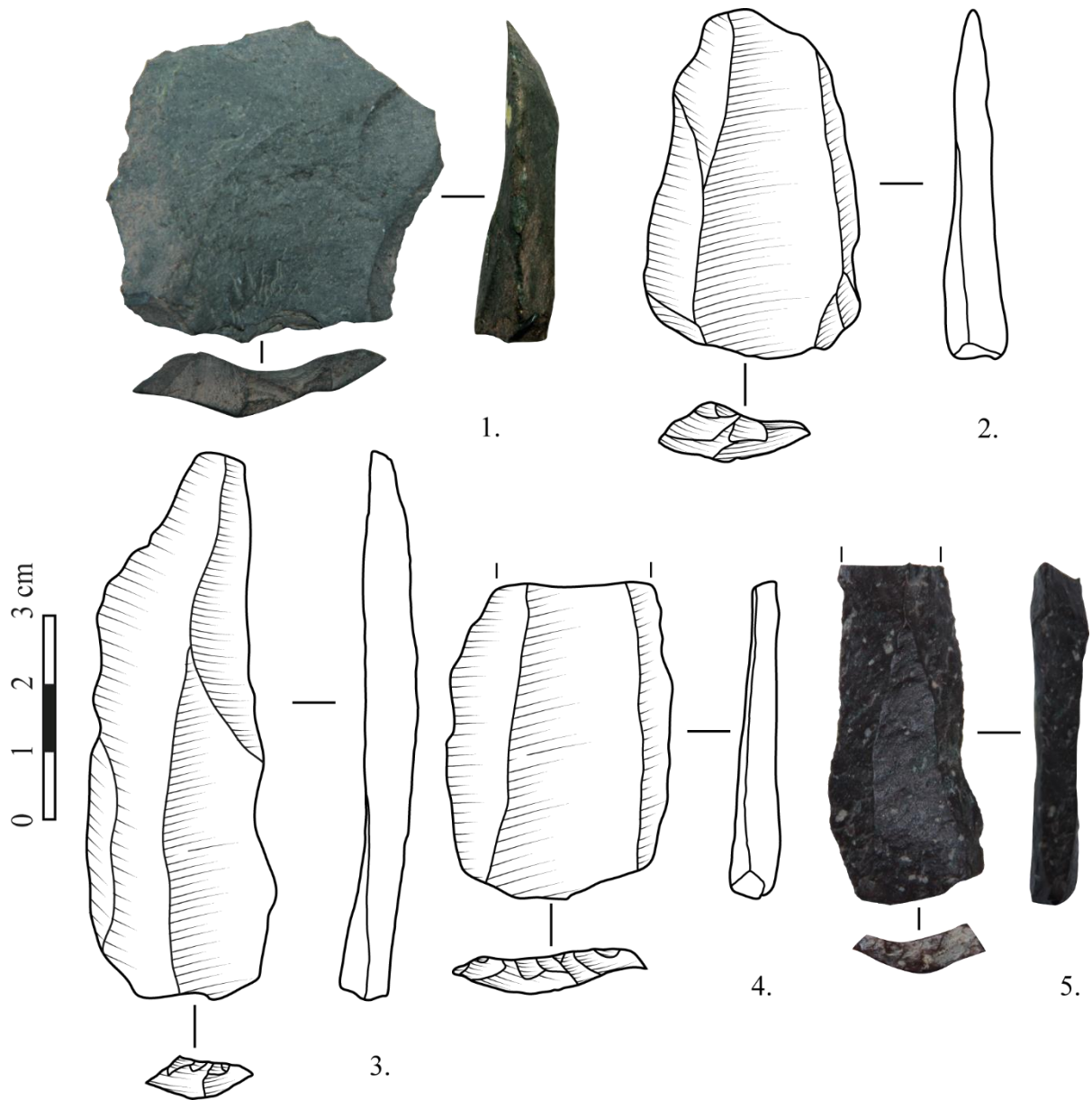


Figure 79: Ust'-Kanskaya, layer 3. Levallois flakes (1, 2), Levallois blades (3, 4, 5).

- Breakage

About half the assemblage is fragmented, but the rate reaches 4/5th for the blades and bladelets (Table 66).

	Blades	Flakes	Total
<i>Distal</i>	35	49	84
<i>Mesio-distal</i>	27	12	39
<i>Mesial</i>	49	12	61
<i>Mesio-proximal</i>	55	44	99
<i>Proximal</i>	31	31	62
<i>Complete</i>	51	173	224
<i>Fragment</i>	3	16	19
<i>Total</i>	251	337	588

Table 66: *Ust'-Kanskaya, layer 3. Breakage.*

- Size

The average flake is 46 x 33 x 10 mm (Figure 80); the Levallois flakes are longer and wider, at 55 x 37 x 8 mm, and the blades long and thin (66 x 25 x 8 mm).

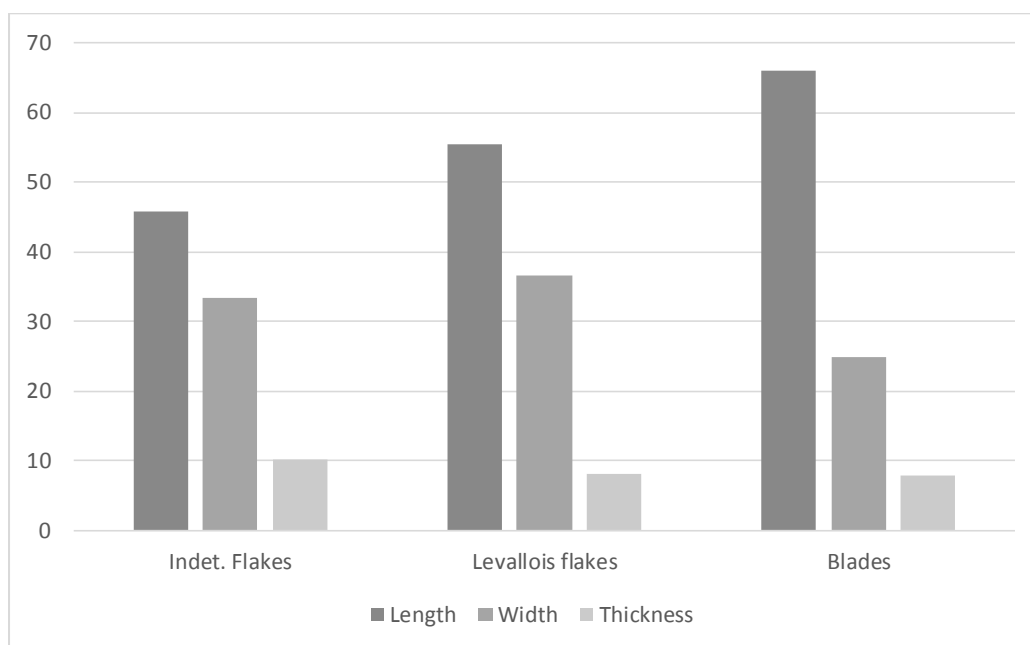


Figure 80: *Ust'-Kanskaya, layer 3. Mean measurements of the products.*

- Dorsal scar pattern

The unidirectional parallel reduction dominates the assemblages with more than half the total of products (Table 67). The Levallois products, dominated by points, display a majority of unidirectional convergent patterns.

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Unidirectional parallel</i>	9	6	141	6	183	345
<i>Unidirectional convergent</i>	47		9		24	80
<i>Bidirectional parallel</i>	1	4	17	1	41	64
<i>Bidirectional orthogonal</i>	2	1	6		38	47
<i>Centripetal</i>					7	7
<i>Multidirectional</i>		1			14	15
<i>Cordal</i>					6	6
<i>Cortical</i>					9	9
<i>Indet</i>			1		14	15
Total	59	12	174	7	336	588

Table 67: Ust'-Kanskaya, layer 3. Dorsal scar pattern.

- Platform preparation

Most of the products present an unprepared platform (Table 68), even the blades. However, the Levallois products platforms are mainly faceted.

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Plain</i>	15	6	53	1	150	225
<i>Dihedral</i>	9		7		15	31
<i>Facetted</i>	26		25	1	12	64
<i>Punctual</i>		2	2	2	7	13
<i>Cortical</i>	1	1	2		29	33
<i>Missing</i>				1	6	7
<i>Broken</i>	1		4		6	11
<i>ND</i>	7	3	81	2	111	204
Total	59	12	174	7	336	588

Table 68: Ust'-Kanskaya, layer 3. Platform preparation.

- Morphologies

The average product is quadrangular (Table 69), with a straight profile (Table 70) and either a triangular or a trapezoidal cross-section (Table 71). However, triangular artefacts are common, and dominate the Levallois products.

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Quadrangular</i>	18	12	139	7	212	388
<i>Triangular</i>	41		35		112	188
<i>Oval</i>					2	2
<i>Semi-circular</i>					5	5
<i>Indet.</i>					5	5
<i>Total</i>	59	12	174	7	336	588

Table 69: Ust'-Kanskaya, layer 3. Product shape.

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Straight</i>	46	11	149	7	285	498
<i>Concave</i>	12	1	24		29	66
<i>Convex</i>	1		1		18	20
<i>Sinuuous</i>					3	3
<i>Indet.</i>					1	1
<i>Total</i>	59	12	174	7	336	588

Table 70: Ust'-Kanskaya, layer 3. Product profile.

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Triangular</i>	1	5	74	2	164	246
<i>Trapezoidal</i>	58	6	98	5	139	306
<i>Semi-circular</i>					11	11
<i>Rectangular</i>		1	2		20	23
<i>Indet.</i>					2	2
<i>Total</i>	59	12	174	7	336	588

Table 71: Ust'-Kanskaya, layer 3. Product cross-section.

4.1.2.8.3 Transformed products

The transformed products represent 12% of the flakes. The selection rate of predetermined blanks was quite high, as 28 blades and Levallois points were retouched (i.e. 41% of the tool kit). Upper Palaeolithic type tools are present, but scrapers are still numerous (Table 72). Most of the burins were made on blades (n = 11), the others on non-predetermined blanks (n = 8; Figure 81). Two endscrapers were identified, although both are fragmented and their support was not ascertainable.

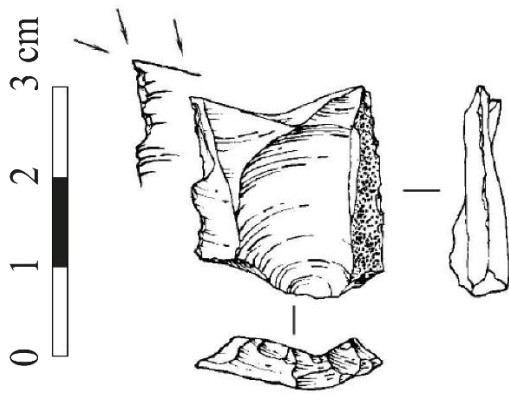


Figure 81: Ust'-Kanskaya, layer 3. Burin.

The retouch is usually continuous, scaled, semi-abrupt and forms a rectilinear edge. Its extent varies from marginal to invasive. Only six tools present more than one episode of retouch.

	<i>Nb</i>
<i>Scraper</i>	22
<i>Simple</i>	18
<i>Double</i>	4
<i>Endscraper</i>	2
<i>Retouched blade</i>	11
<i>Notch</i>	6
<i>Denticulate</i>	4
<i>Burin</i>	19
<i>Truncated flake</i>	1
<i>Bifacial tool</i>	1
<i>Indet.</i>	2
Total	69

Table 72: Ust'-Kanskaya, layer 3. Types of tools.

4.1.2.9 Layer 2

4.1.2.9.1 Reduction sequences

Only one core has been identified in this layer. It is manufactured on a pebble, and opposes two flaking surfaces, the main one being bidirectional orthogonal, with 9 removals, and the second one unidirectional parallel, with 3 removals.

4.1.2.9.2 Production

This level has yielded a much sparser collection than the underlying layers (n=172). Flakes dominate the assemblage (n=129), with a presence of blades (n=40) and some bladelets (n=3). The artefacts do not generally bear any residual cortex (n=108).

The Levallois production is composed of four Levallois flakes and two Levallois points (Figure 82).

- Breakage

Half of the assemblage is complete (Table 73), but only about a fourth of the blades.

	Blades	Flakes	Total
<i>Distal</i>	4	19	23
<i>Mesio-distal</i>	5		5
<i>Mesial</i>	6	7	13
<i>Mesio-proximal</i>	7	20	27
<i>Proximal</i>	6	4	10
<i>Fragment</i>	3	4	7
<i>Complete</i>	12	74	86
<i>Indet.</i>		1	1
<i>Total</i>	43	129	172

Table 73: Ust'-Kanskaya, layer 2. Breakage.

- Size

The average flake is 40 x 31 x 10 mm (Figure 83); Levallois products are scarce in this level (n=6), and all the flakes are mesio-proximal fragments. Their dimensions are 25 x 5 mm, 25 x 7 mm, 49 x 8 mm and 37 x 11 mm. The two Levallois points are complete, and are respectively 66 x 60 x 17 mm and 59 x 56 x 15mm. The blades on average measure 65 x 23 x 7 mm.

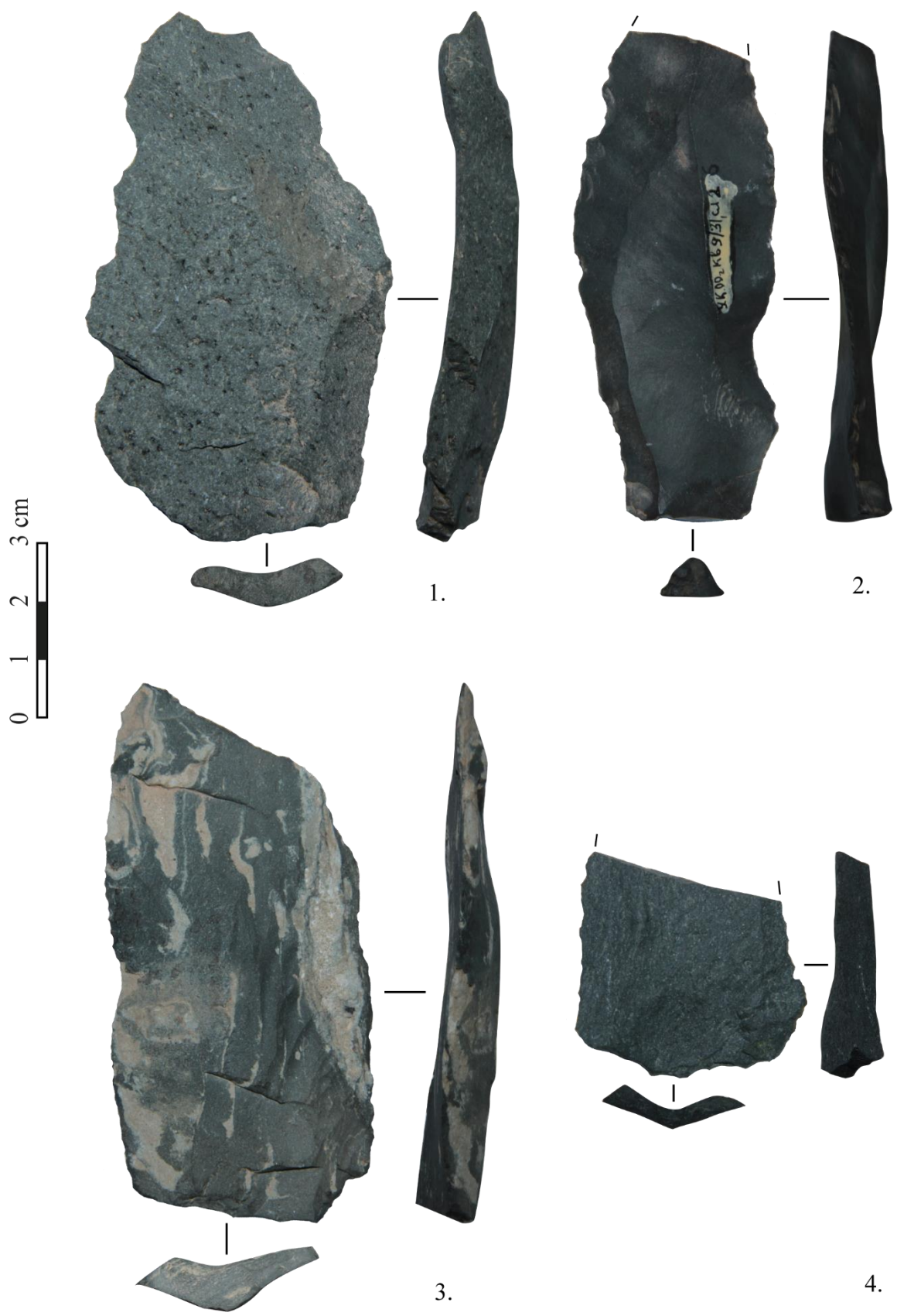


Figure 82: Ust'-Kanskaya, layer 2. Levallois flakes (1, 3), blades (2, 4).

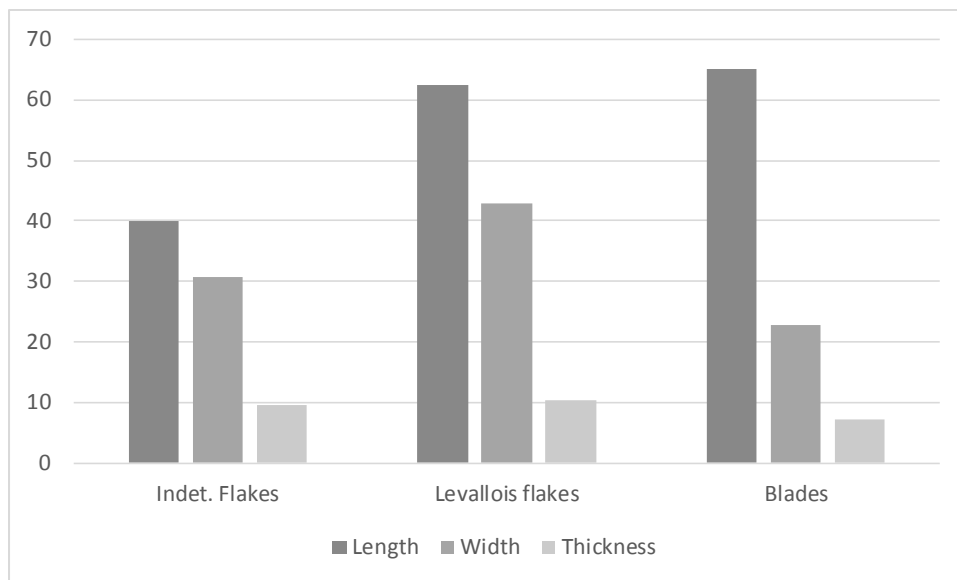


Figure 83: Ust'-Kanskaya, layer 2. Mean measurements of the products.

- Dorsal scar pattern

Most of the products present a unidirectional parallel scar pattern (Table 74). It is especially prevalent amongst the blades, with only one bidirectional laminar blank.

	Levallois	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Unidirectional parallel</i>	1	26	2	68	97
<i>Unidirectional convergent</i>	3	3		5	11
<i>Bidirectional parallel</i>				9	9
<i>Bidirectional orthogonal</i>		1		25	26
<i>Centripetal</i>	2			2	4
<i>Multidirectional</i>				5	5
<i>Cordal</i>		1		4	5
<i>Cortical</i>				7	7
<i>Indet</i>				8	8
Total	6	31	2	133	172

Table 74: Ust'-Kanskaya, layer 2. Dorsal scar pattern.

- Platform preparation

The platforms are unprepared at 71% (Table 75); however, we can note that a third of the indeterminate blades present a faceted platform, which may link them to the Levallois reduction sequence.

	Levallois	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Plain</i>	3	9	1	74	87
<i>Dihedral</i>				2	2
<i>Facetted</i>	3	5		4	12
<i>Punctual</i>				4	4
<i>Cortical</i>		1		9	10
<i>Broken</i>		1		6	7
<i>ND</i>		15	1	34	50
<i>Total</i>	6	31	2	133	172

Table 75: Ust'-Kanskaya, layer 2. Platform preparation.

- Morphologies

The average flake is quadrangular, with a straight profile and a triangular cross-section (Table 76, Table 77, and Table 78). Triangular shapes and trapezoidal cross-sections are also common.

	Levallois	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Quadrangular</i>	5	22	2	76	105
<i>Triangular</i>	1	9		53	63
<i>Oval</i>				1	1
<i>Indet.</i>				3	3
<i>Total</i>	6	31	2	133	172

Table 76: Ust'-Kanskaya, layer 2. Product shape.

	Levallois	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Straight</i>	5	25	2	109	141
<i>Concave</i>	1	5		20	26
<i>Convex</i>		1		4	5
<i>Total</i>	6	31	2	133	172

Table 77: Ust'-Kanskaya, layer 2. Product profile.

	Levallois	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Triangular</i>	2	16	2	66	86
<i>Trapezoidal</i>	4	15		47	66
<i>Semi-circular</i>				9	9
<i>Rectangular</i>				10	10
<i>Indet.</i>				1	1
<i>Total</i>	6	31	2	133	172

Table 78: Ust'-Kanskaya, layer 2. Product cross-section.

4.1.2.9.3 Transformed products

The transformed products represent 10% of the blanks (Table 79). Simple scrapers are the most numerous tools. Three blades have been selected as a support, one as a burin, one as a truncated blade and the last one as a retouched blade.

The retouch is usually direct, total, continuous, scaled, and forms a rectilinear edge and delineation. Its extent can be short or long, and the angle semi-abrupt or low.

	<i>Nb</i>
<i>Scraper</i>	9
<i>Simple</i>	8
<i>Double</i>	1
<i>Retouched blade</i>	1
<i>Notch</i>	1
<i>Burin</i>	4
<i>Truncated blade</i>	1
<i>Truncated flake</i>	1
<i>Partially retouched flake</i>	1
<i>Total</i>	18

Table 79: Ust'-Kanskaya, layer 2. Types of tools.

4.1.2.10 Layer 1

4.1.2.10.1 Reduction sequences

This layer didn't yield any core.

4.1.2.10.2 Production

The topmost layer has yielded only 15 artefacts, 3 of them blades. They either present no residual cortex (n=10) or less than 25% of their surface is covered (n=4); only one blade is mostly cortical.

The Levallois production is composed of a Levallois flake.

- Breakage

Two thirds of the assemblage are fragmentary, including the 3 blades (Table 80).

	Blades	Flakes	Total
<i>Distal</i>		4	4
<i>Mesial</i>	2	1	3
<i>Mesio-proximal</i>	1	1	2
<i>Fragment</i>		1	1
<i>Complete</i>		5	5
<i>Total</i>	3	12	15

Table 80: Ust'-Kanskaya, layer 1. Breakage.

- Size

Only 5 products are complete, thus it is not possible to observe any trend on artefacts' lengths in layer 1. One of these products is a Levallois flake, which is 56 x 30 x 8 mm (Figure 84). The three blades are respectively 29, 18 and 16 mm wide and 8, 11 and 4 mm thick. The average flake is 35 x 27 x 9 mm.

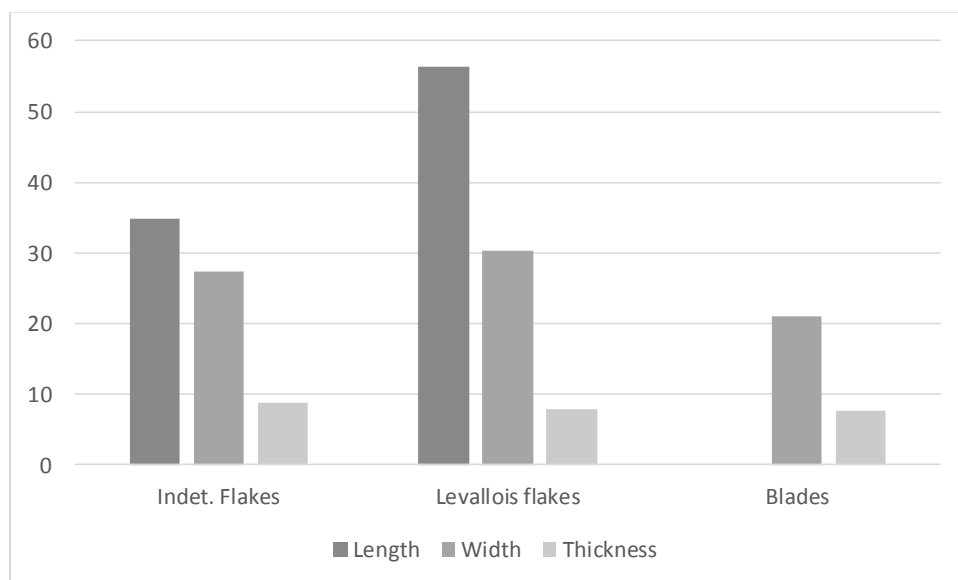


Figure 84: Ust'-Kanskaya, layer 1. Mean measurements of the products.

- Dorsal scar pattern

The products present mainly unidirectional parallel patterns (Table 81), while the Levallois flake displays scars that indicate a unidirectional convergent reduction.

	Levallois	Volumetric laminar	Blades (ind.)	Indet./low predet.	Total
<i>Unidirectional parallel</i>		1	2	7	10
<i>Unidirectional convergent</i>	1				1
<i>Bidirectional parallel</i>				2	2
<i>Bidirectional orthogonal</i>				1	1
<i>Indet</i>				1	1
<i>Total</i>	1	1	2	11	15

Table 81: Ust'-Kanskaya, layer 1. Dorsal scar pattern.

- Platform preparation

All the platforms are unprepared (Table 82).

	Levallois	Volumetric laminar	Blades (ind.)	Indet./low predet.	Total
<i>Plain</i>	1	1		5	7
<i>ND</i>			2	6	8
<i>Total</i>	1	1	2	11	251

Table 82: Ust'-Kanskaya, layer 1. Platform preparation.

- Morphologies

The average product is quadrangular or triangular, with a straight profile and a triangular cross-section (Table 83, Table 84, and Table 85); trapezoidal cross-sections are present as well.

	Levallois	Volumetric laminar	Blades (ind.)	Indet./low predet.	Total
<i>Quadrangular</i>	1	1	2	4	8
<i>Triangular</i>				6	6
<i>Semi-circular</i>				1	1
<i>Total</i>	1	1	2	11	15

Table 83: Ust'-Kanskaya, layer 1. Product shape.

	Levallois	Volumetric laminar	Blades (ind.)	Indet./low predet.	Total
<i>Straight</i>	1	1	2	11	15
<i>Total</i>	1	1	2	11	15

Table 84: Ust'-Kanskaya, layer 1. Product profile.

	Levallois	Volumetric laminar	Blades (ind.)	Indet./low predet.	Total
<i>Triangular</i>		1	1	7	9
<i>Trapezoidal</i>	1		1	3	5
<i>Rectangular</i>				1	1
<i>Total</i>	1	1	2	11	15

Table 85: Ust'-Kanskaya, layer 1. Product cross-section.

4.1.2.10.3 Transformed products

The only transformed product is a mesio-proximal fragment of flake with a direct, continuous, scaled, short retouch on its right side.

4.1.3 Summary

4.1.3.1 Chaînes opératoires

As we saw, we have identified in the sequence both high-predetermination and low-predetermination knapping methods. The high-predetermination methods associate Levallois and volumetric blade and bladelet technologies, while low-predetermination methods group various types of reduction sequences, from 1 to 3 flaking surfaces – exceptionally 4 – and are usually not extensively flaked. Discoïd cores do not belong to any of these categories, as they display a certain level of predetermination of the convexities and ridges, but not as high as Levallois and blade/bladelet productions.

When comparing the mean measurements of the cores, we note that the low predetermination types are on the whole bigger, with a higher standard derivation and coefficient of variation for all dimensions (Table 86), thus a greater variability.

	<i>Levallois</i>				<i>Low predetermination</i>			
	Mean	σ	C.V.	Nb	Mean	σ	C.V.	Nb
<i>L (mm)</i>	59.7	10.8	18.1	14	70.8	20.1	28.4	61
<i>W (mm)</i>	54.9	14.0	25.5	14	59.2	15.4	25.9	61
<i>T (mm)</i>	23.3	8.3	35.5	14	37.3	14.6	39.2	61

Table 86: *Ust'-Kanskaya*. Mean, standard derivation and coefficient of variation of the measurements of the cores.

The scatterplot of the length/width measurements confirms the greater variability of the low predetermination cores compared to the Levallois cores (Figure 85). We can see that the extreme measurements all correspond to low predetermination cores. Levallois cores are also quite variable in size, with a group of four smaller ones, all extremely reduced centripetal cores, and another group of various sizes.

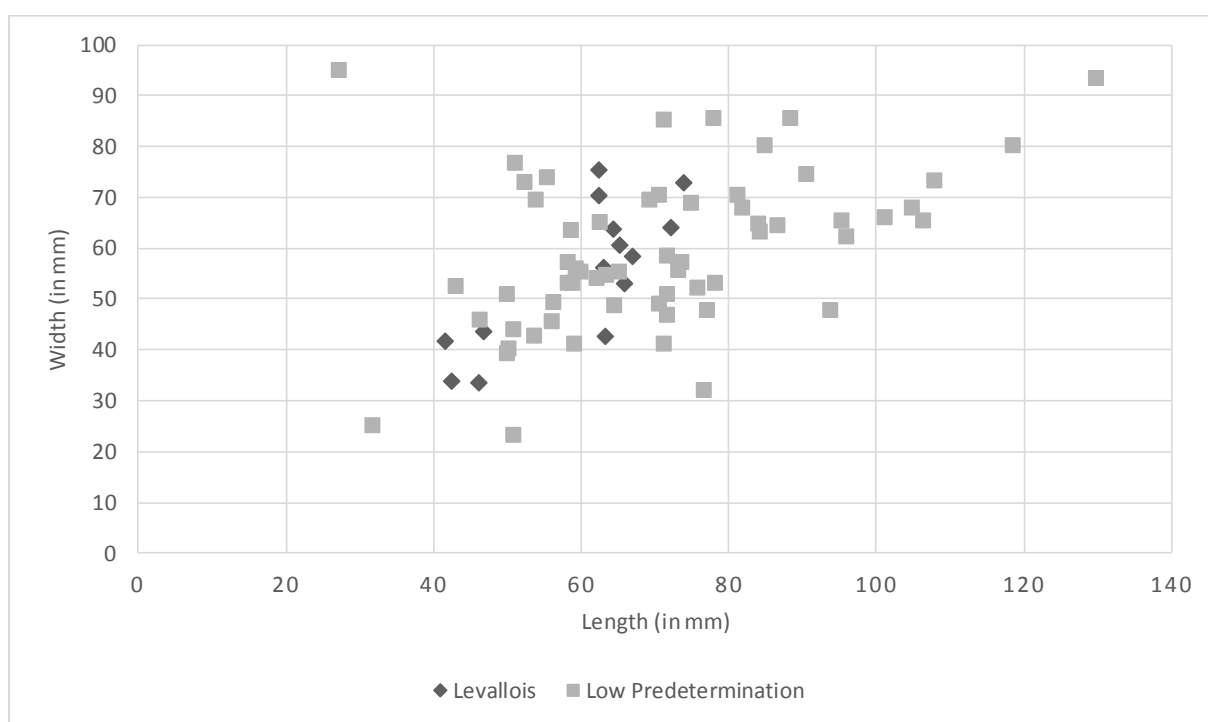


Figure 85: *Ust'-Kanskaya*. Repartition of the cores according to their length and width.

These low predetermination cores produced a variety of flakes, but they usually present high ridges and a platform with a very open angle.

4.1.3.1.1 The Levallois chaîne opératoire

In the total assemblage, we identified different types of Levallois reduction sequences, either on the cores or on the products: recurrent centripetal, unidirectional parallel or convergent, preferential... The information gathered on the cores seemed to express a chronological variability, with recurrent centripetal Levallois scheme in the layers 9 to 5, and unidirectional

parallel in layer 3. However, when taking into account the data provided by the products, a greater uniformity seems to prevail. A reconstruction of the Levallois *chaînes opératoires* implemented in the different layers should thus mirror these differences. Only layers 3 and 5 yielded enough material to allow these reconstructions.

- Layer 5

The extreme stage of reduction visible on the cores makes the interpretation of the initiation phases impossible. However, stages of management of the cores are documented by 45 débordant flakes, and 22 maintenance flakes. While the former shows a reconfiguration of the core implemented by its rim, the latter are centered flakes, usually quite wide with a thick butt, often displaying hinges on their upper face, that were removed to clean and reorganize the convexity of the flaking surface. The débordant flakes present for the most part an oblique back (n = 34) – including 25 “débordant à dos limité” flakes (Meignen, 1993) – which shows that the reorganization of the convexities was done through cordal direction knapping.

The end products to be obtained are blades, flakes and points. More than 50% of them are broken (75% for the blades), though it seems that it was not intentional, but due to post-depositional processes.

The scars on the blades indicates a unidirectional reduction pattern for a great majority of them. The platforms are generally plain, yet the striking platform was not unprepared. In some cases we can see the beginning of a faceted preparation, but it does not extend to the surface that was actually struck, probably to soften the overhang. The bulbs are characteristic of direct percussion with a hard hammer.

The Levallois flakes are generally quadrangular, consistently with the unidirectional parallel mode carried out for their production. The platforms are more frequently faceted than for the blades. This may be the result of a less pronounced distal convexity on the core, which necessitates more precision on the impact point.

Levallois points are also present, though less numerous. They are issued from a unidirectional convergent mode that is not documented by the cores.

The disparity between the cores, mostly centripetal, and the products, mostly uni- and bidirectional parallel, may be due to a shift in the reduction sequence from a parallel reduction to a centripetal reduction throughout the knapping process. The repartition of the products in size classes according to their scar pattern seems consistent with this hypothesis (Figure 86).

However, no Levallois product consistent with the small size of the cores was identified in the assemblage, even among the blanks presenting a centripetal scar pattern. It seems that this stage of the reduction sequence is absent from the assemblage.

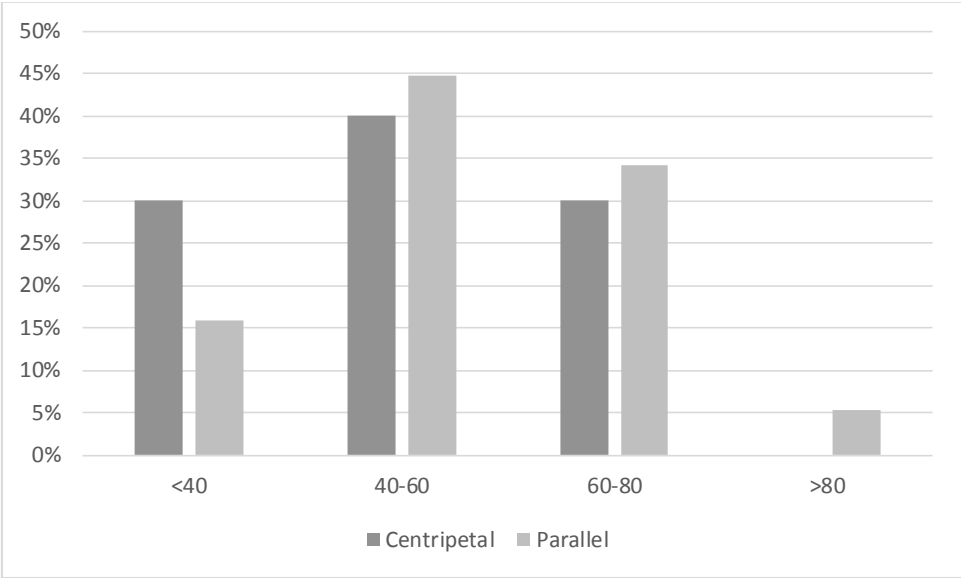


Figure 86: Ust'-Kanskaya, layer 5. Repartition of the Levallois products according to their size class and scar patterns.

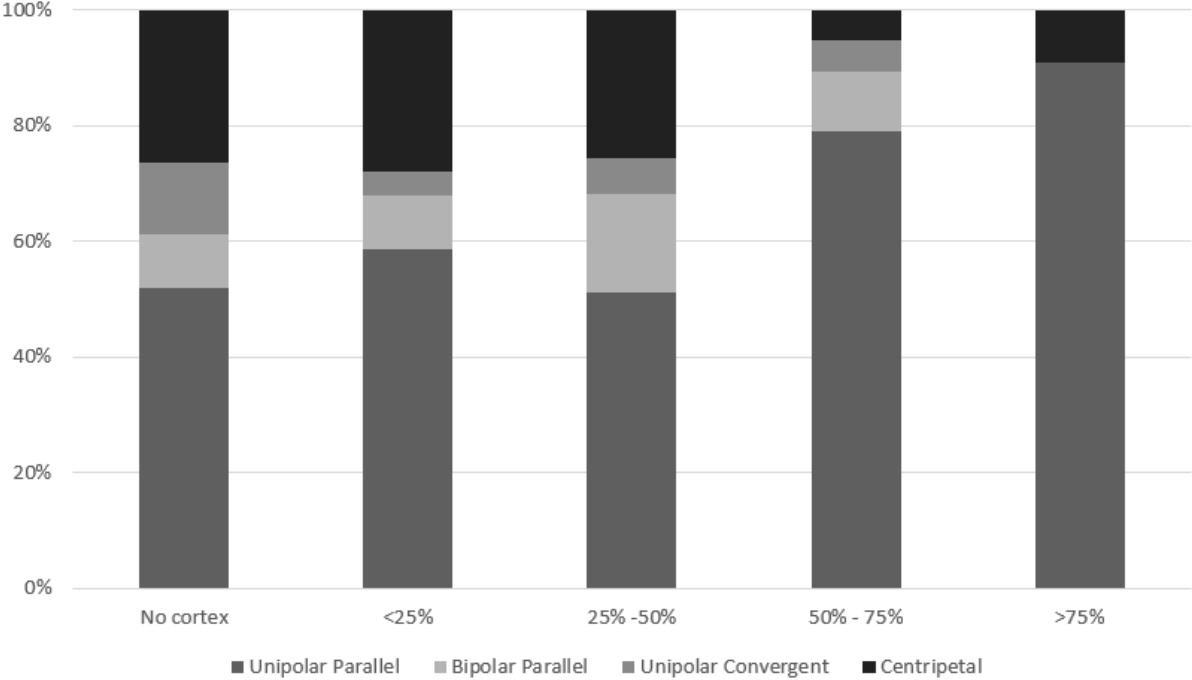


Figure 87: Ust'-Kanskaya, layer 5. Repartition of the Levallois products scar patterns by classes of percentage of cortex.

Even more than size, the presence and percentage of cortex on the dorsal surface is an indicator of the stage of reduction (Dibble, 1995); in our assemblage, we see that the centripetal products are more represented amongst the more non-cortical blanks, and the uni-bidirectional products

amongst the more cortical blanks (Figure 87), which seems congruent with a shift in the reduction sequence.

- Layer 3

The Levallois cores are recurrent parallel, one bidirectional and the other one unidirectional. Their reduction is less extensive than the recurrent centripetal cores of layer 5, consequently they are bigger (mean of 67 x 70 x 33 mm). At the stage when the cores have been discarded, the scars indicate that the intended products were short blades or rectangular flakes. It is highly plausible that in the earlier stages of reduction, these cores were used to produce longer blades consistent with the archaeological record.

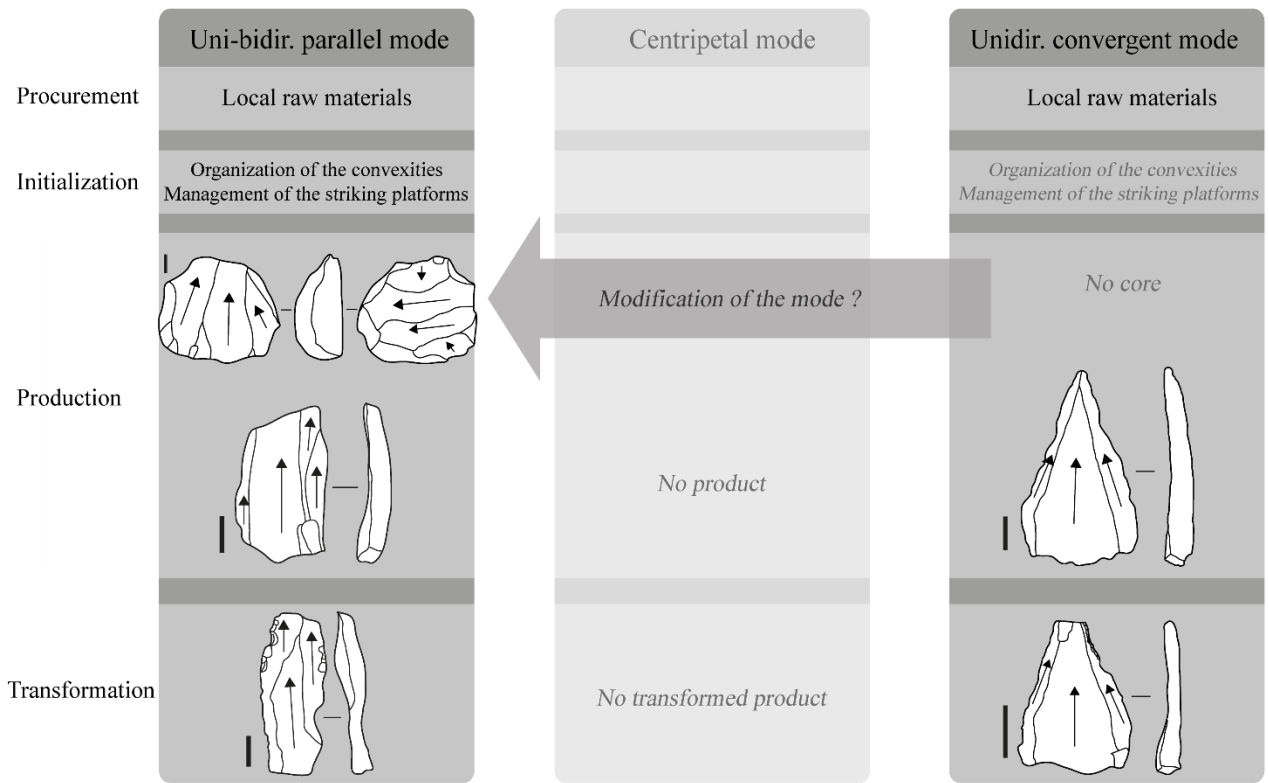
Stages of reorganization of the convexities of the cores are attested by 25 débordant flakes, half presenting a longitudinal back (n = 13), the other half consisting of “débordant à dos limité” flakes. Only 3 maintenance flakes have been identified.

Unidirectional reduction, parallel and convergent, is by far the most documented by the products, whether they be blades, flakes or points. As in layer 5, the platforms of the blades are generally plain, while the flakes and points present more faceted platforms. The frequency of faceted ($\chi^2=(1) 3.57, p=0.06$) and plain ($\chi^2=(1) 0.16, p=0.69$) platforms do not differ significantly from one assemblage to the other, but show some variability. Contrary to layer 5, points are twice as numerous as flakes.

- Comparison between the two *chaînes opératoires*

It seems that the techno-typological differences between layers 5 and 3, however sensible, are subtle. In terms of presence, the same reduction sequences characterize the two layers: Levallois, blade and bladelet technology, co-occurring with expedient removals out of pebble cores. It is in smaller details that layers 5 and 3 differ, as the comparison between the Levallois reduction sequences implemented in each layer shows (Figure 88). While the cores in layer 5 document a recurrent centripetal reduction, led to an extreme stage, the two cores in layer 3 are uni-bidirectional parallel, and less reduced. Thus the cores are more consistent with the products in layer 3 (mostly blade-like blanks or rectangular flakes) than in layer 5. This disparity between cores and products in layer 5, supported by the fact that the dimensions of the cores are much reduced, leads us to think that the pattern of reduction shifted from a uni-bidirectional parallel to a centripetal method throughout the reduction sequence, which is not the case in layer 3. Yet it would be imprudent to try to take the analysis further, for the number of cores in either of those layers is weak and does not allow drawing conclusions.

Levallois reduction sequences of layer 3



Levallois reduction sequences of layer 5

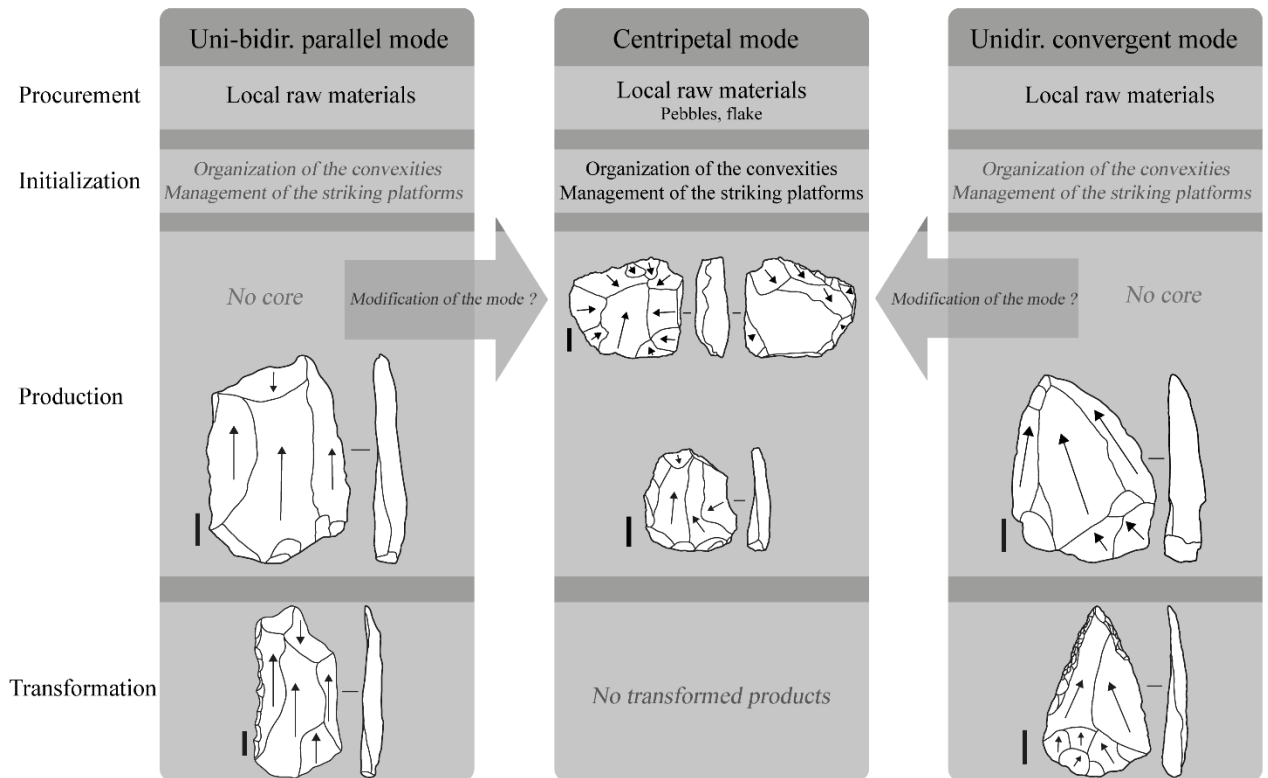


Figure 88: Ust'-Kanskaya. Levallois reduction sequences of layers 5 and 3.

Both in layers 5 and 3, the Levallois products outnumber the cores by far, with an output of 33 preferential products for one core in layer 5, and of 153 for one core in layer 3. The high degree of exhaustion of the cores in layer 5 is in agreement with these numbers, but it is still highly likely that we miss a certain amount of cores – in view of the extent of the excavation surface, it is probable that this is not a sampling bias. In addition, few traces of the initiation of the reduction sequence have been identified, as the number of cortical flakes is quite low. This could be the result of a first rough shaping of the raw material pebbles directly on the river bank, before bringing the raw materials up in the cave, maybe to ensure their quality.

4.1.3.1.2 The blade production

In layer 3, we found a fragment of a probable bidirectional laminar volumetric core. Unfortunately its state of conservation does not allow us to precise the reduction process used.

All of the blades identified on the site have not been obtained through the Levallois reduction sequence. A small number of them display volumetric features that are not relevant for this method. However, no technical flake (e.g. crests or core tablets) that could help us understand the scheme of production of those blades has been identified in either layer.

4.1.3.1.3 The bladelet production

Two bladelet cores have been identified, one in layer 5 and one in layer 3. They are both produced on fragments of thick blanks and not intensively reduced. The core from layer 5 is unidirectional, and the core from layer 3 bidirectional.

Some typological bladelets have been identified throughout the sequence: 3 in layer 5, 4 in layer 4, 7 in layer 3 and 2 in layer 2. They are all unidirectional, except a bidirectional one in layer 3. The only retouched bladelet, in layer 5, presents a direct, total, continuous, invasive semi-abrupt retouch on both sides.

If bladelets can be the intended artefact of a lamellar chaîne opératoire, it can also be a by-product of the Levallois reduction sequence, for the guide-ridges maintenance or for the preparation of the striking platform (Brenet, 2011; Vaissié, in prep.). They are here non diagnostic, and seem to not seem to be issued from a burin-core reduction.

4.1.3.2 Revision of the sequence

We noted earlier the contrasted abundance of archaeological remains in the different layers (Table 10). This undeniably makes the comparison between assemblages difficult, as they cannot bear the same significance.

In all the layers, we identify features usually considered as Middle Palaeolithic – Levallois products and/or cores, hard hammer percussion, scrapers dominating the toolkit⁹. Typologically, layer 3 presents tools that are mostly associated with Upper Palaeolithic: numerous burins and two endscrapers. However, layer 2 presents the same characteristics than the underlying assemblages – with a dominance of scrapers and a persistence of Levallois products – while it would be expected that the Upper Palaeolithic traits should become more prominent¹⁰. The increasing proportion of blades in upper layers could indicate an Upper Palaeolithic attribution, but they don't seem to differ technologically throughout the sequence. In the absence of absolute dates and of any other typical Upper Palaeolithic trait (ornaments, developed bladelet reduction sequences, bone industry...), the presence of UP-type tools isn't sufficient to claim layers 3 and upper as Upper Palaeolithic, as it was done before. The Upper Palaeolithic component of the assemblage is purely typological, and no modification of the technology implemented for the production of the material has been detected. Initial Upper Palaeolithic technological features, such as massive blades, neo-crests or burin-cores have not been identified in the sequence, and especially not in layers 5 and 4 that had been attributed as MP-UP transition. Moreover, the same type of Upper Palaeolithic tools can be found in the lowermost layers, which are clearly Middle Palaeolithic. These Upper Palaeolithic type elements could be an intricate feature of the Middle Palaeolithic of Ust'-Kanskaya, or, more likely, the result of intrusions of a more recent material through post-depositional processes.

⁹ Except for layers 8 and 7, dominated by retouched blades.

¹⁰ Layer 1 yielded only 15 artefacts, including one fragment of possible scraper.

4.2 DENISOVA

4.2.1 Raw materials

According to (Derevianko *et al.*, 2003), the raw materials used in the Central chamber span more than ten petrographic categories:

- Marls and marbles
- Siltstone
- Sandstone
- Gravelite
- Sedimentary rocks
- Aphyric effusive rocks
- Porphyric effusive rocks
- Jasperoids
- Hornfels
- Slate
- Quartz
- Granite
- Dike porphyrite

In Anoikin & Postnov (2005), the authors showed that the petrographic composition of analysed artefacts from the cave was absolutely identical to the pebble samples from the Anui and Karakol rivers, except one type of jasperoid that probably was from a more distant source. However, there was a selection of the raw materials according to their petrophysical characteristics, notably their clastic properties: aleurolites and volcanic rocks represent respectively 9.8% and 10.3% in the Karakol River and 10.4% and 11.4% in the Anui River, but 21% and 44.6% of Denisova's artefacts.

4.2.2 Technological study

This study focuses on material issued from the most ancient layers of the cave, *i.e.* layers 22 to 20 of the Central chamber and layers 15 and 14 of the Eastern gallery. Due to the great number of artefacts, and to the fact that a PhD student was already working on Denisova material at the time of the research (Kozlikin, 2017), we chose to sort the artefacts that could be linked to a Levallois-type reduction sequence, and restrict the study to this material (Table 87).

LAYER	20CC	21CC	22CC	14EG	15EG	Total*
Cores	1 (?)	(20)	(20)	(106)	(31)	1
<i>Levallois</i>	<i>1 (?)</i>					<i>1</i>
Flakes	42 (?)	(143)	3 (160)	9 (4209)	(1516)	54
<i>Maybe linked to Levallois</i>	23		3	6		32
<i>Levallois flakes and points</i>	3		(3)			3
<i>Blades</i>	16	(10)	(4)	3 (8)	(2)	19
Debris and fragments	(?)	(130)	(139)	(6476)	(2364)	1
Total	43 (908)	(293)	3 (319)	9 (10801)	(3913)	55

Table 87: Denisova. Composition of the assemblage. Between brackets, count coming from Derevianko et al., 2003 for the Central chamber (CC) and from Kozlikin, 2017 for the Eastern gallery (EG). * The total includes only the artefacts selected for this study.

4.2.2.1 Layer 22 (Central chamber)

In this layer, we identified only 3 artefacts that could be linked to a Levallois-like reduction sequence. Two of them are *débordant* flakes (one a pseudo-Levallois point). All of them are complete, with a plain striking platform, there is thus no faceting.

The two *débordant* flakes are 58.1 x 49.4 x 21.7 mm and 55.5 x 37.6 x 12 mm; the other flake is 75.7 x 49.8 x 23.7 mm. They all display different dorsal scar patterns: centripetal and unidirectional parallel for the *débordant* flakes, bidirectional orthogonal for the other.

The pseudo-Levallois point has been retouched on its right side. The retouch is direct, total, continuous, scaled and semi-abrupt, with a short extent.

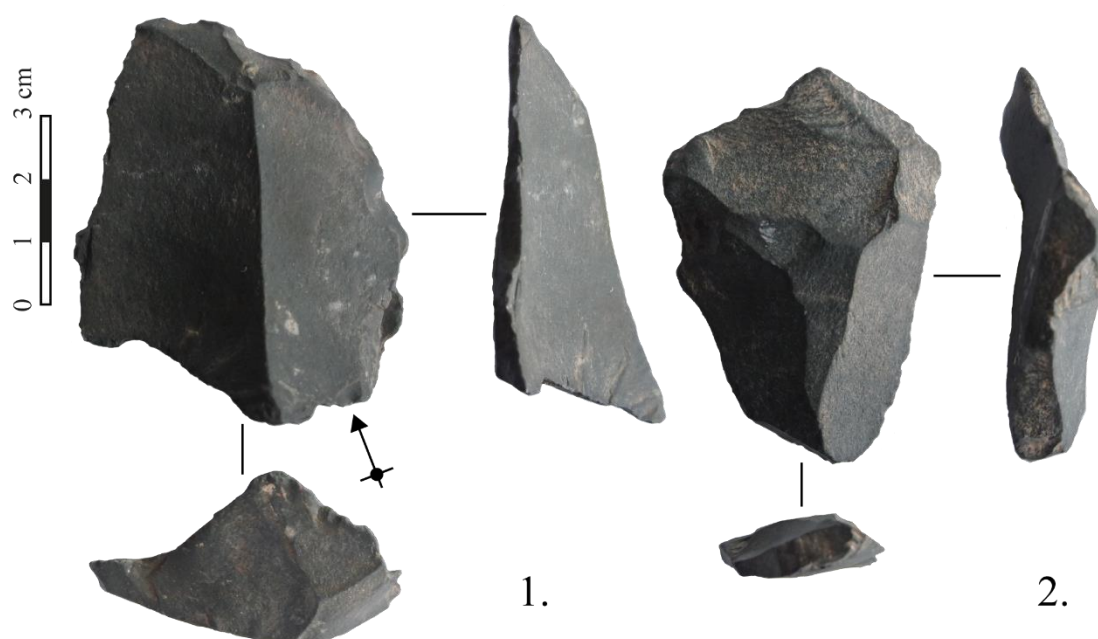


Figure 89: Denisova, layer 22CC. *Débordant* flakes.

4.2.2.2 Layer 21 (Central chamber)

This layer has not yielded any artefact that could be linked to a Levallois reduction sequence. The flakes and cores seemed to illustrate low-predetermined schemes of flaking, with thick, short flakes, most of them presenting a natural back, and roughly worked polyhedral cores.

4.2.2.3 Layer 20 (Central chamber)

Forty-three artefacts have been recognized as Levallois, or possibly linked to a Levallois reduction sequence.

4.2.2.3.1 Cores

One core has been identified as possibly Levallois (Figure 90). It is completely flaked, so its matrix is unknown. It opposes two surfaces, which both display a centripetal production. The back is prepared by a series of centripetal removals, with smaller, more precise removals on the edge of the ridge, corresponding to the actual striking platform for the production of flakes on the other surface. The flaking surface illustrates a series of centripetal removals, first subparallel, and then more secant along with the continuation of the reduction. We identify this core as a recurrent centripetal Levallois core, which is flaked more expediently as it becomes exhausted.

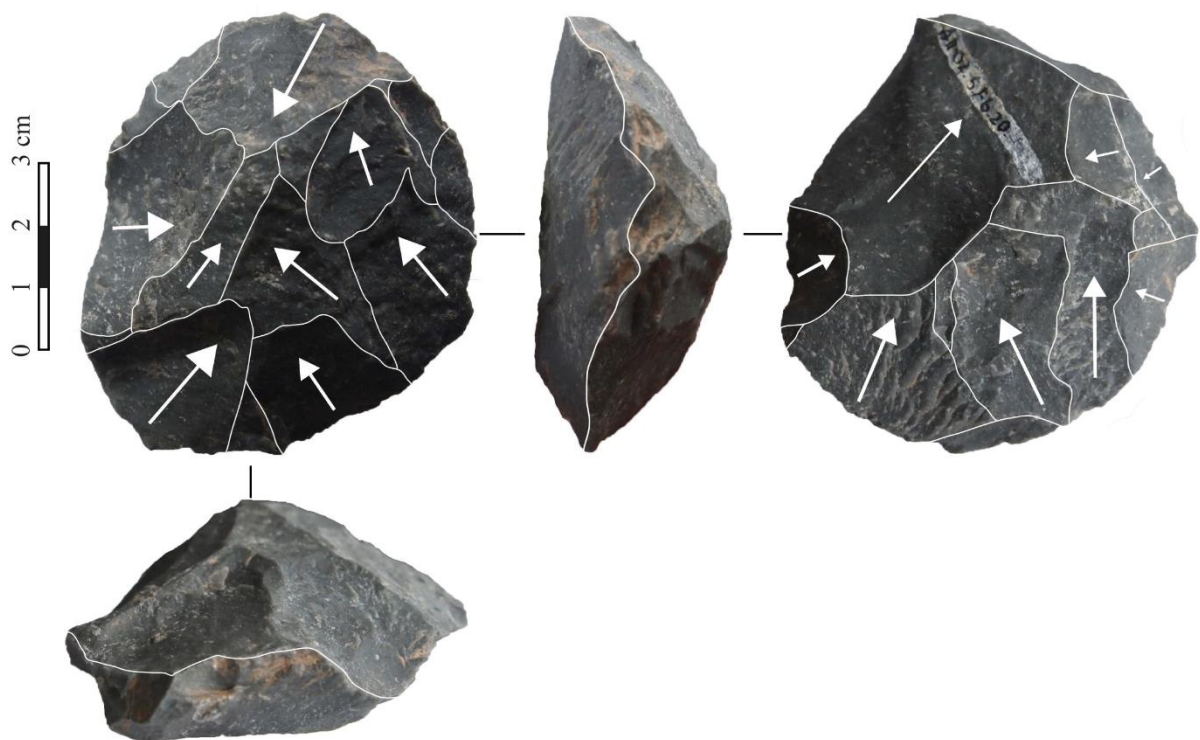


Figure 90: Denisova, layer 20CC. Centripetal Levallois core.

4.2.2.3.2 Production

The Levallois-linked production (n=42) is composed of flakes (n=26) and blades (n=16; Figure 91). The Levallois production is composed of 2 Levallois blades, 2 Levallois points, and a fragmented Levallois flake; 8 *débordant* flakes and 15 various flakes could be part of the Levallois reduction sequence, 7 of which being fragments of possible blades or predetermined flakes.

Most of the products do not bear residual cortex (n=34), and only 2 are more than half covered.

- Breakage

Only less than a third of the products are complete (Table 88).

	Blades	Flakes	Total
<i>Distal</i>	1	4	5
<i>Mesio-distal</i>	2		2
<i>Mesial</i>	3	1	4
<i>Mesio-proximal</i>	4	8	12
<i>Proximal</i>	3	2	5
<i>Fragment</i>		1	1
<i>Complete</i>	3	10	13
<i>Total</i>	16	26	42

Table 88: Denisova, layer 20CC. Breakage.

- Size

The average flake measures 63.2 x 40 x 11.3 mm (Figure 92); we can note that the complete Levallois flake is 82.6 x 33.9 x 14.4 mm and the complete Levallois point 59.7 x 33.5 x 5.1 mm. The blades are on average 32.9 wide and 8.9 mm thick. The three complete blades lengths are respectively 101.6 mm, 71.4 mm and 62.7 mm.



Figure 91: Denisova, layer 20CC. Blade.

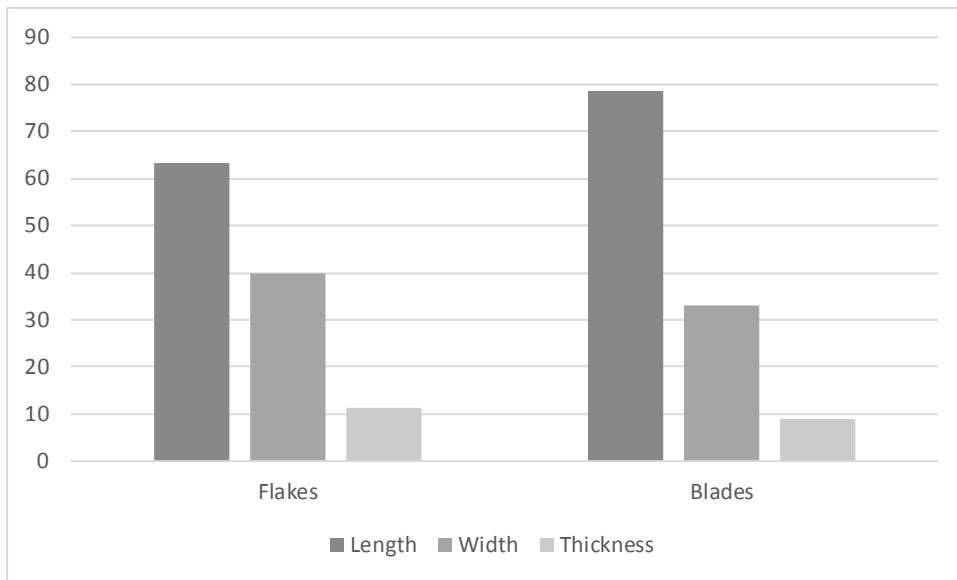


Figure 92: Denisova, layer 20CC. Mean measurements of the products.

- Dorsal scar pattern

Half the products present unidirectional parallel dorsal scar patterns (Table 89). The Levallois products are mainly unidirectional convergent, with two points and one of the blades.

	Levallois products	Other flakes	Blades (ind.)	Total
<i>Unidirectional parallel</i>	1	12	8	21
<i>Unidirectional convergent</i>	3	3	1	7
<i>Bidirectional parallel</i>			3	3
<i>Bidirectional orthogonal</i>		6	1	7
<i>Centripetal</i>	1	1	1	3
<i>Cordal</i>		1		1
Total	5	23	14	42

Table 89: Denisova, layer 20CC. Dorsal scar pattern.

- Platform preparation

The platforms are diverse, mainly plain, but also faceted, dihedral, punctual or cortical (Table 90). The Levallois products and blades present a majority of carefully prepared platforms, whether they are faceted or punctual.

	Levallois products	Other flakes	Blades (ind.)	Total
<i>Plain</i>	1	7	3	11

<i>Dihedral</i>	1	2		3
<i>Facetted</i>	2	2	4	8
<i>Punctual</i>		1	2	3
<i>Cortical</i>		5		5
<i>ND</i>	1	5	5	11
<i>Total</i>	5	23	14	42

Table 90: Denisova, layer 20CC. Platform preparation.

- Morphology

The objective of the reduction sequences was a quadrangular flake (Table 91), with a straight profile (Table 92) and a trapezoidal or triangular cross-section (Table 93).

	Levallois products	Other flakes	Blades (ind.)	Total
<i>Quadrangular</i>	3	15	13	31
<i>Triangular</i>	1	7	1	9
<i>Semi-circular</i>	1	1		2
<i>Total</i>	5	23	14	42

Table 91: Denisova, layer 20CC. Product shape.

	Levallois products	Other flakes	Blades (ind.)	Total
<i>Straight</i>	5	20	11	36
<i>Concave</i>		1	3	4
<i>Convex</i>		2		2
<i>Total</i>	5	23	14	42

Table 92: Denisova, layer 20CC. Product profile.

	Levallois products	Other flakes	Blades (ind.)	Total
<i>Triangular</i>	1	12	5	18
<i>Trapezoidal</i>	4	10	9	23
<i>Rectangular</i>		1		1
<i>Total</i>	5	23	14	42

Table 93: Denisova, layer 20CC. Product cross-section.

4.2.2.3.3 Transformed products

Only 3 products have been retouched, one blade and two flakes (Table 94).

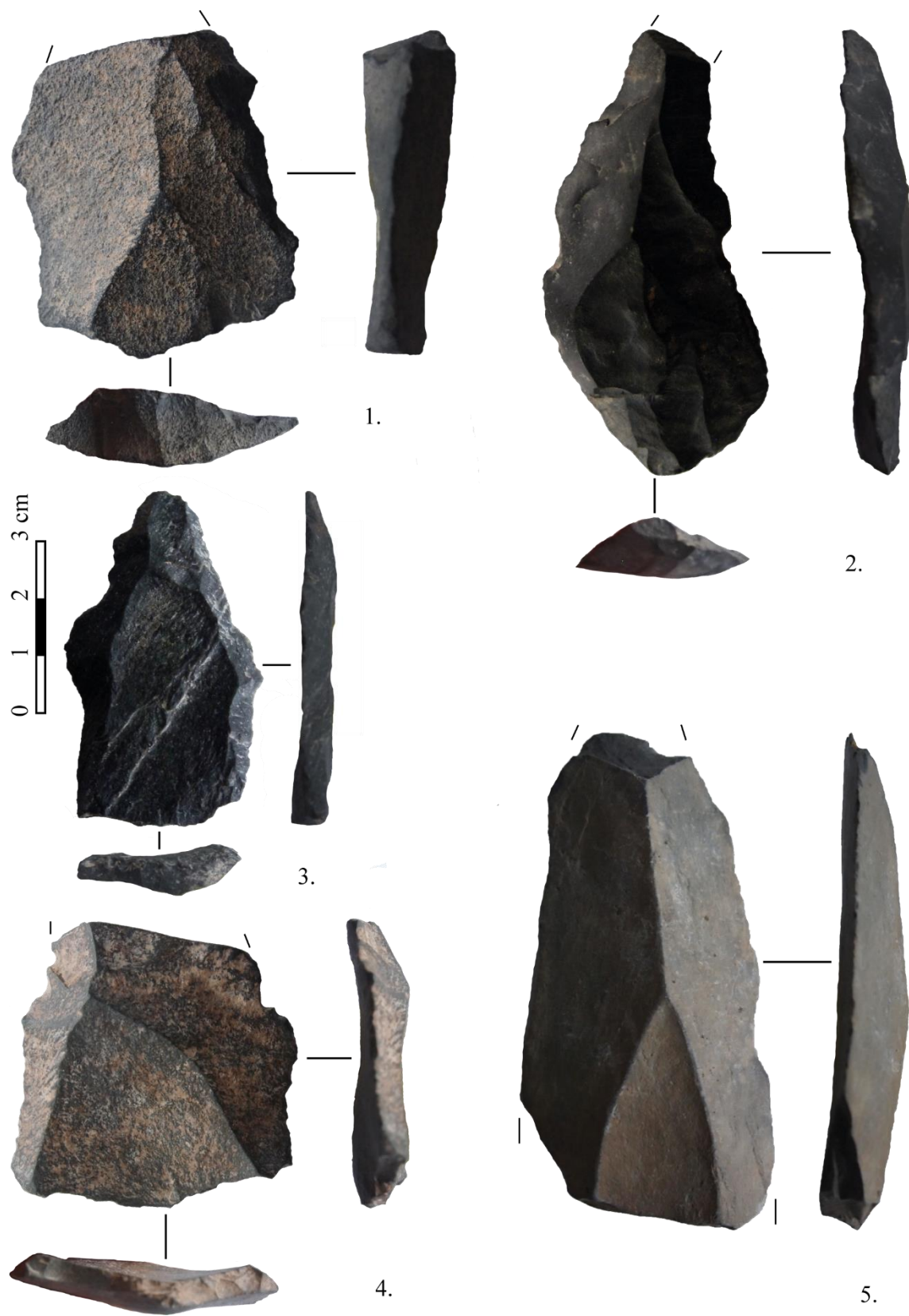


Figure 93: Denisova, layer 20CC. Levallois point (3), fragments of Levallois products (1, 2, 4, 5).

The retouch is always direct, semi-abrupt and scaled, but the other characteristics vary. The notch has been worked in the mesial part of the flake, with a concave delineation, discontinuous distribution and a long extent, while the retouched blade and partially retouched flake present a total retouch on the side, with a rectilinear delineation, and an extent that varies from marginal for the flake, to short for the blade.

	<i>Nb</i>
<i>Notch</i>	1
<i>Retouched blade</i>	1
<i>Partially retouched flake</i>	1
Total	3

Table 94: Denisova, layer 20CC. Tool types.

4.2.2.4 Layer 15 (Eastern gallery)

No artefact linked with the Levallois reduction sequence has been recognized in this assemblage, dominated by low predermination flaking schemes, with roughly worked radial and Kombewa cores producing thick, short flakes.

4.2.2.5 Layer 14 (Eastern gallery)

Eight artefacts have been recognized as possibly linked to a Levallois reduction sequence, two blades and six flakes (5 of them being *débordant* flakes; Figure 94). However, no clear Levallois product or by-product has been identified. A third blade was identified, but its morphology indicates a volumetric approach.

Most of the artefacts do not bear residual cortex (n=6).

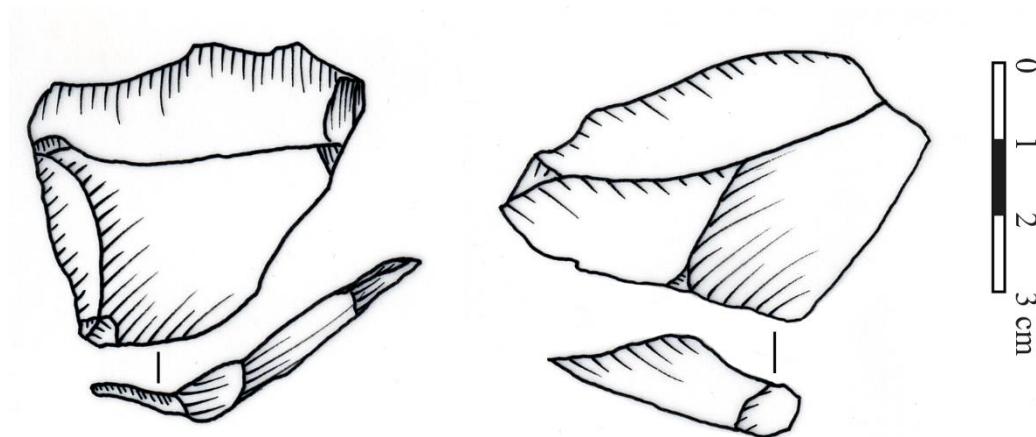


Figure 94: Denisova, layer 14EG. *Débordant* flakes.

- Breakage

All of the artefacts are complete (Table 95).

	Blades	Flakes	Total
<i>Complete</i>	2	6	8
<i>Total</i>	2	6	8

Table 95: Denisova, layer 14EG. Breakage.

- Size

The average flake measures 55.9 x 51.2 x 11 mm (Figure 95); the two blades are respectively 83.3 x 41.5 x 12.1 mm and 80.7 x 39.1 x 13.1 mm.

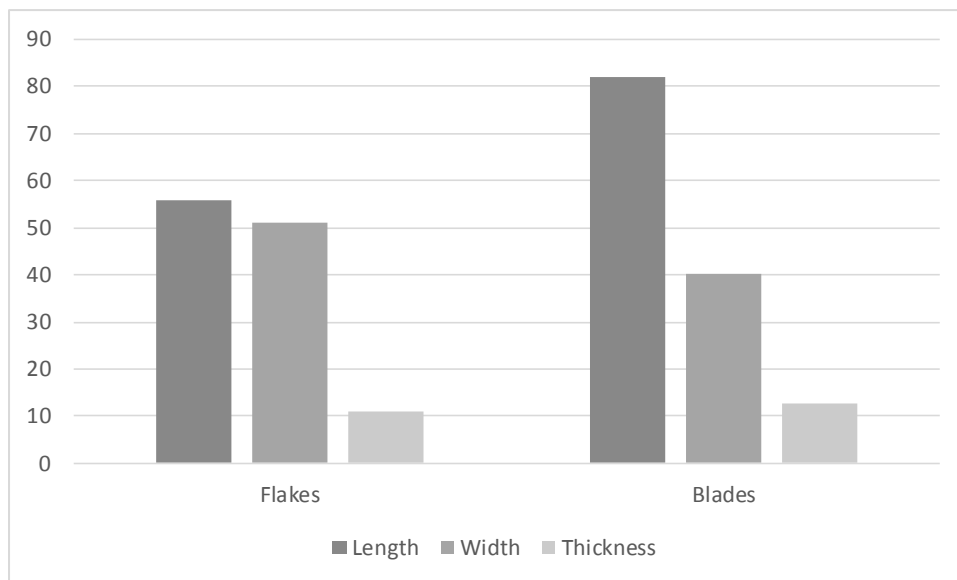


Figure 95: Denisova, layer 14EG. Mean measurements of the products.

- Dorsal scar pattern

The products present mainly unidirectional parallel dorsal scars (Table 96). However, a wide range of patterns has been identified, considering the small number of artefacts.

	Flakes	Blades (ind.)	Total
<i>Unidirectional parallel</i>	2	1	3
<i>Unidirectional convergent</i>	1		1
<i>Bidirectional parallel</i>		1	1
<i>Bidirectional orthogonal</i>	1		1
<i>Centripetal</i>	1		1
<i>Cordal</i>	1		1
<i>Total</i>	6	2	8

Table 96: Denisova, layer 14EG. Dorsal scar pattern.

- Platform preparation

The platforms do not seem to be carefully prepared, as they are either plain or cortical (Table 97).

	Flakes	Blades (ind.)	Total
<i>Plain</i>	3	2	5
<i>Cortical</i>	3		3
<i>Total</i>	6	2	8

Table 97: Denisova, layer 14EG. Platform preparation.

- Morphology

The products have either a quadrangular or triangular shape (Table 98), with a straight profile (Table 99) and a triangular cross-section (Table 100).

	Flakes	Blades (ind.)	Total
<i>Quadrangular</i>	2	2	4
<i>Triangular</i>	4		4
<i>Total</i>	6	2	8

Table 98: Denisova, layer 14EG. Product shape.

	Flakes	Blades (ind.)	Total
<i>Straight</i>	4	2	6
<i>Concave</i>	1		1
<i>Convex</i>	1		1
<i>Total</i>	6	2	8

Table 99: Denisova, layer 14EG. Product profile.

	Flakes	Blades (ind.)	Total
<i>Triangular</i>	4	2	6
<i>Trapezoidal</i>	2		2
<i>Total</i>	6	2	8

Table 100: Denisova, layer 14EG. Product cross-section.

4.2.2.5.1 Transformed products

No artefact has been transformed in this layer.

4.2.3 Summary

Very few artefacts can be linked to the Levallois reduction sequence in the most ancient layers of Denisova cave. Layer 22 was claimed to present the oldest Levallois production in Altai, with the identification of 3 cores, 2 flakes, 2 fragments of blades and 5 points; 6 of the products are said to present *chapeau de gendarme* platforms (Derevianko *et al.*, 2003). However, we were not able to identify these Levallois characteristics in the material we studied. In the site's monograph, we can see only one artefact from layer 22 that is related to the Levallois reduction sequence: an elongated Levallois point (*ibid.*, fig. 58, 6)¹¹. The other cores and flakes that are represented seem to illustrate low-predetermination methods. Although the point is undoubtedly issued from a Levallois reduction sequence, its presence alone is not sufficient to conclude that Levallois appeared in Altai at that time, since the rest of the assemblage doesn't hint towards a full-on Levallois production. It could be the result of contamination, as layer 22 presents signs of freeze-thaw processes, like vertically tilted gravel clasts (Jacobs *et al.*, 2019).

In the Central chamber, layer 20 is the first to yield an unquestionable, yet small, Levallois industry, illustrated by the production of blades, points and flakes, and a probable core.

In the Eastern gallery, we can see some artefacts that could be linked to a Levallois reduction sequence in layer 14. However, we will not go as far as to conclude to a real Levallois presence in this layer, since no core or predetermined product has been identified – the indeterminate blades could have been produced by a volumetric method.

¹¹ This point was not in the assemblage that we sampled, for still unknown reasons.

4.3 UST'-KARAKOL

4.3.1 Raw materials

According to (Derevianko *et al.*, 2003), the raw materials used in Ust'-Karakol 1 span more than ten petrographic categories:

- Marls and marbles
- Siltstone
- Sandstone
- Gravelite
- Sedimentary rocks
- Aphyric effusive rocks
- Porphyric effusive rocks
- Jasperoids
- Hornfels
- Slate
- Quartz
- Granite
- Dike porphyrite

The remaining cortex indicates that, for the most part, the Palaeolithic occupants selected pebbles from the local Anui and Karakol rivers. The comparison of the proportions of raw materials naturally present in the riverbeds and in Ust'-Karakol show that there was a careful selection of knappable raw materials (Anoikin and Postnov, 2005). For example, the volcanic rocks constitute 10.3% and 11.4% of the material from the Karakol and Anui rivers, but 40.8% of Ust'-Karakol material. Aleurolites follow the same pattern, with 9.8% and 10.4% in the Karakol and Anui riverbeds, but 30% in Ust'-Karakol; on the contrary, sandstones are more frequent in the riverbeds (56% in the Karakol river and 43.7% in the Anui river) than in the archaeological site (21.5%).

4.3.2 Technological study

This study focuses on material which was recovered during the 1993-1997 campaign of excavations, in the Ust'-Karakol 1-2 locus. The excavation covers a surface of 250 m², with a 6.5 m deep profile. We studied here the assemblages associated with the Middle Palaeolithic occupation, *i.e.* layers 19 to 13. The overwhelming majority of the artefacts have been found in

layer 18 (Table 101). Some differences in number can be noted with the count in Derevianko *et al.* (2003). This can be explained by different reasons. First, a refitting study was ongoing, and some refits were too big to assess the number of artefacts included; secondly, some artefacts were exhibited at the Museum of History and Culture of the people of Siberia and the Far-East in Novosibirsk and at the temporary exhibit “The third man. Prehistory of Altai” in the National Museum of Prehistory at Les Eyzies-de-Tayac in France, and thus not available for study.

LAYER	13	14	15	16	17	18	19	Total
Cores		1				4		5
<i>Levallois</i>						<i>1</i>		<i>1</i>
Flakes	7	27	15	12	13	200	6	280
<i>100 % cortex</i>	<i>1</i>					<i>2</i>		<i>3</i>
<i>>50 % cortex</i>		<i>1</i>		<i>3</i>	<i>1</i>	<i>16</i>		<i>21</i>
<i>< 50 % cortex</i>		<i>6</i>	<i>7</i>	<i>3</i>	<i>6</i>	<i>49</i>		<i>71</i>
<i>No cortex</i>	<i>6</i>	<i>20</i>	<i>8</i>	<i>6</i>	<i>6</i>	<i>133</i>	<i>6</i>	<i>185</i>
<i>Levallois flakes and points</i>	<i>1</i>	<i>3</i>	<i>1</i>	<i>2</i>		<i>24</i>		<i>31</i>
<i>Blades</i>		<i>5</i>	<i>2</i>	<i>1</i>	<i>1</i>	<i>20</i>	<i>2</i>	<i>582</i>
Debris and fragments	17	44	39	18	15	215	41	389
Total	24	72	54	30	28	419	47	674

Table 101: Ust'-Karakol. Composition of the assemblage

4.3.2.1 Layer 19

Forty-seven artefacts have been recorded in layer 19. They are heavily weathered by water circulation, with rounded edges and natural “retouch”.

4.3.2.1.1 Production

Most of the production consists in fragments and debris, and according to our study only 6 pieces can be recognized as lithic products (Figure 96). Two of them are Levallois blades; one is a proximal of a possible Levallois product; another proximal could be a fragment of a very thick blade. A *débordant* flake could also be linked with the Levallois reduction sequence.

- Breakage

Half of the assemblage is complete, the other half consisting in proximal fragments (Table 102).

	Blades	Flakes	Total
<i>Proximal</i>		3	3
<i>Complete</i>	2	1	3
<i>Total</i>	2	4	6

Table 102: Ust'-Karakol, layer 19. Breakage.

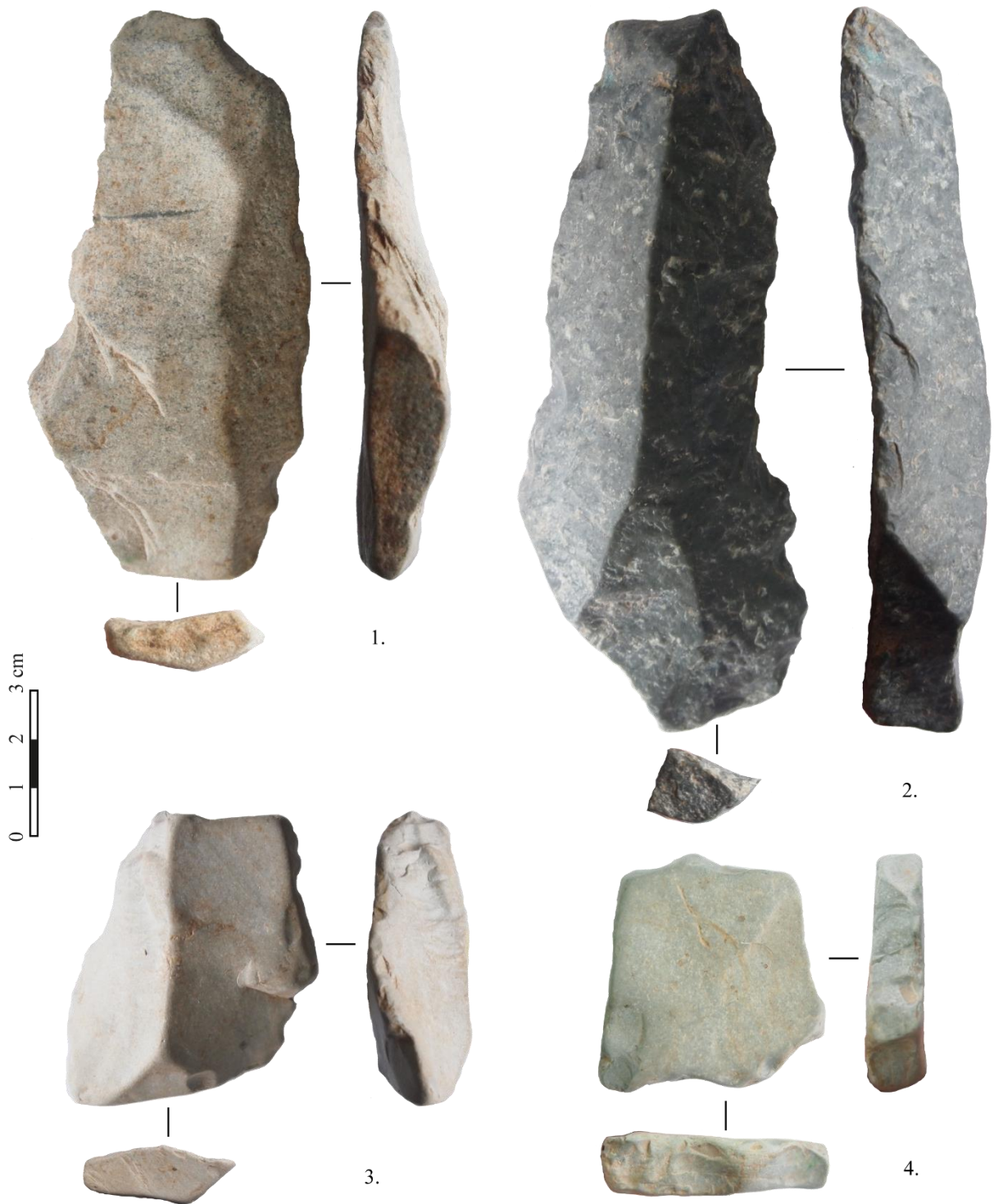


Figure 96: Ust'-Karakol, layer 19. Levallois blades with an oblique back (1, 2), proximal fragment of a blade (3), proximal fragment of Levallois product (4).

- Sizes

Only three products are complete in this layer. It is thus impossible to observe any trend on the lengths. The two blades are respectively 131.2 x 52.3 x 19.8 mm and 100.5 x 49.3 x 14.9 mm;

the complete flake is 83.4 x 58.8 x 20.4 mm. For the average flake, the width is 52.7 mm and the thickness is 24 mm (Figure 97).

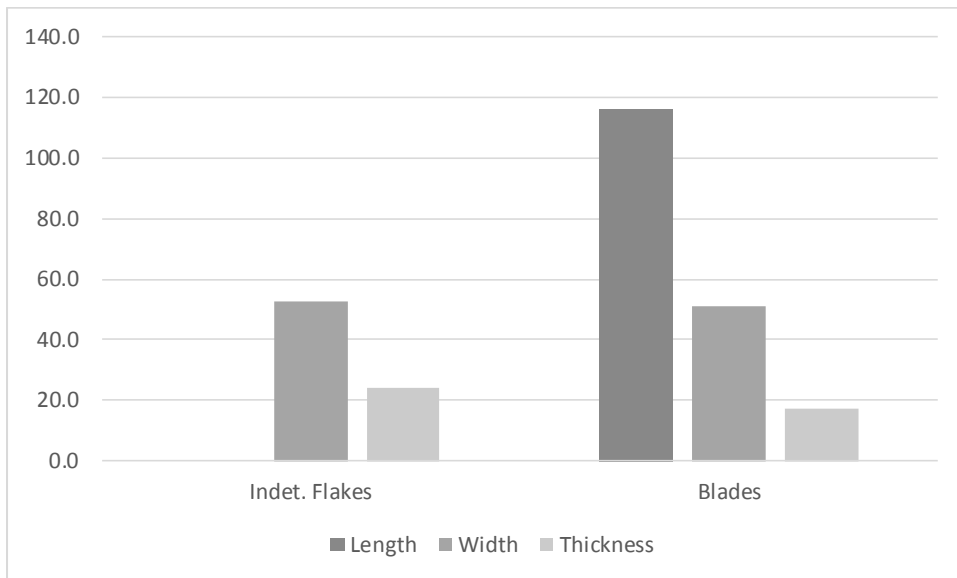


Figure 97: Ust'-Karakol, layer 19. Mean measurements of the products.

- Dorsal scar pattern

The removals direction identification was impossible for 3 of the products because of the taphonomical wear (Table 103). The other three artefacts display different orientations: unidirectional parallel and bidirectional orthogonal for the two blades, and unidirectional parallel for the *débordant* flake.

	Levallois	Indet.	Total
<i>Unidirectional parallel</i>		1	1
<i>Unidirectional convergent</i>	1		1
<i>Bidirectional orthogonal</i>	1		1
<i>Indet</i>		3	3
<i>Total</i>	2	4	6

Table 103: Ust'-Karakol, layer 19. Dorsal scar pattern.

- Platform preparation

Most of the platforms are unprepared, except the *débordant* flake which presents a faceted platform (Table 104).

	Levallois	Indet.	Total
<i>Plain</i>	2	2	4
<i>Facetted</i>		1	1
<i>Indet</i>		1	1
<i>Total</i>	2	4	6

Table 104: Ust'-Karakol, layer 19. Platform preparation.

- Morphology

All of the products are quadrangular (Table 105), and most of them present a straight profile (Table 106). The two Levallois blades have a trapezoidal cross-section, as they are based on two guide-ridges; the other products present a triangular cross-section (Table 107).

	Levallois	Indet.	Total
<i>Quadrangular</i>	2	4	6
<i>Total</i>	2	4	6

Table 105: Ust'-Karakol, layer 19. Product shape.

	Levallois	Indet.	Total
<i>Straight</i>	2	3	5
<i>Concave</i>		1	1
<i>Total</i>	2	4	6

Table 106: Ust'-Karakol, layer 19. Product profile.

	Levallois	Indet.	Total
<i>Triangular</i>		4	4
<i>Trapezoidal</i>	2		2
<i>Total</i>	2	4	6

Table 107: Ust'-Karakol, layer 19. Product cross-sections.

4.3.2.1.2 Transformed products

As the artefacts from this layer are heavily rolled and altered, they all display some “retouch”, and most of them were identified as tools in Derevianko *et al.*, 2003. We opted for a conservative approach, and only considered artefacts wearing a clear and intentional retouch. Four products have been retouched: the two blades, the *débordant* flake and an indeterminate flake (Table 108).

The retouch is always direct, continuous and scaled, abrupt (n=2) or semi-abrupt (n=2), and mainly shapes a rectilinear delineation and edge. Its extent can be marginal (n=1) to long (n=2), even invasive (n=1).

	<i>Nb</i>
<i>Scraper</i>	1
<i>Simple</i>	1
<i>Retouched blade</i>	2
<i>Partially retouched flake</i>	1
<i>Total</i>	4

Table 108: Ust'-Karakol, layer 19. Types of tools.

4.3.2.2 Layer 18

This is the richest Middle Palaeolithic assemblage of the site, with more than two thirds of the products in this layer. Contrary to what we observed in layer 19, the artefacts appear fresh, without traces of post-depositional processes.

4.3.2.2.1 Reduction sequences

Four cores have been identified in this layer, all manufactured on pebbles (Table 109).

<i>Method</i>	<i>Mode</i>	<i>Matrix</i>	<i>Nb</i>
<i>Levallois</i>	Bidirectional parallel	Pebble	1
<i>Low Predetermination</i>	2 FS	Pebble	3
<i>Total</i>			4

Table 109: Ust'-Karakol, layer 18. Cores.

All the cores show a Levallois-like management of the surfaces and convexities. However, in most cases, either the raw material or an insufficient preparation of the core have made it impossible to remove the invasive blanks.

- UK-I.96.18/3.52.18B

This core, produced on a pebble, opposes two hierarchized surfaces. The striking platform, mainly cortical, is shaped by a series of centripetal removals around the periphery. The removals corresponding to the last preferential negative show a thorough preparation of the striking platform, with the removal of small elongated blanks.

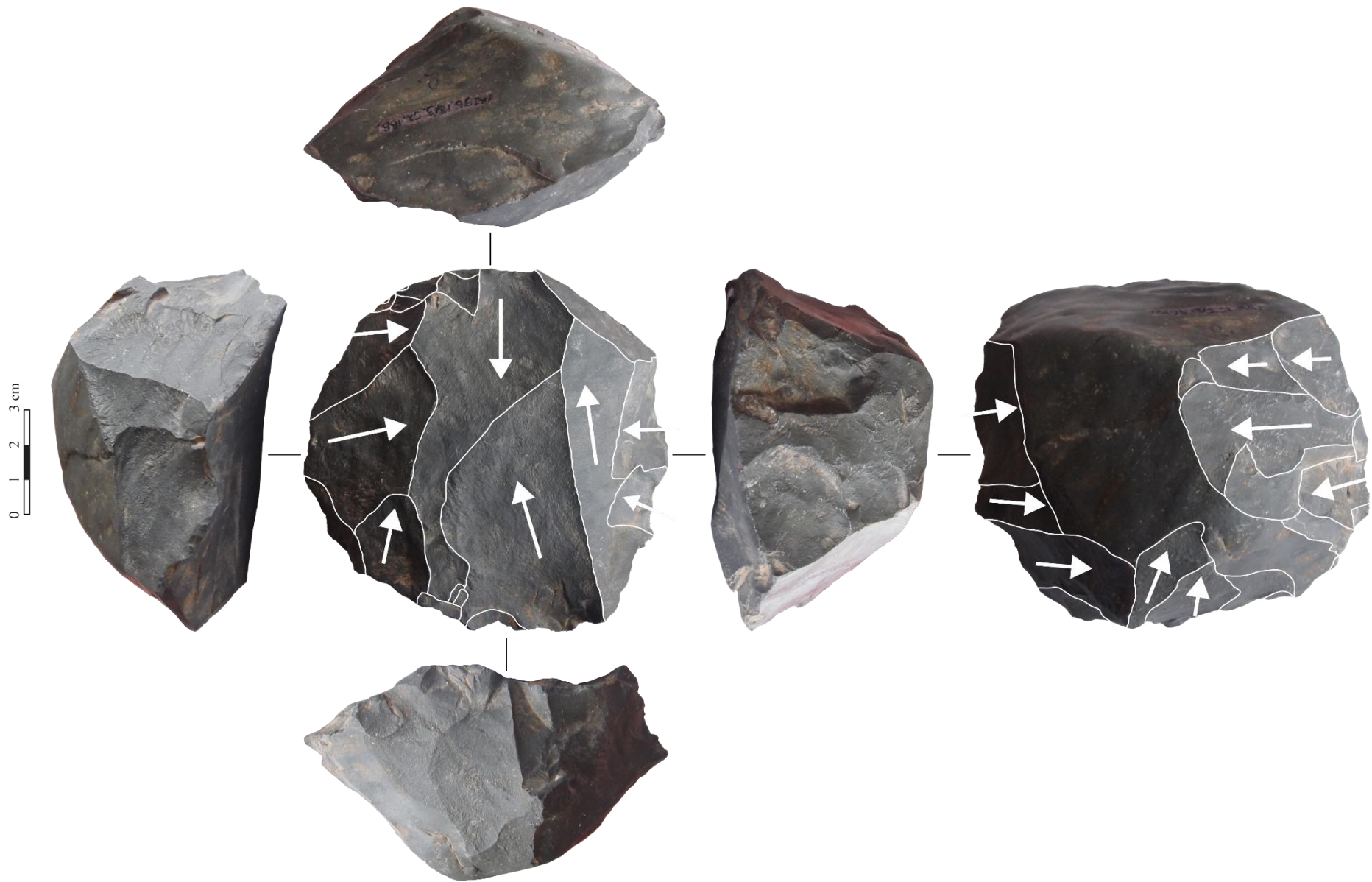


Figure 98: Ust'-Karakol, layer 18. UK-196.18/3.52.18B

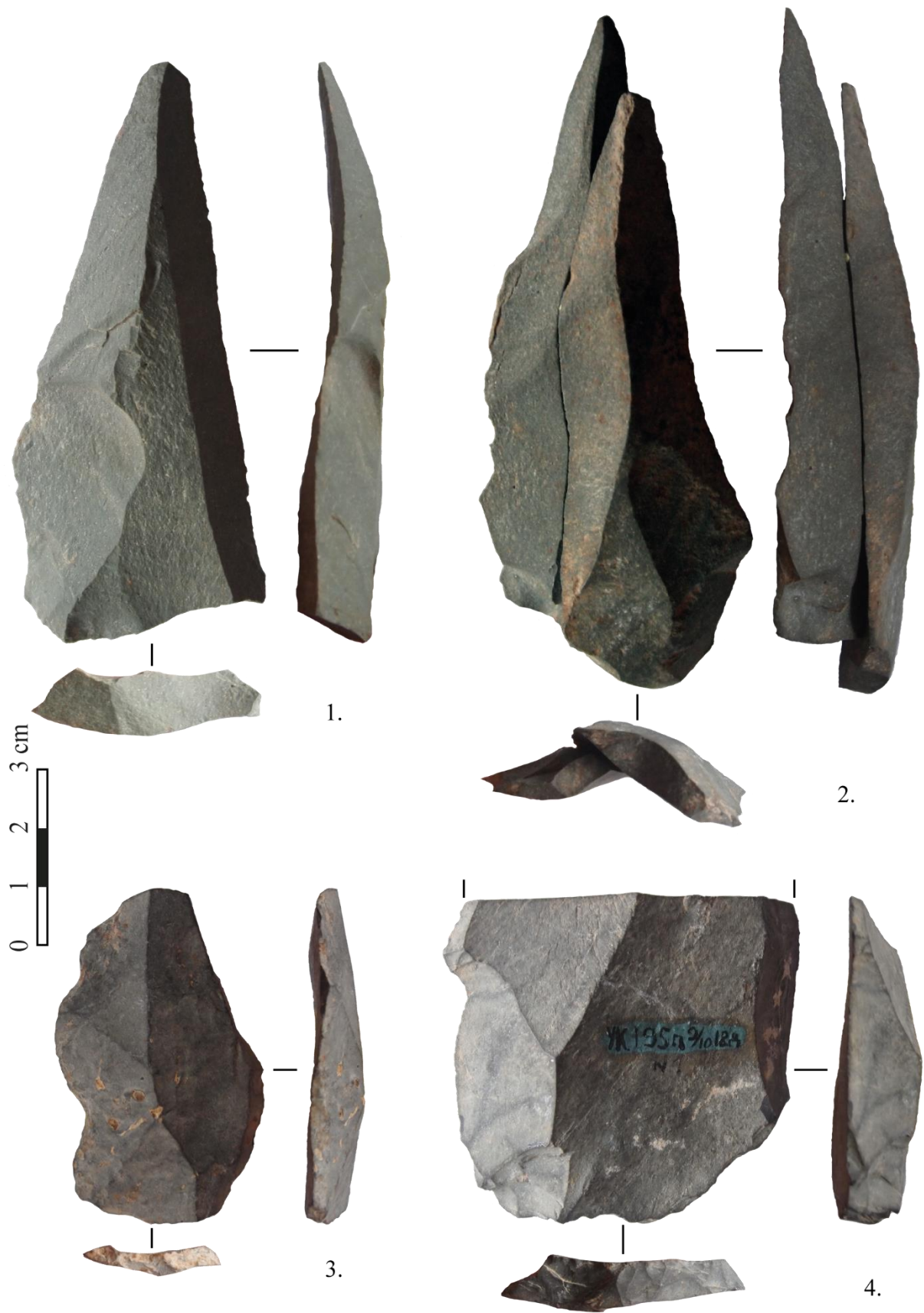


Figure 99: Ust'-Karakol; layer 18. Elongated points (1, 2), Levallois flakes (3,4)

4.3.2.2.2 Production

The production (n=200) is dominated by flakes (n=180), with a sporadic presence of blades (n=19) and one bladelet. Most of the artefacts do not bear residual cortex (n=133), or less than 25% (n=32).

The Levallois production is composed of 10 Levallois blades, 15 Levallois points and 10 Levallois flakes. In addition, 4 *débordant* flakes and 6 other flakes have been identified as part of the Levallois reduction sequence, as they refit with Levallois products.

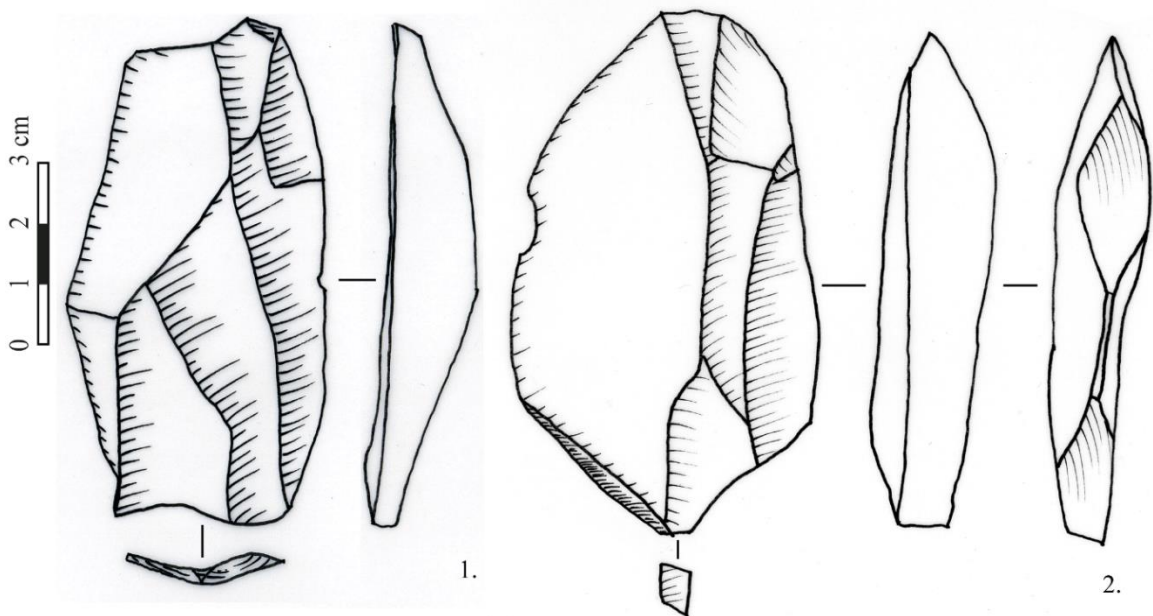


Figure 100: Ust'-Karakol, layer 18. Levallois flake (1) and débordant flake (2).

- Breakage

Most of the products are complete (Table 110), except for the blade category, where only a fourth of the products remained unbroken.

	Blades	Flakes	Total
<i>Distal</i>	2	16	18
<i>Mesio-distal</i>	2	2	4
<i>Mesial</i>	4	2	6
<i>Mesio-proximal</i>	5	25	30
<i>Proximal</i>	1	4	5
<i>Fragment</i>		1	1
<i>Complete</i>	6	130	136
<i>Total</i>	20	180	200

Table 110: Ust'-Karakol, layer 18. Breakage.

- Size

The average flake measures 34.1 x 26 x 7.2 mm, while Levallois flakes are around 75.5 x 38.6 x 9.1 mm, more than twice as long (Figure 101). Blades are on average 94.8 x 28.3 x 6.9 mm.

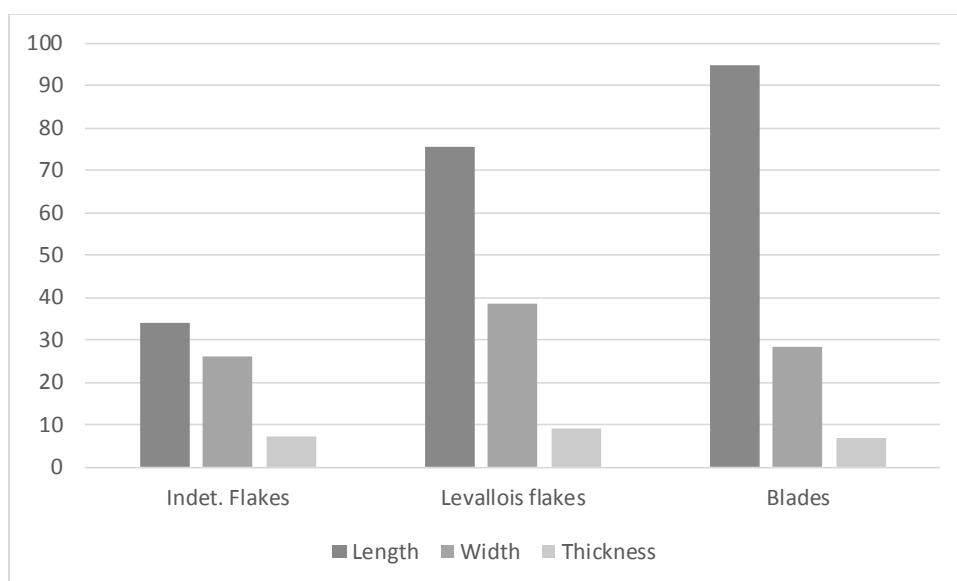


Figure 101: Ust'-Karakol, layer 18. Mean measurements of the products.

- Dorsal scar pattern

Most of the products present unidirectional parallel dorsal scars (Table 111). The Levallois products also display unidirectional convergent patterns.

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Unidirectional parallel</i>	16		6	1	82	105
<i>Unidirectional convergent</i>	15				10	25
<i>Bidirectional parallel</i>	5	1	1		4	11
<i>Bidirectional orthogonal</i>	8	1			19	28
<i>Centripetal</i>					3	3
<i>Multidirectional</i>					6	6
<i>Cordal</i>	1				11	12
<i>Cortical</i>					2	2
<i>Indet</i>					8	8
Total	45	2	7	1	145	200

Table 111: Ust'-Karakol, layer 18. Dorsal scar pattern.

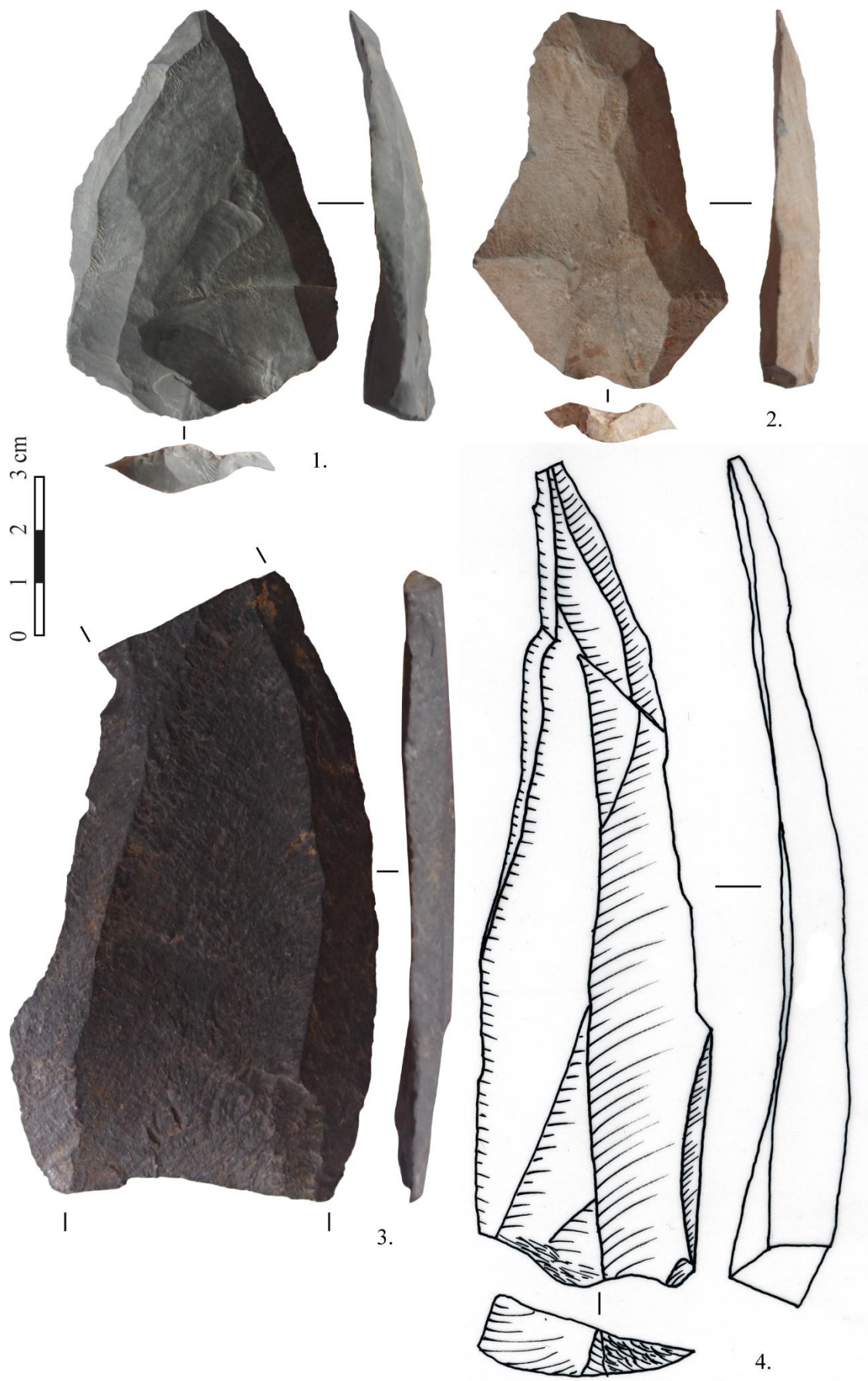


Figure 102: Ust'-Karakol, layer 18. Levallois points (1, 2, 3) and elongated point (4).

- Platform preparation

Most of the platforms are unprepared, even for the Levallois or blade productions (Table 112). However, the Levallois products also present faceted (n=10) and dihedral (n=6) preparations.

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Plain</i>	17	2	3		93	115
<i>Dihedral</i>	6				6	12
<i>Facetted</i>	10		1		3	14
<i>Punctual</i>	2				11	13
<i>Cortical</i>	3				12	15
<i>Missing</i>						
<i>Broken</i>					2	2
<i>ND</i>	7		3	1	18	29
<i>Total</i>	45	2	7	1	145	200

Table 112: Ust'-Karakol, layer 18. Platform preparation.

- Morphology

The objective of the production seemed to be a quadrangular product (Table 113), with a straight profile (Table 114), and a triangular cross-section (Table 115). However, Levallois products mainly present a trapezoidal cross-section and a triangular shape.

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Quadrangular</i>	17	2	4	1	90	114
<i>Triangular</i>	27		3		52	82
<i>Oval</i>					1	1
<i>Semi-circular</i>	1				2	3
<i>Total</i>	45	2	7	1	145	200

Table 113: Ust'-Karakol, layer 18. Product shape.

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Straight</i>	32	2	7	1	108	150
<i>Concave</i>	12				25	37
<i>Convex</i>	1				8	9
<i>Sinuuous</i>					4	4
<i>Total</i>	45	2	7	1	145	200

Table 114: Ust'-Karakol, layer 18. Product profile.

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Triangular</i>	12	1	4	1	96	114
<i>Trapezoidal</i>	32	1	3		39	75
<i>Semi-circular</i>					5	5
<i>Rectangular</i>	1				5	6
<i>Total</i>	45	2	7	1	145	200

Table 115: Ust'-Karakol, layer 18. Product cross-section.

4.3.2.2.3 Transformed products

Only one artefact has been transformed (Table 116). The support is a mostly cortical, thick flake. The retouch, on the right distal part, is direct, continuous, semi-abrupt and scaled, and has a short extent. It forms a concave delineation, making this tool a notch.

	<i>Nb</i>
<i>Notch</i>	1
<i>Total</i>	1

Table 116: Ust'-Karakol, layer 18. Tool types.

4.3.2.3 Layer 17

4.3.2.3.1 Reduction sequences

No core has been identified in this layer.

4.3.2.3.2 Production

The assemblage is very scarce, with only 13 artefacts, one of which is a typological bladelet (but entirely cortical). Except for this bladelet, no artefact presents more than 50% of residual cortex, and most present none (n=6). No artefact could be linked with the Levallois reduction sequence.

- Breakage

The artefacts are mainly complete (Table 117).

	Bladelet	Flakes	Total
<i>Distal</i>		1	1
<i>Mesio-proximal</i>	1	3	4
<i>Complete</i>		8	8
<i>Total</i>	1	12	13

Table 117: Ust'-Karakol, layer 17. Breakage.

- Size

The bladelet is 10.2 x 5 mm (while broken, its length is 32.6 mm). The flakes are on average 32 x 32.2 x 8.4 mm (Figure 103); we can note that the length and width are nearly the same, and the overall size is quite reduced compared to the underlying layers.

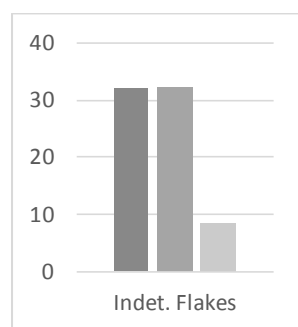


Figure 103: Ust'-Karakol, layer 17. Mean measurements of the products.

- Dorsal scar pattern

The products mainly present a unidirectional parallel pattern (Table 118).

	Bladelet	Indet./low predet.	Total
<i>Unidirectional parallel</i>		8	8
<i>Bidirectional orthogonal</i>		1	1
<i>Multidirectional</i>		1	1
<i>Cordal</i>		2	2
<i>Cortical</i>	1		1
<i>Total</i>	1	12	13

Table 118: Ust'-Karakol, layer 17. Dorsal scar pattern.

- Platform preparation

The platforms are mainly plain, but can be punctual or cortical (Table 119). Thus there is no visible preparation of the platforms in this assemblage.

	Bladelet	Indet./low predet.	Total
<i>Plain</i>		10	10
<i>Punctual</i>	1		1
<i>Cortical</i>		1	1
<i>ND</i>		1	1
<i>Total</i>	1	12	13

Table 119: Ust'-Karakol, layer 17. Platform preparation.

- Morphology

The average product is quadrangular (Table 120), with a straight profile (Table 121). Its cross-section can be triangular or trapezoidal (Table 122).

	Bladelet	Indet./low predet.	Total
<i>Quadrangular</i>	1	10	11
<i>Triangular</i>		2	2
<i>Total</i>	1	12	13

Table 120: Ust'-Karakol, layer 17. Product shape.

	Bladelet	Indet./low predet.	Total
<i>Straight</i>	1	8	9
<i>Concave</i>		2	2
<i>Convex</i>		2	2
<i>Total</i>	1	12	13

Table 121: Ust'-Karakol, layer 17. Product profile.

	Bladelet	Indet./low predet.	Total
<i>Triangular</i>	1	6	7
<i>Trapezoidal</i>		5	5
<i>Rectangular</i>		1	1
<i>Total</i>	1	12	13

Table 122: Ust'-Karakol, layer 17. Product cross-section.

4.3.2.3.3 Transformed products

No artefact transformation has been identified in this layer.

4.3.2.4 Layer 16

4.3.2.4.1 Reduction sequences

This layer didn't yield any core.

4.3.2.4.2 Production

The production (n=12) is composed of flakes (n=11), with one fragment of blade. They mainly do not present residual cortex (n=6), or are less than 50% covered (n=3).

The Levallois production is composed of two Levallois flakes (Figure 104).

- Breakage

Most of the products are fragmented (Table 123).

	Blades	Flakes	Total
<i>Distal</i>	1	1	2
<i>Mesial</i>		1	1
<i>Mesio-proximal</i>		3	3
<i>Proximal</i>		1	1
<i>Complete</i>		5	5
<i>Total</i>	1	11	12

Table 123: Ust'-Karakol, layer 16. Breakage.

- Size

Since the blade is fragmentary and only one Levallois flake is complete, no trend can be observed on the lengths of the predetermined products of this layer. The Levallois flakes are respectively 100.1 x 54.5 x 17.7 mm for the complete one, and 35.7 x 9.1 mm for the mesio-proximal fragment. The fragment of blade measures 15.9 x 4.3 mm. On average, indeterminate flakes are 26.1 x 25.8 x 7.7 mm (Figure 105).

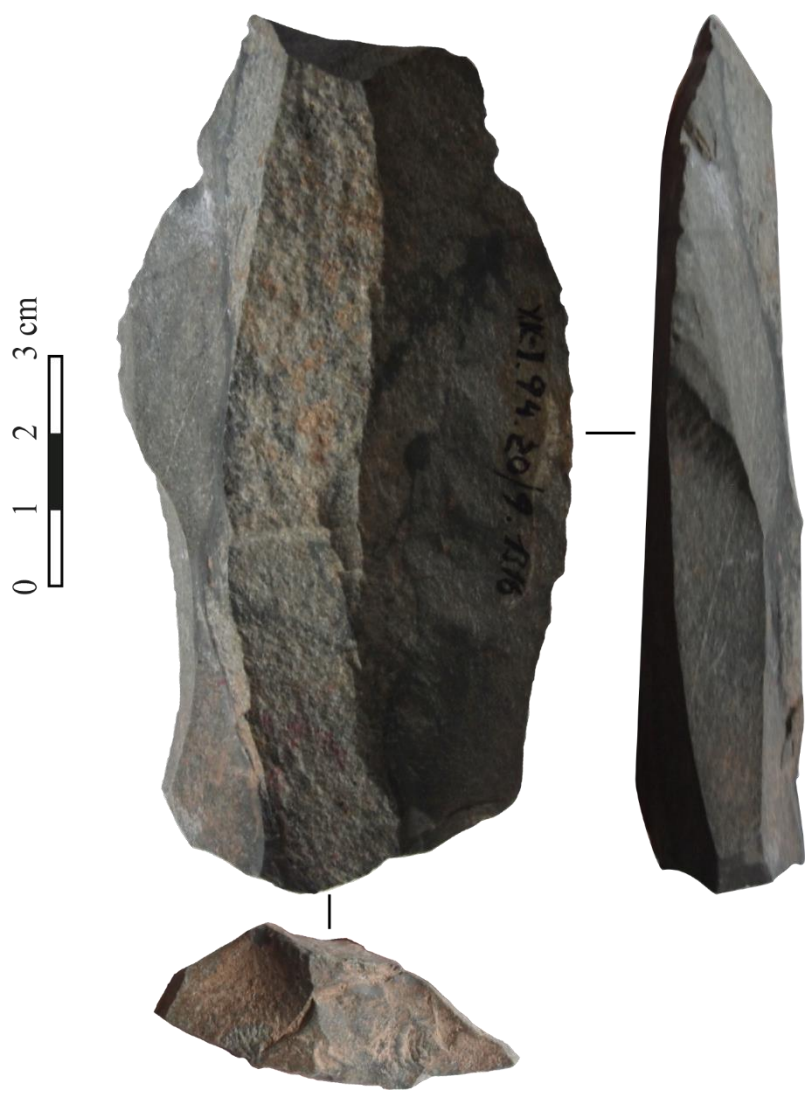


Figure 104: Ust'-Karakol, layer 16, Levallois flake.

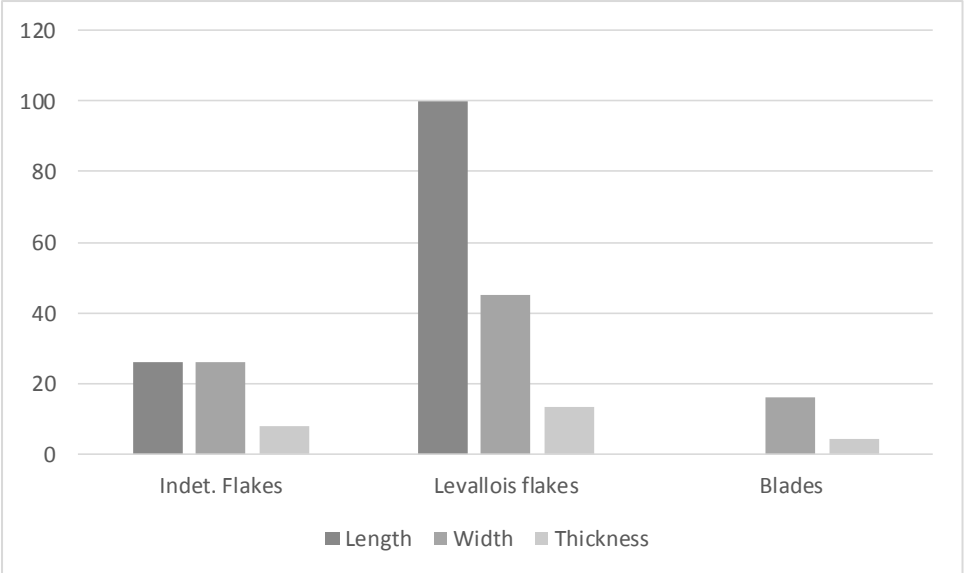


Figure 105: Ust'-Karakol, layer 16. Mean measurements of the products.

- Dorsal scar pattern

Most of the products present a unidirectional parallel dorsal pattern (Table 124). The Levallois flakes are uni- and bidirectional parallel.

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Unidirectional parallel</i>	1		4	5
<i>Unidirectional convergent</i>		1		1
<i>Bidirectional parallel</i>	1		1	2
<i>Multidirectional</i>			1	1
<i>Indet</i>			3	3
<i>Total</i>	2	1	9	12

Table 124: Ust'-Karakol, layer 16. Dorsal scar pattern.

- Platform preparation

Whereas the platforms are mostly plain for the indeterminate flakes, they are dihedral for the Levallois flakes (Table 125).

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Plain</i>			5	5
<i>Dihedral</i>	2			2
<i>Punctual</i>			1	1
<i>Cortical</i>			1	1
<i>ND</i>		1	2	3
<i>Total</i>	2	1	9	12

Table 125: Ust'-Karakol, layer 16. Platform preparation.

- Morphology

Most of the products have a quadrangular shape (Table 126), with a straight profile (Table 127) and a triangular cross-section, although the blade and a Levallois flake present trapezoidal cross-sections (Table 128).

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Quadrangular</i>	2		8	10
<i>Triangular</i>		1		1
<i>Semi-circular</i>			1	1
<i>Total</i>	2	1	9	12

Table 126: Ust'-Karakol, layer 16. Product shape.

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Straight</i>	2	1	7	10
<i>Concave</i>			1	1
<i>Convex</i>			1	1
<i>Total</i>	2	1		12

Table 127: Ust'-Karakol, layer 16. Product profile.

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Triangular</i>	1		6	7
<i>Trapezoidal</i>	1	1	2	4
<i>Semi-circular</i>			1	1
<i>Total</i>	2	1	9	12

Table 128: Ust'-Karakol, layer 16. Product cross-section.

4.3.2.4.3 Transformed products

One indeterminate flake has been retouched on its right side, forming a sidescraper (Table 129). The retouch is direct, total, continuous, short, scaled and semi-abrupt, and forms a convex delineation.

	<i>Nb</i>
<i>Scraper (simple)</i>	1
<i>Total</i>	1

Table 129: Ust'-Karakol, layer 16. Types of tools.

4.3.2.5 Layer 15

4.3.2.5.1 Reduction sequences

No core was identified in this layer.

4.3.2.5.2 Production

The production (n=15) is dominated by flakes (n=13), with two fragments of blades. Most of the products wear no residual cortex (n=8), and none is more than 50% covered.

The Levallois production is composed of one fragmented Levallois flake (Figure 106).

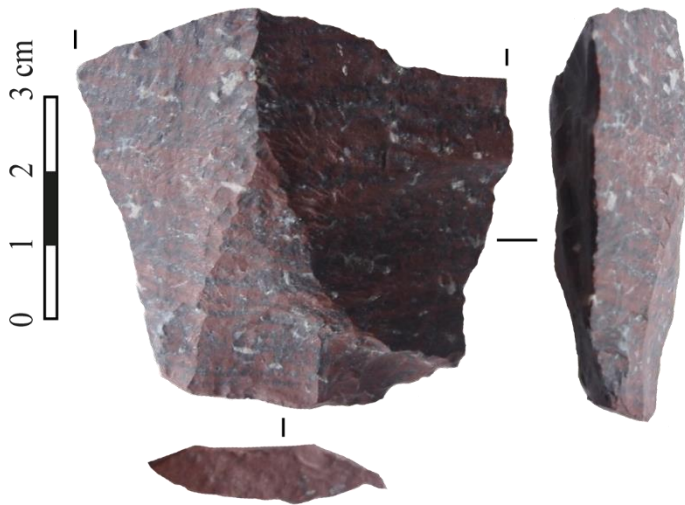


Figure 106: Ust'-Karakol, layer 15. Levallois flake.

- Breakage

Less than half the assemblage is complete (Table 130). Both the blades and the Levallois flake are fragmented.

	Blades	Flakes	Total
<i>Distal</i>		1	1
<i>Mesial</i>	1	1	2
<i>Mesio-proximal</i>		2	2
<i>Proximal</i>	1	1	2
<i>Fragment</i>		2	2
<i>Complete</i>		6	6
<i>Total</i>	2	13	15

Table 130: Ust'-Karakol, layer 15. Breakage.

- Size

The two fragments of blade are respectively 26.4 x 4.9 mm and 28.6 x 8 mm (Figure 107); the Levallois flake is 48.8 x 15.7 mm. An average flake is 32.8 x 28.2 x 7.5 mm; we can note that the Levallois flake is the widest product, except one indeterminate flake with a width of 51.7 mm. Moreover, even in its fragmented state, it is the second longest product in this layer, at 44.6 mm, after another indeterminate flake measuring 51.1 mm.

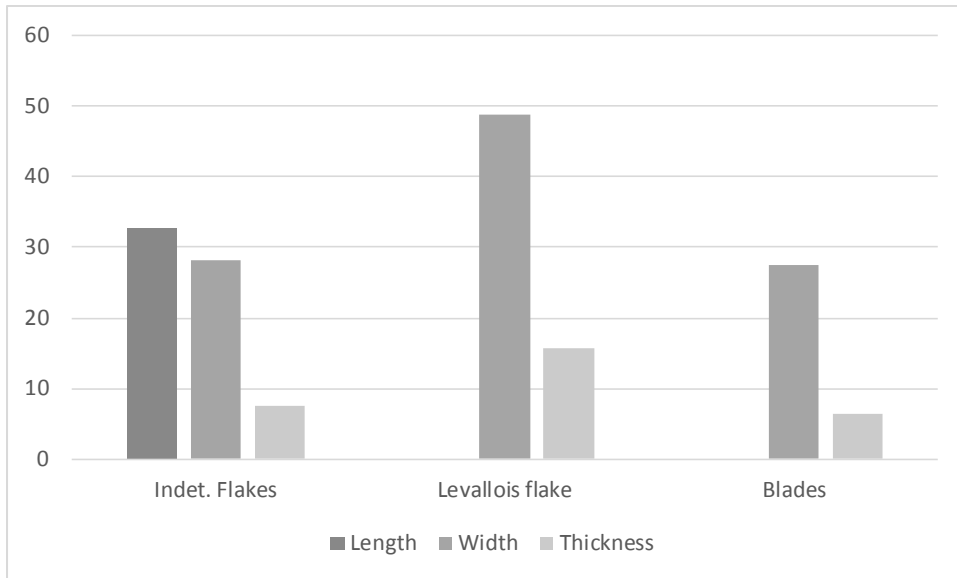


Figure 107: Ust'-Karakol, layer 15. Mean measurements of the products.

- Dorsal scar pattern

The indeterminate flakes are mostly unidirectional or bidirectional parallel, and bidirectional orthogonal, but the Levallois and blades only present a unidirectional parallel dorsal scar pattern (Table 131).

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Unidirectional parallel</i>	1	2	3	6
<i>Unidirectional convergent</i>			1	1
<i>Bidirectional parallel</i>			3	3
<i>Bidirectional orthogonal</i>			3	3
<i>Multidirectional</i>			1	1
<i>Indet</i>			1	1
<i>Total</i>	1	2	12	15

Table 131: Ust'-Karakol, layer 15. Dorsal scar pattern.

- Platform preparation

The platforms are mainly plain (Table 132), but can also be cortical or broken.

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Plain</i>	1	1	6	8
<i>Cortical</i>			1	1
<i>Broken</i>			1	1
<i>ND</i>		1	4	5
<i>Total</i>	1	2	12	15

Table 132: Ust'-Karakol, layer 15. Platform preparation.

- Morphology

The typical product has a quadrangular shape (Table 133), a straight profile (Table 134) and a triangular cross-section (Table 135).

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Quadrangular</i>	1	2	10	13
<i>Triangular</i>			2	2
<i>Total</i>	1	2	12	15

Table 133: Ust'-Karakol, layer 15. Product shape.

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Straight</i>	1	2	8	11
<i>Concave</i>			3	3
<i>Sinuuous</i>			1	1
<i>Total</i>	1	2	12	15

Table 134: Ust'-Karakol, layer 15. Product profile.

	Levallois	Blades (ind.)	Indet./low predet.	Total
<i>Triangular</i>	1	2	7	10
<i>Trapezoidal</i>			3	3
<i>Rectangular</i>			2	2
<i>Total</i>	1	2	12	15

Table 135: Ust'-Karakol, layer 15. Product cross-section.

4.3.2.5.3 Transformed products

One indeterminate flake was truncated in its distal part by a direct, continuous, subparallel and abrupt retouch (Table 144).

	<i>Nb</i>
<i>Truncated flake</i>	1
<i>Total</i>	1

Table 136: Ust'-Karakol, layer 15. Types of tools.

4.3.2.6 Layer 14

4.3.2.6.1 Reduction sequences

We identified one core in this layer, manufactured on a nodule (Table 137). This core opposes two surfaces; the first one, identified as a flaking surface, displays the scars of the removals of more than 15 centripetal flakes, with a lot of hinges. The second one, the striking platform, bears the traces of 4 centripetal flakes. This organization hints towards a Levallois-like reduction sequence. However, the lack of preparation of the platforms, the secant flaking angle and the short negatives prevent us from categorizing this core as fully Levallois.

<i>Method</i>	<i>Mode</i>	<i>Matrix</i>	<i>Nb</i>
<i>Low Predetermination</i>	2 FS	Nodule	1
<i>Total</i>			1

Table 137: Ust'-Karakol, layer 14. Cores.

4.3.2.6.2 Production

The production (n=27) is dominated by flakes (n=22), with some blades (n=3) and bladelets (n=2). Most of the artefacts do not present any residual cortex (n=20).

The Levallois production is composed of three Levallois flakes (Figure 108).

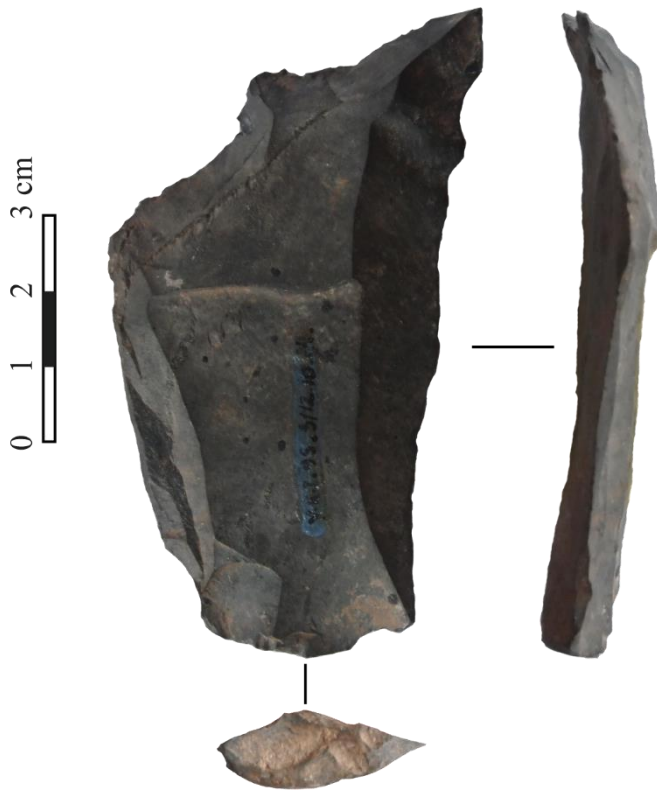


Figure 108: Ust'-Karakol, layer 14. Levallois flake.

- Breakage

Most of the flakes are complete, but the blades and bladelets are all fragmented (Table 138).

	Blades	Flakes	Total
<i>Distal</i>	1		1
<i>Mesial</i>	2	3	5
<i>Mesio-proximal</i>	1	4	5
<i>Proximal</i>	1	2	3
<i>Fragment</i>		1	1
<i>Complete</i>		12	12
<i>Total</i>	5	22	27

Table 138: Ust'-Karakol, layer 14. Breakage.

- Size

On average, the indeterminate flakes measure 35.7 x 30.4 x 10.9 mm (Figure 109). The complete Levallois flake is 82.4 x 43.8 x 9.4 mm, and the two fragments are respectively 38.1 x 8.3 mm and 78 x 18.8 mm; the complete Levallois flake is the longest product of this assemblage and the second fragment is the widest. The blades are on average 25.1 x 5.1 mm, the thinnest of all the products.

The two bladelets are respectively 12.3 x 4 mm and 10.3 x 1.8 mm.

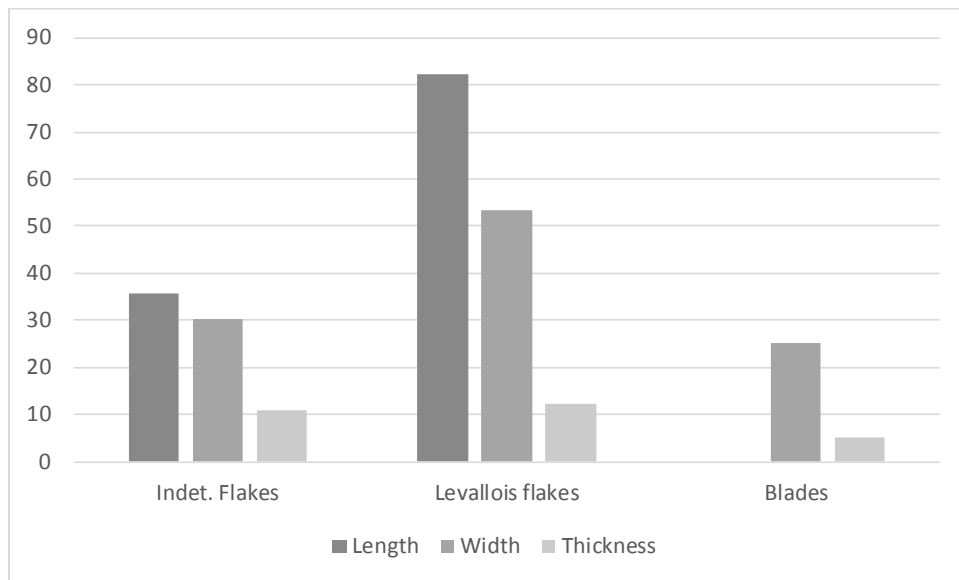


Figure 109: Ust'-Karakol, layer 14. Mean measurements of the products.

- Dorsal scar pattern

Most of the products present a unidirectional parallel pattern (Table 139), although the Levallois flakes are also bidirectional parallel and centripetal.

	Levallois	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Unidirectional parallel</i>	1	2	2	9	14
<i>Unidirectional convergent</i>		1		1	2
<i>Bidirectional parallel</i>	1			2	3
<i>Bidirectional orthogonal</i>				2	2
<i>Centripetal</i>	1				1
<i>Multidirectional</i>				1	1
<i>Cordal</i>				1	1
<i>Cortical</i>				1	1
<i>Indet</i>				2	2
Total	3	3	2	19	27

Table 139: Ust'-Karakol, layer 14. Dorsal scar pattern.

- Platform preparation

The platforms are generally plain, the only faceted platform belongs to a blade (Table 140).

	Levallois	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Plain</i>	3			10	13
<i>Facetted</i>		1		2	3
<i>Punctual</i>			1		1
<i>Cortical</i>				2	2
<i>ND</i>		2	1	5	8
<i>Total</i>	3	3	2	19	27

Table 140: Ust'-Karakol, layer 14. Platform preparation.

- Morphology

The products mainly have a quadrangular shape (Table 141), with a straight profile (Table 142) and a triangular cross-section (Table 143).

	Levallois	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Quadrangular</i>	3	3	2	15	23
<i>Triangular</i>				3	3
<i>Semi-circular</i>				1	1
<i>Total</i>	3	3	2	19	27

Table 141: Ust'-Karakol, layer 14. Product shape.

	Levallois	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Straight</i>	2	3	2	14	21
<i>Concave</i>				2	2
<i>Convex</i>				1	1
<i>Sinuuous</i>	1			2	3
<i>Total</i>	3	3	2	19	27

Table 142: Ust'-Karakol, layer 14. Product profile.

	Levallois	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Triangular</i>	2	1	1	13	17
<i>Trapezoidal</i>	1	2	1	5	9
<i>Indet.</i>				1	1
<i>Total</i>	3	3	2	19	27

Table 143: Ust'-Karakol, layer 14. Product cross-section.

4.3.2.6.3 Transformed products

Three tools have been identified, two notches and a bifacial tool (Table 144). The latter has been produced on a slab blank, and is still partly cortical on one face. The notches were produced on a complete Kombewa flake and a proximal fragment of indeterminate flake. The retouch, on the right side of the blanks, is short, semi-abrupt, and scaled. Its position is direct for one and inverse for the other one.

	<i>Nb</i>
<i>Notch</i>	2
<i>Bifacial tool</i>	1
<i>Total</i>	3

Table 144: Ust'-Karakol, layer 14. Types of tools.

4.3.2.7 Layer 13

4.3.2.7.1 Reduction sequences

No core was identified in this layer. However, in Derevianko *et al.* (2003) and Zwyns (2012), we note the representations of a bidirectional parallel Levallois core and the mention of two other unidirectional parallel cores¹². These artefacts were unfortunately absent from the collection at the moment of the study.

4.3.2.7.2 Production

The production (n=7) is composed of flakes. Only one of them is mainly cortical, all the others do not bear any residual cortex.

The Levallois production is composed of one Levallois flake.

- Breakage

The flakes are mainly fractured, with only two products complete (Table 145).

¹² It is unclear if these cores are Levallois or not, as they are not represented.

	Flakes	Total
<i>Distal</i>	2	2
<i>Mesio-proximal</i>	3	3
<i>Complete</i>	2	2
<i>Total</i>	7	7

Table 145: Ust'-Karakol, layer 13. Breakage.

- Size

The indeterminate flakes are on average 25 x 29.2 x 7.6 mm, while the Levallois flake is 48.1 x 6 mm (Figure 110).

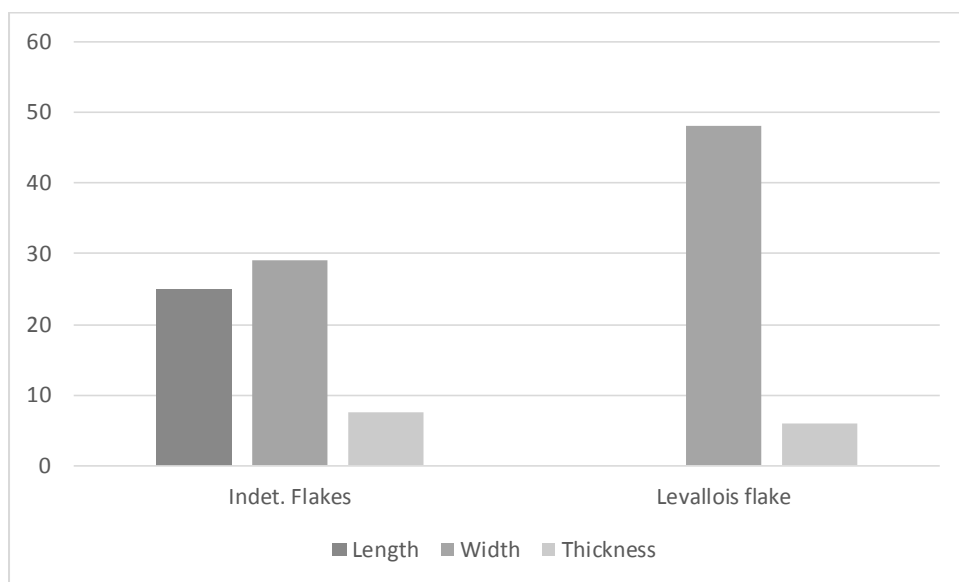


Figure 110: Ust'-Karakol, layer 13. Mean measurements of the products.

- Dorsal scar pattern

Most of the products present a unidirectional parallel scar pattern (Table 146).

	Levallois	Indet./low predet.	Total
<i>Unidirectional parallel</i>	1	2	3
<i>Cordal</i>		2	2
<i>Cortical</i>		1	1
<i>Indet</i>		1	1
<i>Total</i>	1	6	7

Table 146: Ust'-Karakol, layer 13. Dorsal scar pattern.

- Platform preparation

The platforms are mainly plain, but can also be dihedral or punctual (Table 147).

	Levallois	Indet./low predet.	Total
<i>Plain</i>		3	3
<i>Dihedral</i>	1		1
<i>Punctual</i>		1	1
<i>ND</i>		2	2
<i>Total</i>	1	6	7

Table 147: Ust'-Karakol, layer 13. Platform preparation.

- Morphology

The products mainly display a triangular shape (except the Levallois flake; Table 148), with a straight profile (Table 149) and a triangular cross-section (Table 150).

	Levallois	Indet./low predet.	Total
<i>Quadrangular</i>	1	1	2
<i>Triangular</i>		5	5
<i>Total</i>	1	6	7

Table 148: Ust'-Karakol, layer 13. Product shape.

	Levallois	Indet./low predet.	Total
<i>Straight</i>	1	6	7
<i>Total</i>	1	6	7

Table 149: Ust'-Karakol, layer 13. Product profile.

	Levallois	Indet./low predet.	Total
<i>Triangular</i>		5	5
<i>Trapezoidal</i>	1		1
<i>Rectangular</i>		1	1
<i>Total</i>	1	6	7

Table 150: Ust'-Karakol, layer 13. Product cross-section.

4.3.2.7.3 Transformed products

One flake presents a distal truncating that was used as a platform for the removal of two burin chutes (Table 151). These removals are *débordants* on the dorsal surface of the flake.

	<i>Nb</i>
<i>Burin</i>	1
<i>Total</i>	1

Table 151: Ust'-Karakol, layer 13. Types of tools.

4.3.3 Summary

Ust'-Karakol Middle Palaeolithic layers yielded assemblages of various sizes, but quite homogenous on the technological point of view. Layer 19 bears an important significance due to its date at 133 ± 33 ka – therefore attributable to the last interglacial (MIS5e) –, making it one of the most ancient directly dated assemblages in Altai. The material is heavily weathered by water circulation, thus the identification of the technological characteristic was more difficult. However, some artefacts display features that demonstrate the presence of the Levallois reduction sequence: two Levallois blades, a proximal of a Levallois product, and possibly a *débordant* flake. Unfortunately, the layer didn't yield any core that could have borne valuable information on the types of reduction.

Layer 18 is the most informative layer; all the cores in this layer show a Levallois-like management of the surfaces and convexities, although only one fully answers to the criteria of the Levallois concept – a previous series of refits, including one more Levallois core, show a bidirectional parallel reduction (Postnov, 1999). The production is aimed at the obtaining of points, blades and flakes. The Levallois products are generally characterised by larger dimensions than the other flakes, more than twice as long on average.

Layers 17 to 13 yielded few material, but show the same technological characteristics, with the presence of blades and Levallois products, except in layer 17, and very scarce retouched tools. Cores are presents only in layers 14 and 13, although for the latter we only know them through the bibliography, as they were absent from the collection at the time of the study. Layer 14 has yielded a radial flake core, and layer 13 two parallel cores (probably low predetermination) and a bidirectional parallel Levallois core. As mentioned in 3.2.2.6, material from layers 15, 14 and 13 have been mixed with material from layers 8 to 11 (Belousova, 2012; Shunkov and Belousova, 2015). These taphonomic issues make the assemblage's interpretation difficult.

4.4 KARA-BOM

4.4.1 Raw material

As mentioned in 3.2.2.5, Kara-Bom stands out amongst Altai sites as 98% of the raw material consists in the same acidic aphyric cryptocrystalline effusive rock, found in the alluvium of the nearby Semistart and Altairy rivers (Kulik *et al.*, 2003; Kulik, 2014; Slavinsky *et al.*, 2016; 2019). This high quality material allowed the implementation of demanding reduction sequences such as Levallois.

4.4.2 Technological study

This study focuses on material recovered during the 1992 and 1993 campaigns in the 3 and 4 excavation areas. We examined the assemblage associated with the earliest Middle Palaeolithic occupation, in MP2.

Some differences in number can be noted with the count in the monograph (Derevianko *et al.*, 1998d). The reasons are the same as for the Ust'-Karakol material: the ongoing refitting study, and the exhibition of some artefacts at the Museum of History and Culture of the people of Siberia and the Far-East in Novosibirsk and at the temporary exhibit "The third man. Prehistory of Altai" in the National Museum of Prehistory at Les Eyzies-de-Tayac in France.

LAYER	MP2
Cores	19
<i>Levallois</i>	16
Flakes	263
<i>100 % cortex</i>	
<i>>50 % cortex</i>	15
<i>< 50 % cortex</i>	66
<i>No cortex</i>	182
<i>Levallois flakes and points</i>	51
<i>Blades</i>	77
Debris and fragments	39
Total	321

Table 152: Kara-Bom. Repartition of the artefacts.

4.4.2.1 MP2

4.4.2.1.1 Reduction sequences

Out of the nineteen cores that have been identified in MP2, sixteen are recognized as Levallois, one is a blade core, and two have been reduced according to low predetermination schemes (Table 153).

<i>Method</i>	<i>Mode</i>	<i>Matrix</i>	<i>Nb</i>
<i>Levallois</i>	Centripetal	Pebble	5
	Unidirectional parallel	Pebble	4
		Flake	2
	Unidirectional convergent	Pebble	2
		Indet.	1
	Preferential	Pebble	1
		Indet.	1
	<i>Blade core</i>	Unidirectional parallel	Indet.
<i>Low Predetermination</i>	1 FS	Nodule	1
	2 FS	Flake	1
<i>Total</i>			19

Table 153: Kara-Bom, layer MP2. Cores.

The low predetermination cores are produced on a nodule and on a flake. The first one has been flaked on one surface of the nodule, with 5 unidirectional parallel removals. The reason why the flaking was not continued is unclear, as no obstacle or accident occurred. The other core opposes two non-hierarchized flaking surfaces, one with 4 bipolar orthogonal removals and the other one with 4 centripetal removals. No preparation of the striking platforms could be identified, and the flaking angle of most of the removals is secant.

- KB92.M2.I12.2.2073

This core shows two unidirectional removal negatives on a relatively narrow flaking surface (Figure 111). The last removal was hinged, which hindered further production. One hinged removal negative is the only evidence of the striking platform management. We categorize this core as an expedient, volumetric blade core.

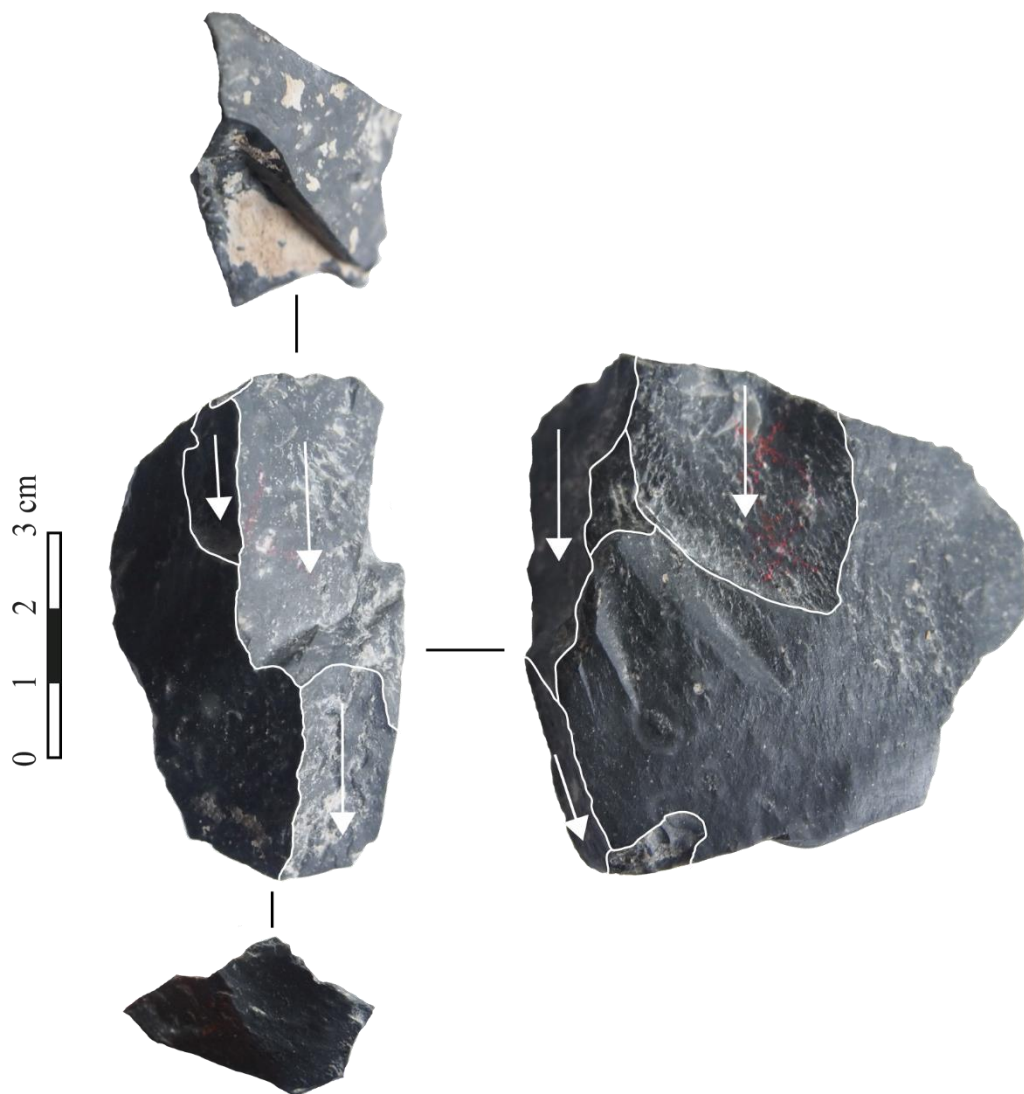


Figure 111: Kara-Bom, layer MP2. KB92.M2.I12.2.2073.

The Levallois production

Centripetal cores

Since the cores in this category are reduced according to the same chaîne opératoire, except for minor variations, we will describe core KB93.M2.I7.7.4167 as a typical example (Figure 112).

This core is produced on a pebble. It opposes two hierarchized surfaces. The back, slightly cortical, is prepared by a series of more than 10 secant, centripetal removals, and forms a dome. The flaking surface illustrates a series of 9 centripetal removals. Some deeper removals were used for the shaping of the surface, but most are predetermined products. The reduction stopped as no more favourable angle was available to knap further.

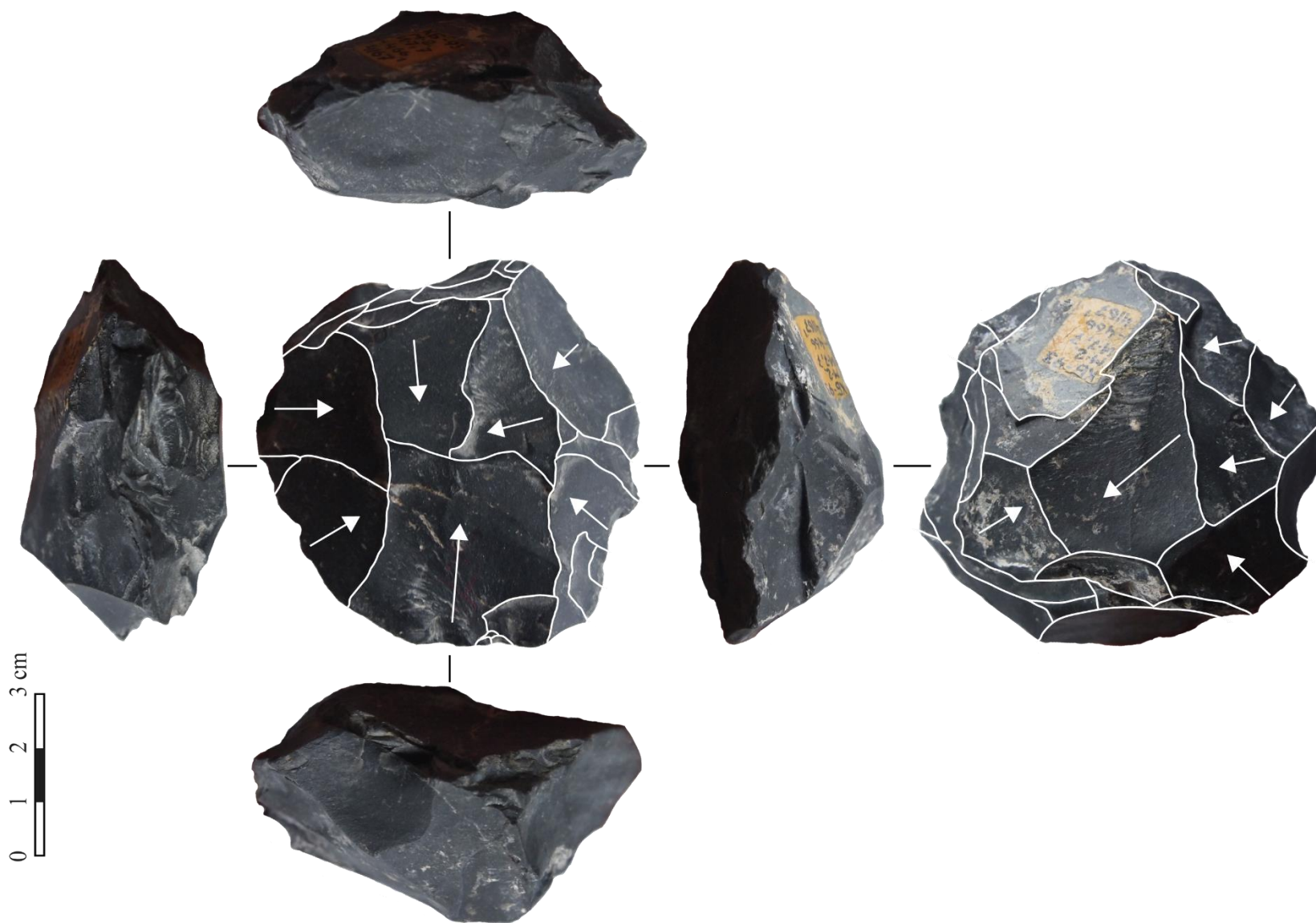


Figure 112: Kara-Bom, layer MP2. KB93.M2.I7.7.4167.

For some other cores, the back surface was less invested, with a lot more residual cortex (Figure 113); the reduction could be interrupted by the presence of deep hinges, or a flat surface not allowing reshaping (*ibid.*).

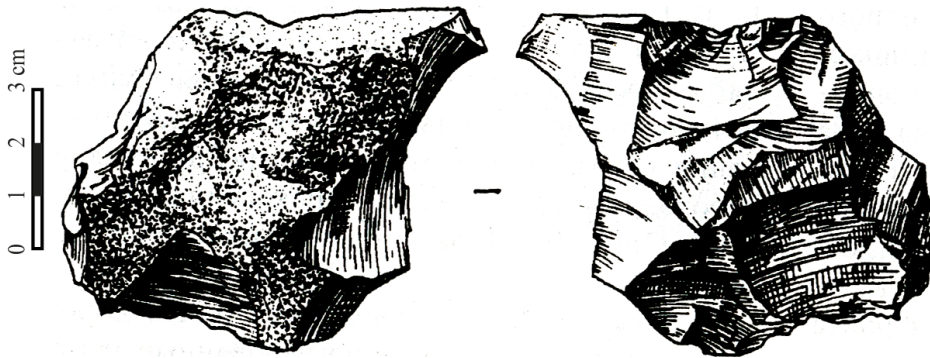


Figure 113: Kara-Bom, layer MP2. KB93.M2.3/7.4056 (Derevianko et al., 1998)

Unidirectional parallel cores

- KB93.M2.E10/13.4142

This core, produced on a pebble, retains a noticeable portion of residual cortex, as the two surfaces are partially flaked (Figure 114). One surface displays a series of secant, centripetal removals which correspond to striking platform preparation for the removals on the flaking surface. Six unidirectional removals can be observed on the flaking surface. It is unclear why the reduction was not continued.

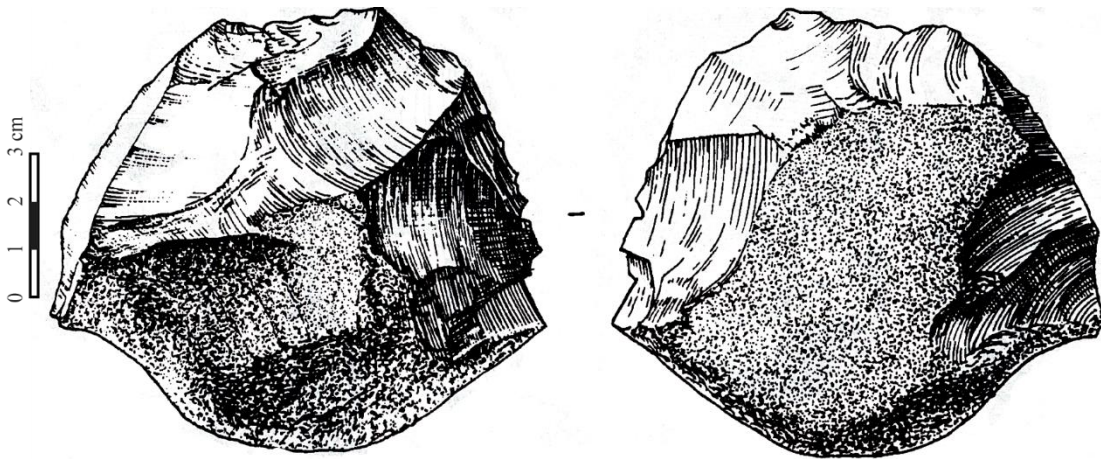


Figure 114: Kara-Bom, layer MP2. KB93.M2.E10/13.4142 (Derevianko et al., 1998)

- KB92.M2.J11.14.2026

This core was manufactured on a pebble. The back is prepared by a series of centripetal removals, leaving only a fraction of residual cortex. The flaking surface, completely flat at the end stage, bears the scars of six unidirectional parallel removals.

- KB92.M2.I13.7.2056

This core is produced on a flake. The ventral surface of the flake is used as a flaking surface, with the removals of at least 4 unidirectional parallel flakes. The dorsal surface was prepared by the removal of centripetal, secant flakes. The resulting core presents a completely flat flaking surface.

- KB92.M2.2456

This core, produced on a pebble, opposes a mainly cortical back to a flat flaking surface (Figure 115). The back is prepared by series of removals, first centripetal, then unipolar parallel, corresponding to the striking platform preparation of the preferential flakes. We observe some removals from the opposite platform but they seem to be only for the shaping of the surface. This core can thus be classified as a unidirectional parallel core.

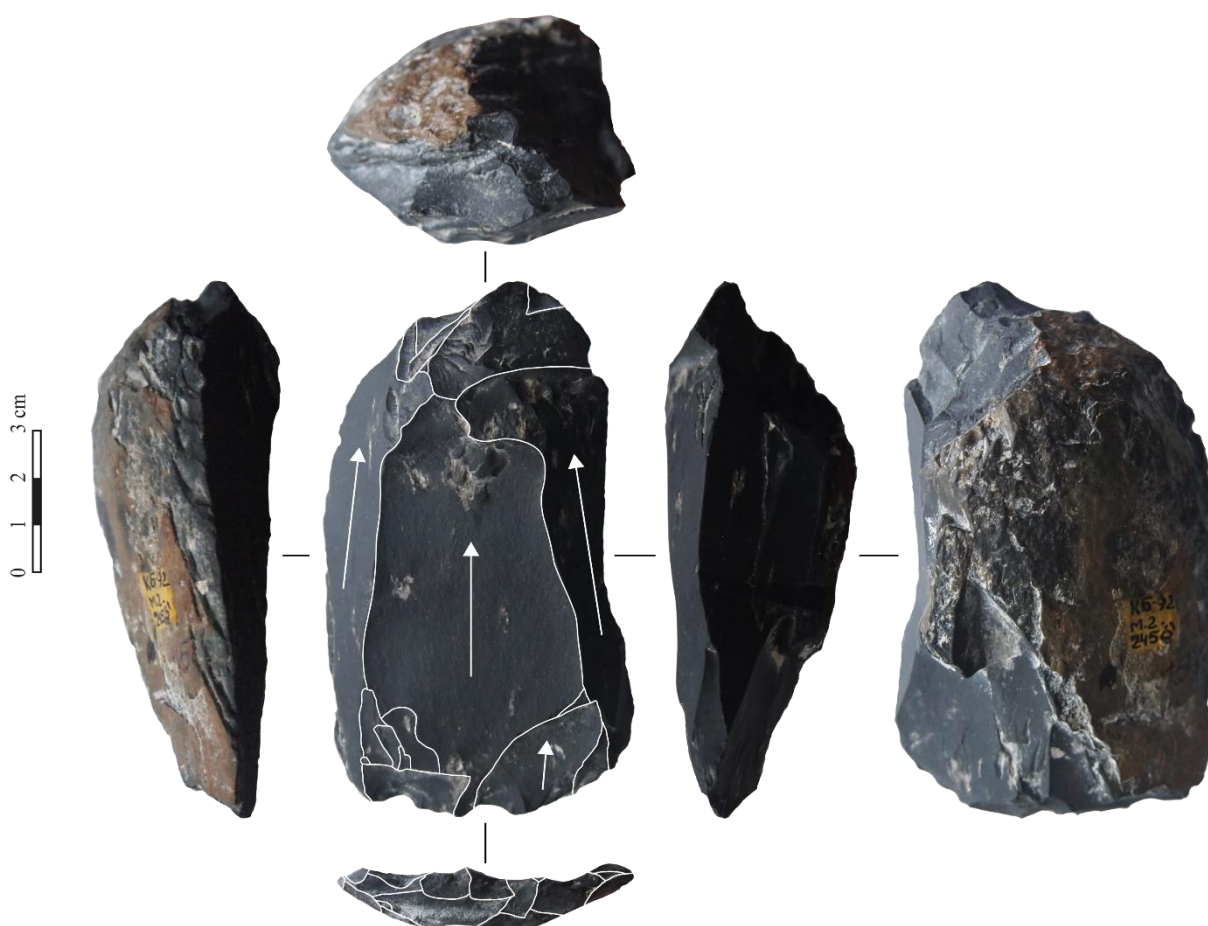


Figure 115: Kara-Bom, layer MP2. KB92.M2.2456.

- KB93.M2.Z7.13.4171

This core is produced on a pebble. It opposes a dorsal surface prepared by a series of centripetal, secant removals, to a flaking surface where we can see the scars of unidirectional parallel flaking.

- KB93.M2.J10.27.4140

This core is produced on a cortical flake, the dorsal surface of which was used as a flaking surface and the ventral surface as a Levallois surface (Figure 116). The back is unprepared except for the platform that was used to produce the preferential flakes on the Levallois surface. The flaking surface displays the removals of several products, the last of which being slightly appointed.



Figure 116: Kara-Bom, layer MP2. B93.M2.J10.27.4140.

Unidirectional convergent cores

- KB93.M2.J10.4.4083

This core, produced on a pebble, opposes two surfaces (Figure 117). The back is prepared by a series of more than 10 centripetal, secant removals. On the flaking surface, we can identify the removals of 7 products, according to a unidirectional convergent reduction.

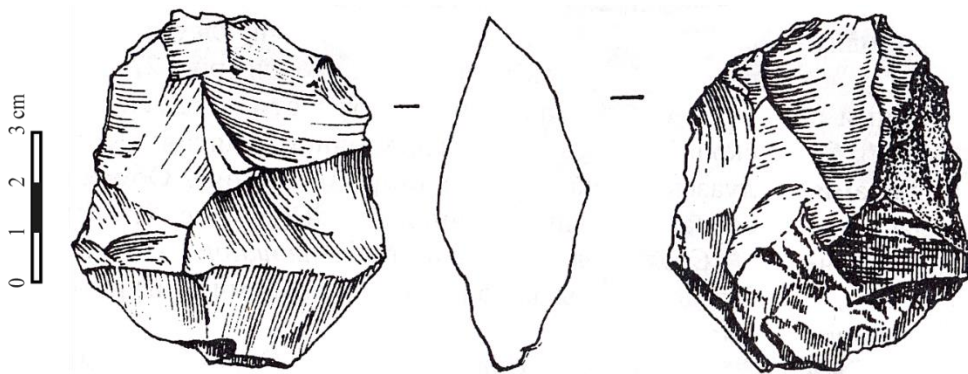


Figure 117: Kara-Bom, layer MP2. KB93.M2.J10.4.4083 (Derevianko et al., 1998).

- KB93.M2.E10.14.4211

The back of this core was prepared by a series of at least 10 centripetal, secant removals; the flaking surface displays the scars of the removals of 7 flakes forming a unidirectional convergent pattern. This core was abandoned after being broken in two, probably voluntarily.

- KB92.M2.G10.2.2054

This core was produced on a pebble. The back bears the scars of the bidirectional removals of 6 flakes. The flaking surface was shaped by alternating secant and subparallel removals, forming a unidirectional convergent pattern allowing the final removal of a Levallois point.

Preferential cores

- KB93.M2.I9/4.4178

This core was produced on a pebble (Figure 118). The back is half cortical, and prepared by unidirectional convergent flaking. The flaking surface bears the traces of numerous centripetal flakes, as preparation for the removal of a preferential product that broke the core in half.

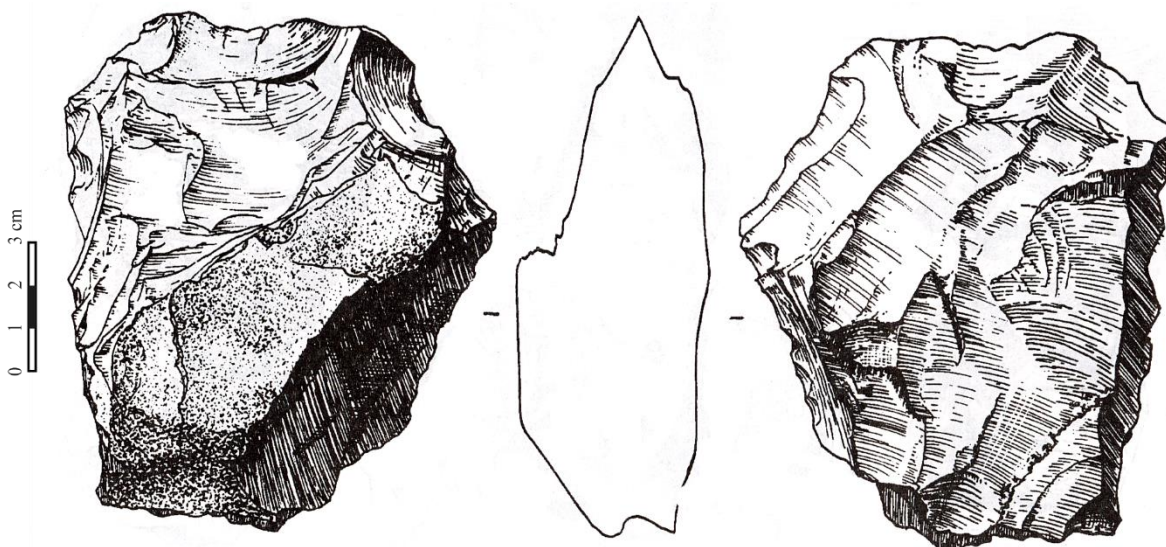


Figure 118: Kara-Bom, layer MP2. KB93.M2.I9/4.4178 (Derevianko et al., 1998)

- KB92.M2.Z13.10.2071

The back of this core was prepared by a series of more than 15 centripetal, secant removals. On the opposed surface, we can see the preparation of the Levallois surface with the removals of small, centripetal flakes. The removal of the preferential flake is so invading that only few information is available on the previous management of the core.

4.4.2.1.2 Production

The production is dominated by flakes (n=184), along with blades (n=78), with one bladelet. Most of the products do not display any residual cortex (n=182); only 15 artefacts are covered for more than 50% of their dorsal surface.

The Levallois production is composed of Levallois flakes (n=28) and Levallois points (n=24; Figure 119), with a smaller portion of Levallois blades (n=16; Figure 120). Some elements of the Levallois reduction sequence were also identified: *débordant* flakes (n=5) and maintenance flakes (n=3).

- Breakage

About half the assemblage is complete (Table 154), although the rate drops to 20% for the blades.

	Blades	Flakes	Total
<i>Distal</i>	9	28	37
<i>Mesio-distal</i>	5	4	9
<i>Mesial</i>	24	7	31
<i>Mesio-proximal</i>	16	20	36
<i>Proximal</i>	9	17	26
<i>Fragment</i>	1	8	9
<i>Complete</i>	15	100	115
<i>Total</i>	79	184	263

Table 154: Kara-Bom, layer MP2. Breakage.

- Size

Indeterminate flakes are the smallest type of product, with an average of 46.5 x 35.3 x 10.7 mm. Levallois flakes are longer and wider (68.6 x 44.6 x 10.5 mm), while blades are the longest, narrowest and thinnest products (80.3 x 29.1 x 9.1 mm; Figure 121).



Figure 119: Kara-Bom, layer MP2. Levallois points.

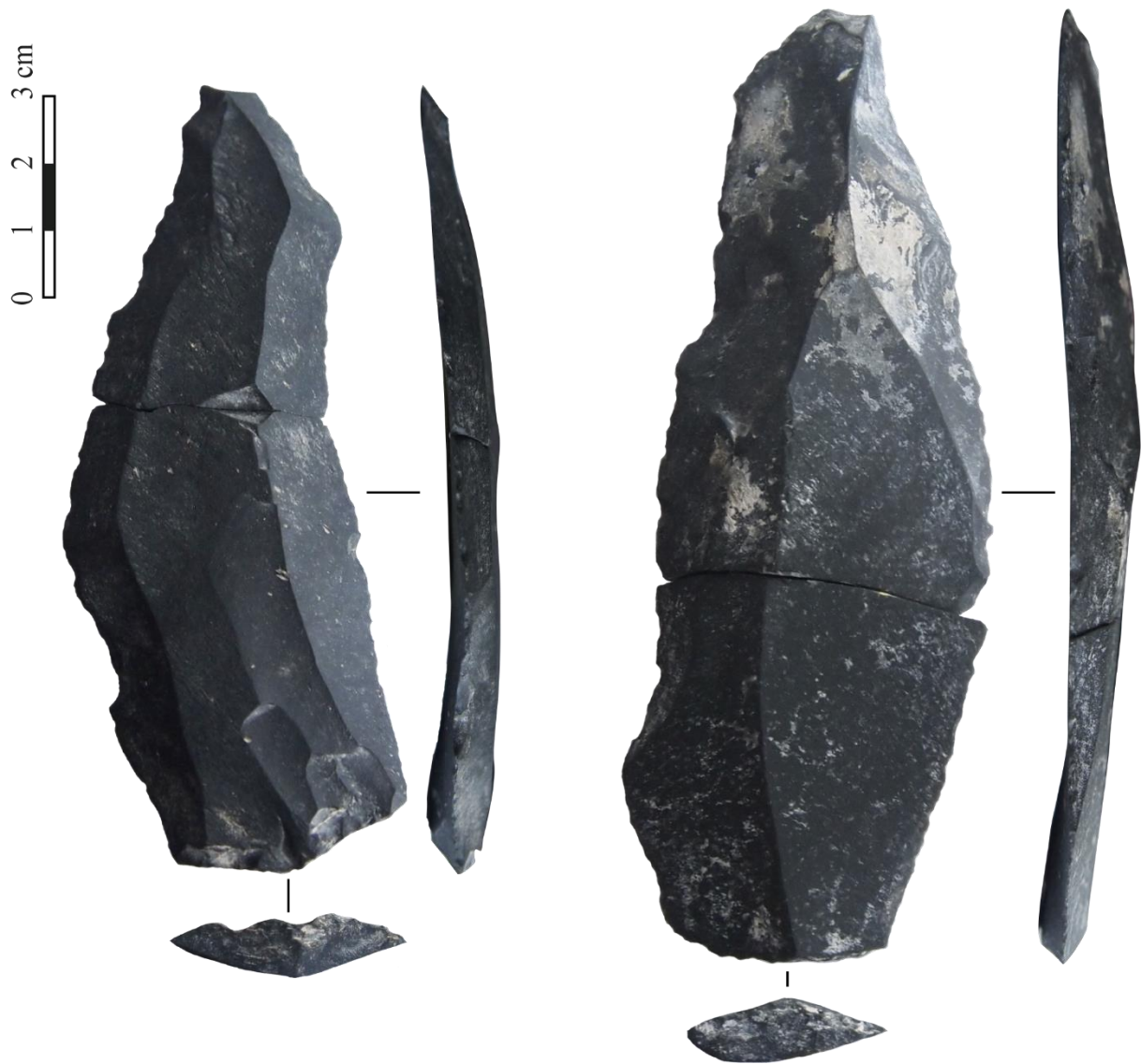


Figure 120: Kara-Bom, layer MP2. Levallois blades.

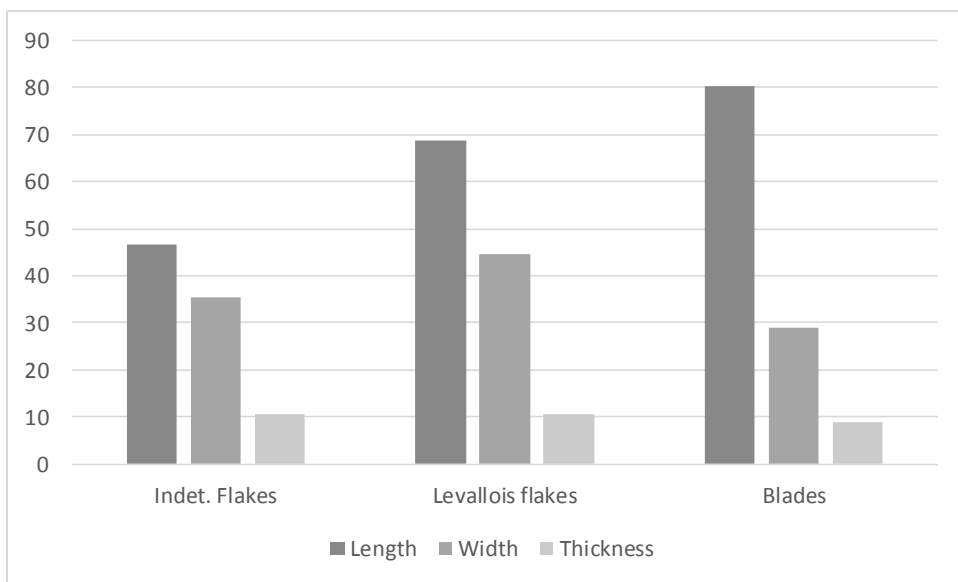


Figure 121: Kara-Bom, layer MP2. Mean measurements of the products.

- Dorsal scar pattern

On the whole, products display mainly unidirectional parallel patterns (Table 155). However, for Levallois products it is closely followed by unidirectional convergent scars.

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Unidirectional parallel</i>	34	1	45	1	60	141
<i>Unidirectional convergent</i>	29		1		9	39
<i>Bidirectional parallel</i>	6	1	9		10	26
<i>Bidirectional orthogonal</i>	3		4		21	28
<i>Centripetal</i>	2				3	5
<i>Multidirectional</i>					7	7
<i>Cordal</i>	2				10	12
<i>Indet</i>					5	5
Total	76	2	59	1	125	263

Table 155: Kara-Bom, layer MP2. Dorsal scar pattern.

- Platform preparation

For the indeterminate flakes, the platforms are mainly plain, but for the Levallois products and the blades faceted platforms are common (Table 156).

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Plain</i>	22	1	11		64	98
<i>Dihedral</i>	10		5		3	18
<i>Facetted</i>	30		8		10	48
<i>Punctual</i>	1		1		1	1
<i>Cortical</i>	1				6	7
<i>Missing</i>	1					1
<i>Broken</i>	1				1	2
<i>ND</i>	10	1	34	1	40	86
Total	76	2	59	1	125	263

Table 156: Kara-Bom, layer MP2. Platform preparation.

- Morphology

The average product is quadrangular (Table 157), with a straight profile (Table 158), and a triangular or trapezoidal cross-section (if indeterminate flakes present mostly triangular

patterns, Levallois products distinguish themselves by their predominantly trapezoidal cross-sections; Table 159).

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Quadrangular</i>	43	1	54	1	78	177
<i>Triangular</i>	33	1	5		44	83
<i>Semi-circular</i>					3	3
<i>Total</i>	76	2	59	1	125	263

Table 157: Kara-Bom, layer MP2. Product shape.

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Straight</i>	63	2	52		97	214
<i>Concave</i>	10		6	1	15	32
<i>Convex</i>	2		1		10	13
<i>Sinuuous</i>	1				3	4
<i>Total</i>	76	2	59	1	125	263

Table 158: Kara-Bom, layer MP2. Product profile.

	Levallois	Volumetric laminar	Blades (ind.)	Bladelet	Indet./low predet.	Total
<i>Triangular</i>	22	2	32	1	75	132
<i>Trapezoidal</i>	54		26		37	117
<i>Semi-circular</i>					3	3
<i>Rectangular</i>					11	11
<i>Total</i>	76	2	59	1	125	263

Table 159: Kara-Bom, layer MP2. Product cross-section.

4.4.2.1.3 Transformed products

The transformed products represent 14% of the artefacts (n=36; Table 160). The selection rate of predetermined blanks is quite high, as 9 blades and 10 Levallois flakes and points were retouched (*i.e.* 50% of the toolkit); however, these tools are very simple, mostly truncated (n=2) and retouched blades (n=6), and one burin for the blades, and truncated (n=4) and partially retouched (n=5), with one simple sidescraper for the Levallois flakes and points (Figure 122).

The retouch is usually continuous, direct, total, scaled and semi-abrupt, with a short extent.

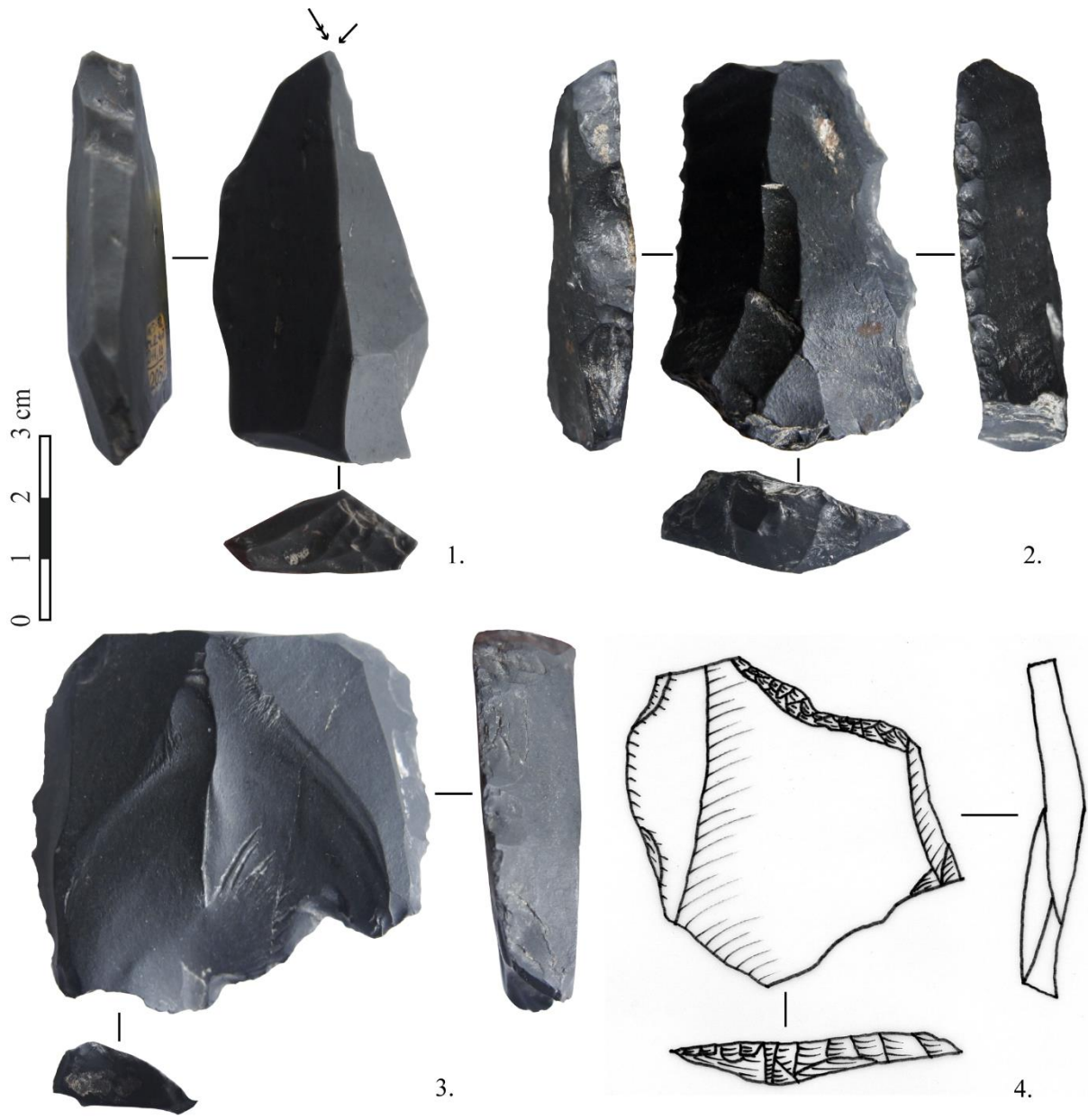


Figure 122: Kara-Bom, layer MP2. Burin (1), scrapers (2, 3), truncated flake (4).

	<i>Nb</i>
<i>Scraper</i>	7
<i>Simple</i>	6
<i>Double</i>	1
<i>Retouched blade</i>	6
<i>Notch</i>	1
<i>Burin</i>	2
<i>Perforator</i>	2
<i>Truncated blade</i>	2
<i>Truncated flake</i>	6
<i>Partially retouched flake</i>	10
<i>Total</i>	36

Table 160: Kara-Bom, layer MP2. Types of tools.

4.4.3 Summary

Kara-Bom MP2 production is nearly completely devoted to Levallois reduction sequences, with the sporadic presence of low-predetermination cores and flakes. The Levallois cores can be linked to various modes: recurrent centripetal, unidirectional parallel and convergent, but also preferential. The production includes numerous Levallois points and flakes; blades are produced by Levallois and volumetric methods (one volumetric blade core has been identified, but no other technological element). A long refitted sequence shows a production of Levallois points on the flat face along with a production of side blades on the narrow face of the core (Slavinsky and Rybin, 2007). Half of the toolkit is produced on Levallois blanks (points, flakes and blades), with a majority of simple tools, such as scrapers, retouched blades or partially retouched flakes.

*5 Discussion
and conclusion*

5.1 THE LEVALLOIS CONCEPT IN ALTAI

5.1.1 Identification and variability

As we saw in the previous chapters, the Levallois concept is well represented in the Altai Middle Palaeolithic, as only one site didn't yield any type of Levallois element: Chagyrskaya Cave. In the four studied sites, the Levallois concept is illustrated by the production of flakes, blades and points. However, the methods used and the importance of the Levallois production in each assemblage are different.

<i>Site</i>	<i>Layer</i>	<i>Most frequent mode(s) (cores)</i>	<i>Most frequent mode(s) (products)</i>	<i>% cores</i>
<i>Ust'-Kanskaya</i>	8	Centripetal	Unidirectional convergent, unidirectional parallel	33%
	7	Centripetal	Unidirectional parallel Unidirectional convergent	25%
	6	Centripetal	Unidirectional parallel Unidirectional convergent	33%
	5	Centripetal	Unidirectional parallel Unidirectional convergent	14%
	4	/	Unidirectional parallel Unidirectional convergent	/
	3	Unidirectional parallel	Unidirectional parallel Unidirectional convergent	11%
	2	/	Unidirectional parallel Unidirectional convergent	/
<i>Denisova</i>	20CC	Centripetal	Unidirectional parallel Unidirectional convergent	?
<i>Ust'-Karakol</i>	18	Bidirectional parallel	Unidirectional parallel Unidirectional convergent	25%
<i>Kara-Bom</i>	MP2	Unidirectional parallel, centripetal	Unidirectional parallel Unidirectional convergent	84%

Table 161: The Levallois concept in the studied assemblages.

The recurrent methods are dominant in all the series (Table 161), the lineal methods are present in some assemblages but remain exceptional.

Kara-Bom is the site where the Levallois concept is the more prevalent, with 84% of the cores and about half of the products being predetermined blanks (Levallois flakes, points and blades). The unidirectional parallel and unidirectional convergent methods are the most used, but the centripetal and preferential method are also present. The platforms are mostly prepared by a careful faceting.

The most informative layer of Ust'-Karakol, layer 18, yielded four cores that all show Levallois tendencies in their conception, although only one could fully correspond to the Levallois criteria. It demonstrates a bidirectional mode that is consistent with the products, mainly unidirectional and bidirectional parallel. Contrary to what we can see at Kara-Bom, the platforms are mainly plain. The goal of the production was to obtain long, raw cutting edges, as none of the products were retouched.

We can see that in both cave sites, Denisova and Ust'-Kanskaya, the cores usually display the scars of a centripetal reduction, although the products indicate a uni-bidirectional flaking pattern. Since the centripetal cores are always heavily reduced, it is possible that a first reduction sequence was implemented uni-bidirectionally, then modified to a centripetal reduction when the size of the core didn't allow the production of long blanks.

5.1.2 Appearance, first elements

The most ancient Levallois in Altai is said to come from layer 22 in Denisova cave, with a *terminus ante quem* at 287 ± 41 ka (Derevianko *et al.*, 2003; Jacobs *et al.*, 2019). In our study, we found no evidence of the implementation of a Levallois reduction sequence in this assemblage, except an elongated Levallois point that is illustrated in Derevianko *et al.* (2003; fig. 58, 6). As we argued in 4.2.3, the presence of only one Levallois product is too tenuous to conclude that the Levallois reduction sequence was implemented in this assemblage.

Without this point, the oldest dated assemblage presenting a clear Levallois reduction sequence is from layer 20 of the Central Chamber of Denisova, which was accumulated between 250 ± 44 ka and 170 ± 19 ka. It consists of Levallois blades, Levallois points and a fragmented Levallois flake, as well as numerous other flakes that could be part of a Levallois reduction sequence (débordant flakes and other predetermining flakes, blades that were non-diagnostic either for Levallois or volumetric methods, as well as fragments of potential predetermined products). A core has been identified as a recurrent centripetal Levallois core that has been flaked more expediently towards the end of its reduction, leading to a slightly less typical morphology.

The predetermined Levallois products of layer 20CC present all the characteristics of a developed Levallois reduction sequence. The platforms are carefully prepared: either by faceting, or by the implementation of a dihedral platform, or by the shaping of a raised plain platform. The products are thin and they are elongated when not fragmented. Their negatives demonstrate that there was a careful management of the convexities of the cores' flaking surfaces.

Due to the small number of artefacts, especially cores, it is hard to draw conclusions on the matter of the first Levallois in Altai. However, we note that the predetermined products seem to result from a fully formed Levallois reduction sequence, and not a typo-Levallois¹³ or “proto-Levallois” concept. The only earlier production in the area is the pebble industry from Karama, dated around 800 ka (Derevianko *et al.*, 2001c). This industry is unlikely to have derived in a Levallois-type reduction, since the volumetric conception is very different. It thus seems that the Levallois concept appeared in the Altai already fully developed.

In the absence of a more representative assemblage, it is hard to address the question of the emergence of the Levallois technology in the region. In our opinion, an *in situ* emergence of the concept seems unlikely, considering there is no cultural foundation for it in the earlier periods, such as Acheulean technology or “proto-Levallois” productions that are said to have developed into Levallois in Africa and Europe (Caton-Thompson, 1946; Movius, 1969; Moncel, 1999; DeBono and Goren-Inbar, 2001; White and Ashton, 2003; Tuffreau, 2004).

5.1.3 Techno-economy

The raw materials used in the assemblages are usually diverse, spanning multiple petrographic categories, from material with good knapping qualities like chert or jasperoids, to material that are harder to work on, like quartz or schist. Most of the material have been affected by tectonic processes, which modified their petrographical characteristics (Kulik and Postnov, 2001). The absence in the region of a universally available high-quality material such as flint led to a necessary adaptation to the various raw material and selection strategies (Kulik, 2014). The raw materials were usually collected among the local river pebbles, but the difference in the composition between the river pebbles and the lithic assemblages show a careful selection of some types of raw materials for their knappable qualities (Figure 123, Figure 124).

¹³ Corresponding to Boëda's D1-type structure (Boëda, 2013).

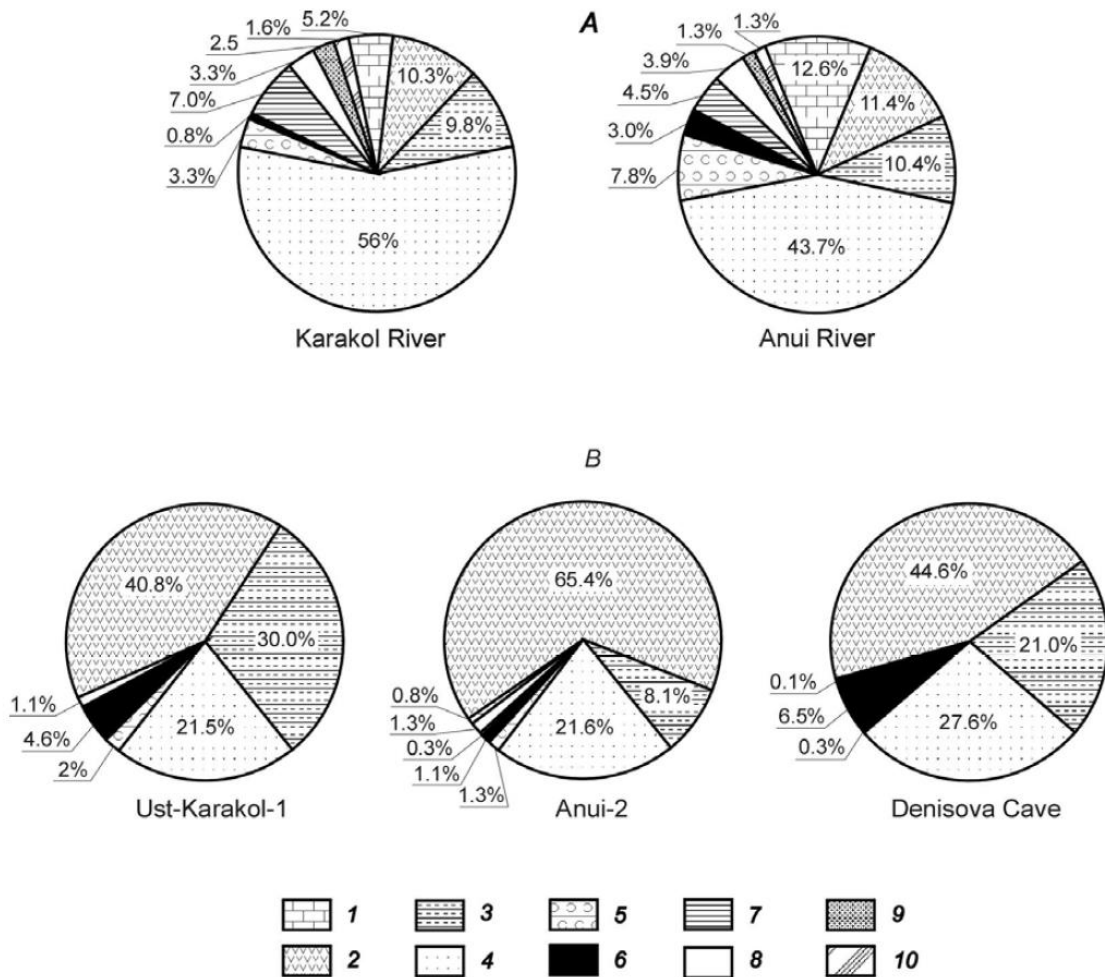


Figure 123: Comparison of petrographical differences in pebble materials (A) and the Palaeolithic assemblages (B). 1: limestones; 2: volcanic rocks; 3: aleurolites; 4: sandstones; 5: gravelites; 6: hornfels; 7: slates; 8: quartz; 9: granite; 10: dyke rocks (Anoikin and Postnov, 2005)

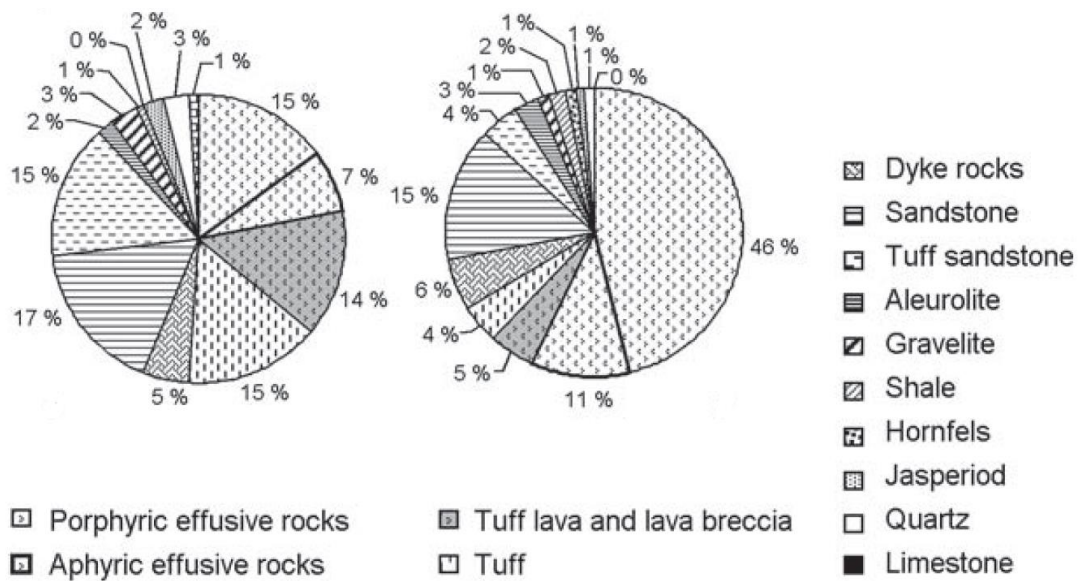


Figure 124: Petrographic composition of the Charysh river pebble assemblage (on the left) and Ust'-Kanskaya lithic assemblage (on the right; Kulik, 2014)

It is interesting to note that in the studied assemblages, the initialization steps of the debitage, documented by the cortical blanks, are mostly absent, even if the raw material source was near, when we could expect that the whole pebble had been brought (Tavoso, 1984; Geneste, 1991a). We can assume that the knapper tried and tested the pebbles, and roughly shelled them before bringing them to the sites.

We were not able to distinguish a real differentiated economy of the raw materials (Perlès, 1980; 1991) in Denisova or Ust'-Karakol, where all the types of materials were used in the same proportions for different types of reduction. However in Ust'-Kanskaya, we saw that the quartz and schist were reserved for low predetermination methods, while jasperoids were selected at 70% for HDP methods.

Kara-Bom is a particular site in the Altai Middle Palaeolithic, as it is situated near an outcrop of aphyric cryptocrystalline effusive rock, and the knappers nearly exclusively worked this high quality material (amounting to 98% of the total of artefacts). Here too, cortical flakes are poorly represented in the assemblage, and it is likely that the slabs were shelled directly where they were collected.

5.1.4 Relations with other concepts

None of the assemblages we studied yielded a production that was 100% Levallois, as it was always accompanied by other types of volumetric concepts. What is the complementarity between the different *chaînes opératoires*, and why was there a need for multiple types of production, depending on different mental templates?

5.1.4.1 The low predetermination production

In all the assemblages, the Levallois production coexists with low predetermination schemes, whether they are a majority or not.

In Ust'-Kanskaya, the Levallois production is always a minority compared to low predetermination schemes. The cores (n=62) are usually discarded after only a few removals, for no apparent reason. Most of them present one (n=28) or two (n=28) flaked surfaces. Usually, the surfaces are opposed, but they are adjacent for 3 of the cores. On half the cores (n=29), identifying an organization of the removals was impossible; the others are mostly centripetal or unidirectional parallel.

The products are varied, and are on the whole smaller than Levallois products or blades, since there is not this research for elongation; however, we also find in this category some very large,

thick flakes. The artefacts mostly present a quadrangular shape, a rectangular profile and a triangular section. They were usually selected over Levallois products as supports for tools, especially the thicker ones (Figure 125). Besides, we identified in layer 5 three “chopping tools”, pebbles that have been flaked on their narrow extremity. It is the only assemblage where we found this type of artefact.

The aim of the low predetermination production seem to be different from Levallois or laminar production, as there is not this research for elongated pieces, but a variety of products, usually thicker and shorter. The selection of the bigger flakes for scrapers or other tools could mean a need for a large working edge, as well as a thicker, more comfortable prehensive contact zone.

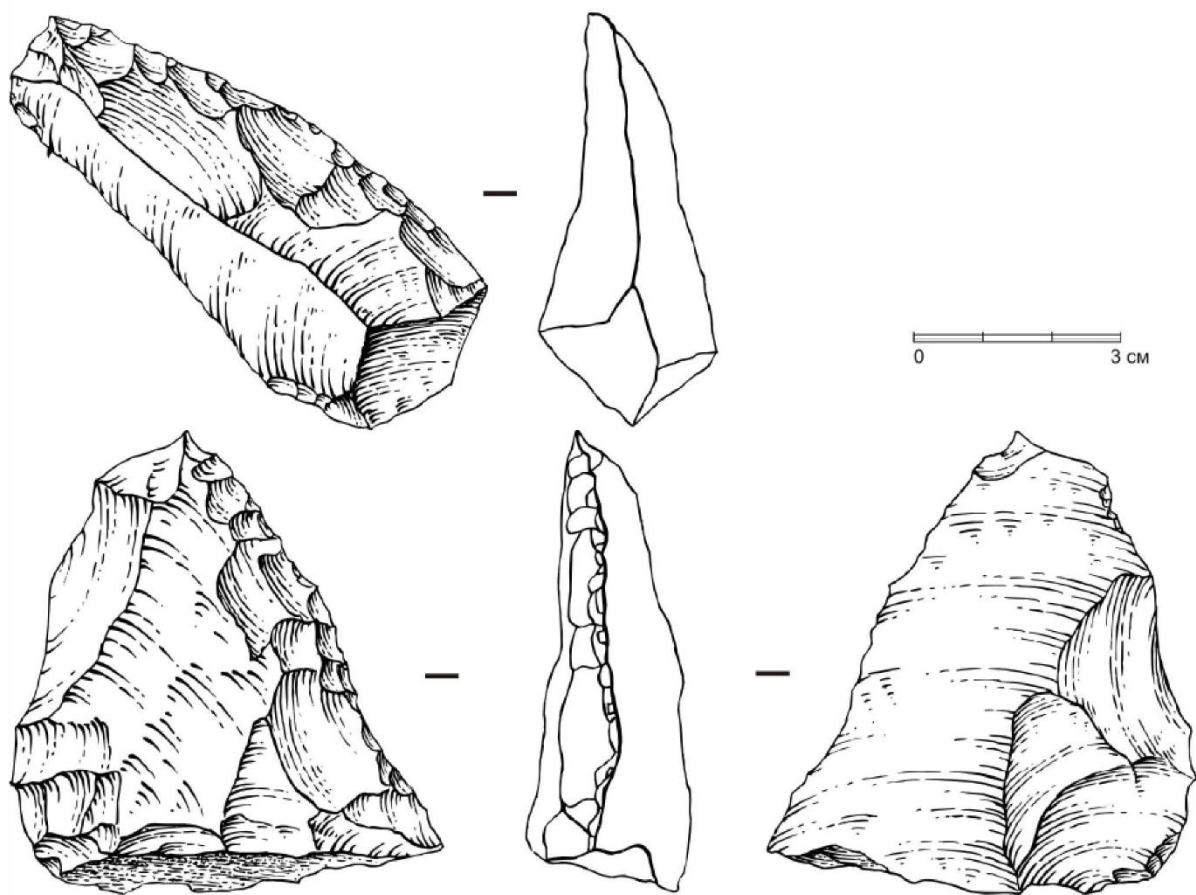


Figure 125: Ust'-Kanskaya, layer 5. Two scrapers on thick flakes (Postnov, 2006).

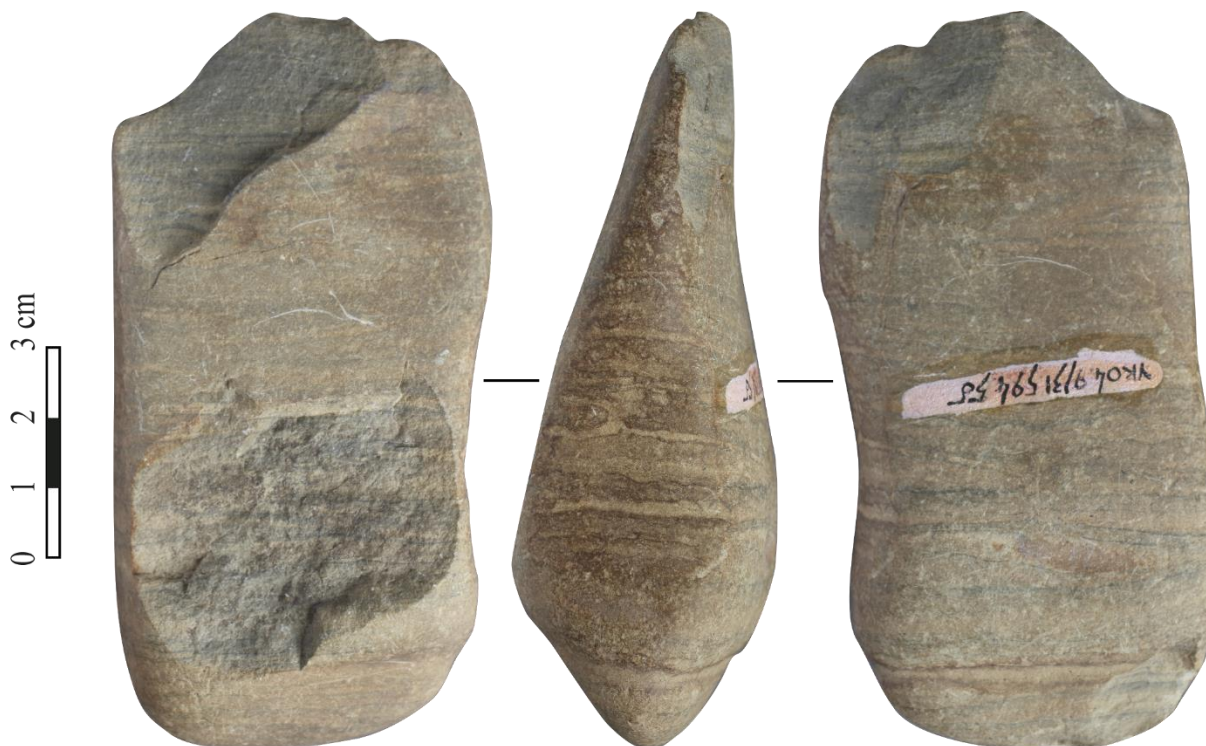


Figure 126: Ust'-Kanskaya, layer 5. Chopping tool.

The non-Levallois cores of Ust'-Karakol are very different from Ust'-Kanskaya's. While in Ust'-Kanskaya, they depend clearly on different mental templates than Levallois, in Ust'-Karakol all the cores show Levallois-like management of the surfaces and convexities. However, for four of them, either the raw material or a lack of preparation of the striking platform made it impossible to remove invasive blanks. Three are centripetal cores, one bidirectional parallel. These cores produced largely shorter flakes than the ones obtained through a full Levallois sequence, and their width is nearly the same as their length, as there is no tendency towards elongation. Very few tools have been identified in Ust'-Karakol's assemblage, and all of them are produced on non-Levallois supports.

In Kara-Bom, the Levallois production is widely dominant, but two cores show low predetermination schemes. They were discarded before exhaustion, and demonstrate little interest for convexities management and recurrence from the knapper. The non-Levallois products are shorter than the others, and mostly present a triangular cross-section. They were not preferentially selected for tool manufacture, as Levallois blades, flakes and points were favored.

We can see than in the three sites¹⁴, there is a different complementarity between the Levallois and the low predetermined reduction sequences. In Ust'-Kanskaya, the types of *chaînes opératoires* are very distinct and generate different products, apparently destined to different functions. In Ust'-Karakol, the reduction sequences are similar, although less predetermination is implemented for the non-Levallois *chaîne opératoire*. In Kara-Bom, the low predetermined scheme are a minority, and produced small flakes that were not selected for retouch; a use-wear analysis could shed some more light on their use.

5.1.4.2 The blade production

In Ust'-Kanskaya we noted a high proportion of blades, most of which are non-diagnostic. However, a small number of them display features that are consistent with a non-Levallois volumetric blade reduction, while others are clearly issued from a Levallois concept. In Kara-Bom, a large proportion of blades are also non-diagnostic, but a volumetric unidirectional blade core has been identified in the assemblage, as well as two blades that we could link to this type of reduction. In Ust'-Karakol, blades are also present, but no volumetric blade core has been identified; however, two of the blades present characteristic features of a non-Levallois volumetric blade reduction.

The framework of the blade production system is based on technical-organisational foundations that are quite close to those inherent in the Levallois system with which it is associated: an investment in production structures, by construction (shaping of the raw material) and/or selection (of pre-existing criteria on the block of raw material), in order to produce predetermined elongated supports with subrectilinear edges. Those products were not differently selected as tool supports whether they are issued from one type of reduction sequence or the other.

In the western European Middle Palaeolithic, it is common to find volumetric blade productions associated with Levallois reduction concepts (Cliquet and Révillion, 1991; Cliquet, 1992; Révillion, 1993; 1995; Ameloot-Van der Heijden, 1994; Gouédo, 1994; Delagnes and Ropars, 1996; Moncel, 2005; Faivre, 2008; Blaser *et al.*, 2012). It is also described in the Near-East (Copeland, 1975; Meignen, 1994; 2004; Marks and Monigal, 1995) and in Georgia (Meignen and Tushabramishvili, 2006). In some sites, we can find Middle Palaeolithic volumetric blade reduction not associated to Levallois productions (Chabai and Sitlivyj, 1994; Slimak, 1999b). There is thus a strong link between the Levallois and laminar productions in the European and

¹⁴ Since, for reasons of organization and timing, we didn't study the non-Levallois assemblage of Denisova Cave, we couldn't include the site here.

Levant Middle Palaeolithic, and the Altai productions fit in this scheme. However, in most northern European sites, the Levallois production consists of shorter flakes, in complement to the volumetric blades, while in the Altai Levallois blades coexist with volumetric blades, as in some sites of southern France (Moncel, 2005), or the Levant (Meignen, 2011). In Hayonim, for example, the thick volumetric blades were mainly used for hide and bone processing, while the thinner Levallois blades were used for butchery (Meignen *et al.*, 2008). Here, in the absence of clearly different techno-morpho-functional characteristics, and without a use-wear analysis, it is hard to assess why two types of reduction sequences were necessary for the production of similar blades.

5.1.5 Who produced the Altai Levallois?

In a region that was home to at least three different hominins, it is important to address the question of the identity of the tool-makers. However, among the sites present in this study, only one yielded human remains and DNA, and can thus contribute to this discussion: Denisova Cave. Most of the remains were discovered in layers that are more recent than the ones we analysed, but some data are available for the most ancient layers:

- Layer 22CC: a deciduous molar yielded Denisovan DNA (Slon *et al.*, 2017a).
- Layer 15EG: Denisovan DNA was discovered in the sediment (Slon *et al.*, 2017b).
- Layer 14EG: Neanderthal DNA was discovered in the sediment (Slon *et al.*, 2017b).

Based on this tenuous data, we could argue that Denisovans did not implement the Levallois concept, since neither layer 22CC nor layer 15EG showed sufficient hints of a Levallois *chaîne opératoire*. However, we have a few reservations concerning this deduction:

- According to Kozlikin (2017), the Levallois concept is present in layers 12, 11.4 and 11.2, where Denisova 8, a Denisovan molar, and Denisova 3, a Denisovan phalanx, have been identified. It is possible that this difference is mostly due to the chronology, with the Levallois appearing in Denisova only after 250 ± 44 ka, and not because it was produced by only one of two different species.
- The presence of a Denisovan-Neanderthal hybrid, Denisova 11, demonstrates that not only Neanderthals and Denisovans met, but also that they bred at least twice: between the Neanderthal mother and the Denisovan father of this individual, but also in the ancestry of her Denisovan father (Slon *et al.*, 2018). Can these admixtures be perceived through the material culture? They indicate exchanges between the two species, which could hint to cultural transfers.

- The presence of an elongated Levallois point in layer 22CC, mentioned and drawn in Derevianko *et al.* (2003), is not enough to conclude to a full Levallois production in this layer; however, we cannot definitely rule it out either, as it could be imported from another site, or the other steps of the chaîne opératoire could have disappeared due to taphonomical reasons.

With the current data about the oldest Denisova layers, a basic scenario of occupation could be proposed:

- The first occupation of the cave occurred before 287 ± 41 ka by Denisovans. They produce a material culture based on simple, low predetermined reduction schemes.
- This population is replaced by unknown Levallois-makers (layer 20CC), between 250 ± 44 ka and 170 ± 19 ka. In the same time period, Neanderthals replace Denisovans in the Eastern Gallery (layer 15EG begins at 203 ± 25.7 ka, layer 14EG ends at 186.8 ± 26.7 ka). The dates between layers 15/14 EG and layer 20CC are unfortunately overlapping, so it is impossible to assess which happened first. However, the most parsimonious hypothesis is that Neanderthals were the first Levallois-makers in Denisova cave.

As the other studied sites didn't yield any remains, it would be imprudent to try to presume on the identity of the maker(s) of the Levallois in Altai, although we can theorize that at least Neanderthals and Denisovans produced Levallois assemblages, Neanderthals probably being the first ones to do it. For the moment, no association of AMH remains with Levallois artefacts has been found in Altai sites.

5.2 INTER-REGIONAL COMPARISONS

While the previous section aimed to present the characteristics of the Levallois concept in the Altai Middle Palaeolithic, the following one presents examples of lithic techno-complexes that have been identified in the neighbouring regions, to try to understand how the Altai Levallois reduction systems compare to them.

5.2.1 Central Asia

The definition of Central Asia varies according to political, geographical or cultural criteria. We will use here the most common definition, where Central Asia is composed of the former Soviet republics of Kazakhstan, Kyrgyzstan, Uzbekistan, Tajikistan and Turkmenistan. Its geography is composed of various types of landscapes, from high mountain ranges to lowlands, steppe and arid plains. Connecting the Altai Mountains in the North to the Hindu Kush in the South, the Inner Asian Mountain Corridor (IAMC) was – and still is – used as a dispersal route for the fauna and the flora. The foothills of the IAMC yielded numerous prehistoric sites, contrary to the steppe and the high mountain ranges. It has been proposed that the IAMC was an important hominin refugium, where necessary resources for survival were available in glacial and interglacial periods (Beeton *et al.*, 2014; Glantz *et al.*, 2018).

5.2.1.1 *Kazakhstan*

Kazakhstan yielded relatively numerous sites, but most of them are surface finds (Vishnyatsky, 1999). Some of them present artefacts that have been described as Mousterian: Tuemainak I, Aidarly II, Perederzhka in central Kazakhstan (Klapchuk, 1969; Voloshin, 1990), Khantau and Semizbugu on the western and northern shores of Lake Balkash, Kanai, Svinchatka, and Narym in the Upper Irtysh Basin (Klapchuk, 1969; Vishnyatsky, 1999). For most sites, handaxes and Discoid cores are common; in Semizbugu, the Levallois reduction dominates the assemblage, mostly uni-bidirectional and centripetal (Derevianko *et al.*, 1993b; 1997). In Semizbugu XI, the Levallois debitage can be considered as poorly standardized, with various shapes, sections, platforms, etc., and the cores are discarded before exhaustion (Osipova and Artyukhova, 2019). The Levallois flakes are elongated, but very few blades are recorded. Interestingly, all the Levallois products are retouched.

In Northern Kazakhstan, the Mugodjary complex is composed of multiple surface collections that are attributed to the Acheulean (Derevianko *et al.*, 2001a). The Levallois reduction is present, mostly unidirectional, with the production of a few blades.

In the Karatau range in southern Kazakhstan, the Koshkurgan I and Shokta I sites are located on travertines, in a spring environment that contrasts with the aridity of the steppe, which probably appealed to the Palaeolithic population. The lithic assemblages are said to belong to Lower and Middle Palaeolithic, with in Koshkurgan-I a Levallois reduction producing short flakes, associated with numerous notches and denticulates. A wide diversity of raw material was used, and the tools were heavily retouched (Artyukhova, 1994; Vishnyatsky, 1999). This industry has been called “small tools”, and is specific to Koshkurgan (Derevianko, 2003). A series of ESR dates on the travertine deposits range from 500 to 170 ka (Derevianko, *ibid.*).

The site of Karasu, or Valikhanov, also near the Karatau range, is one of the very few stratified sites of the region. The stratigraphy is said to be composed of five layers, with a complex chalcedony industry. It is flake-based, and attributed to Middle Palaeolithic, but it presents numerous carinated endscrapers and burins (Vishnyatsky, 1999; Vishnyatsky *et al.*, 2004); a radiocarbon date of 24,800 ± 1,100 BP has been obtained on the upper layer (Taimagambetov and Auberekov, 1996).

5.2.1.2 Uzbekistan

In the Kyzyl-Kum Desert, between the Amu-Darya and the Syr-Darya rivers in western Uzbekistan, numerous surface finds have been reported, all attributed to the Middle Palaeolithic (Vinogradov, 1981). The only sites yielding Levallois products (cores and flakes; Figure 127) are Kuk-ayaz 1, 2 and 3 (Sayfullaev and Cauche, 2004).

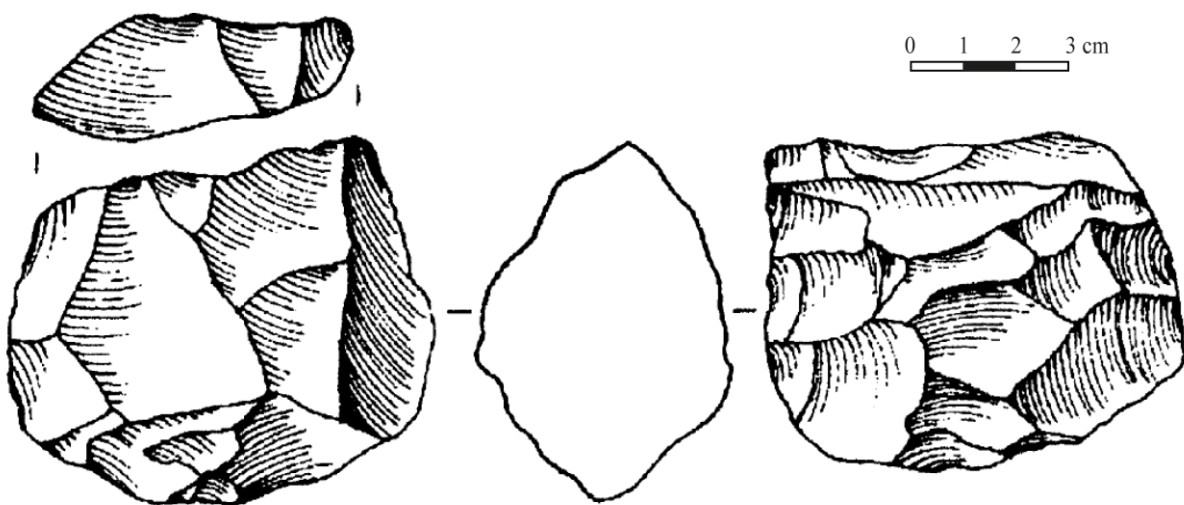


Figure 127: Kuk-ayaz 1, Levallois core (Sayfullaev and Cauche, 2004).

In the Gissar Range, in southern Uzbekistan, the famous cave of Teshik-Tash (“Stone with an Opening”) was discovered by Okladnikov in 1937 (Okladnikov, 1939). The excavation revealed a series of human bones belonging to a young individual, whose mtDNA indicates he was a Neanderthal (Krause *et al.*, 2007). The stratigraphy is composed of five layers, each containing fire structures around which lithic artefacts and bones were concentrated (Okladnikov, 1949). The lithic industry is dominated by scrapers, points and thick blades, and mostly unifacial Discoid cores (Movius, 1953). Some flakes have been described as Levallois by Okladnikov (Figure 128), but no Levallois core.

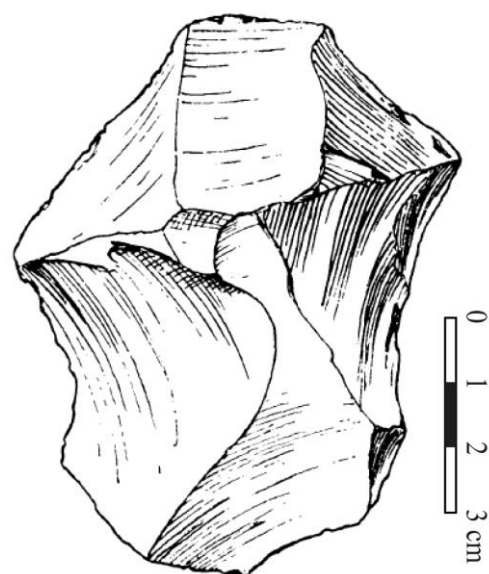


Figure 128: Teshik-Tash, layer I. Preferential Levallois flake (Okladnikov, 1949).

In South-eastern Uzbekistan, in the Kashkadariya region, Anghilak Cave was discovered in 2002 by R. Suleimanov and M. Glantz. The sequence contains five geological units, four of them containing archaeological material (Glantz *et al.*, 2003). Two units yielded a small Middle Palaeolithic assemblage, with scrapers, denticulates and notches, and a very scarce Levallois debitage (Glantz *et al.*, 2003; 2006; 2008). A human metatarsal bone was found in the 2002 test pit; the dates of two charcoal samples that probably were in the same stratum place it between $43,900 \pm 2,000$ BP and $38,100 \pm 2,100$ BP. Unfortunately, studies have shown that morphological features of metatarsals do not allow to differentiate between AMH and Neanderthals (Glantz *et al.*, 2008).

The Tien-Shan region

Kulbulak is a multi-layered open-air site, located on the western edge of the Tien-Shan, on the Chatkal Range. The site was discovered in 1962 by O.M. Rostotsev, and excavated in two main periods: in 1963-1984 under the direction of M.R. Kasymov, then in 2007-2010 under the direction of D. Flas and K.A. Kolobova. In the first series of excavations, 49 cultural layers have been identified: 22 Lower Palaeolithic “Acheulean” layers, 24 Middle Palaeolithic layers and 3 Upper Palaeolithic layers (Kasymov and Grechkina, 1994). The new campaign, spanning 36 m², identified 27 geological layers, with only 11 containing archaeological material (Flas *et al.*, 2010; Vandenberghe *et al.*, 2013). The re-examination of artefacts from the lower layers of the earlier excavation and the study of the lithic assemblage of the new excavations led to the

conclusion that the material previously attributed to the Acheulean actually should be attributed to the Middle Palaeolithic; there is thus no Lower Palaeolithic in Kulbulak (Kolobova *et al.*, 2016). A luminescence dating campaign provided dates for the upper part of the sequence, from 39 ± 4 ka for layer 2 (containing Upper Palaeolithic material) to 82 ± 9 ka for layer 10. Layer 3, which yielded a Middle Palaeolithic industry, is dated to 55 ± 7 ka.

Layer 3 is clearly redeposited, and the artefacts are heavily weathered, creating a pseudo-retouch on most of them (Kolobova *et al.*, 2012). This had led previous researchers to call this industry “Denticulate Mousterian”, but the denticulates and notches were actually taphonomic. The assemblage actually is a mix of artefacts of various ages accumulated by mudflow.

The assemblages of layers 23 of the new excavation and layers 25-46 of Kasymov’s excavation are more informative (Krivoshapkin *et al.*, 2010b; Kolobova *et al.*, 2016). They mostly consist of large blades, produced on prismatic, narrow-face and flat-face cores (Figure 129); blanks and small nodules were also used to produce bladelets. The Levallois technology doesn’t seem present. Similar assemblages have been found in Obi-Rakhmat rockshelter.

Obi-Rakhmat (“Thanks for the water” in Uzbek) is also located in the western Tien-Shan, on the Koksui Mountain range. The rockshelter opens on the southern face of a Paleozoic limestone reef formation, at the bottom of a small ravine. Since its discovery in 1962, it has been excavated in 1964-1965 (Suleimanov, 1972), then occasionally between 1968 and 1986. Investigations were renewed between 1998 and 2012 under a joint research project of the Institute of Archaeology and Ethnography of the SBRAS and the Institute of Archaeology of the Uzbekistan Academy of Sciences (Derevianko *et al.*, 1998c; Krivoshapkin *et al.*, 2012). The sequence contains 37 culture-bearing horizons, yielding a large quantity of artefacts. Different methods of dating have been tried on the site, with varied results. For the middle and upper part of the sequence, radiocarbon dates indicate an age between 40 ka BP and 50 ka BP, close to the limit of the method, while the lowermost cultural layers are dated by ESR and OSL around 70-80 ka (Wrinn, 2004; Krivoshapkin *et al.*, 2010a). Human remains have been found in 2003 in stratum 16 (Glantz *et al.*, 2008; Glantz, 2011). They present mixed traits, but some of them more clearly indicate Neanderthal affinities.

The lithic assemblage is peculiar, as it encompasses Middle and Upper Palaeolithic characteristics in all the strata (Krivoshapkin, 2012). It mostly consists of a Middle Palaeolithic blade technology, with some Levallois traits, and a large number of truncated-faceted pieces, that were used to separate animal and vegetable fibres (Shalagina *et al.*, 2015).

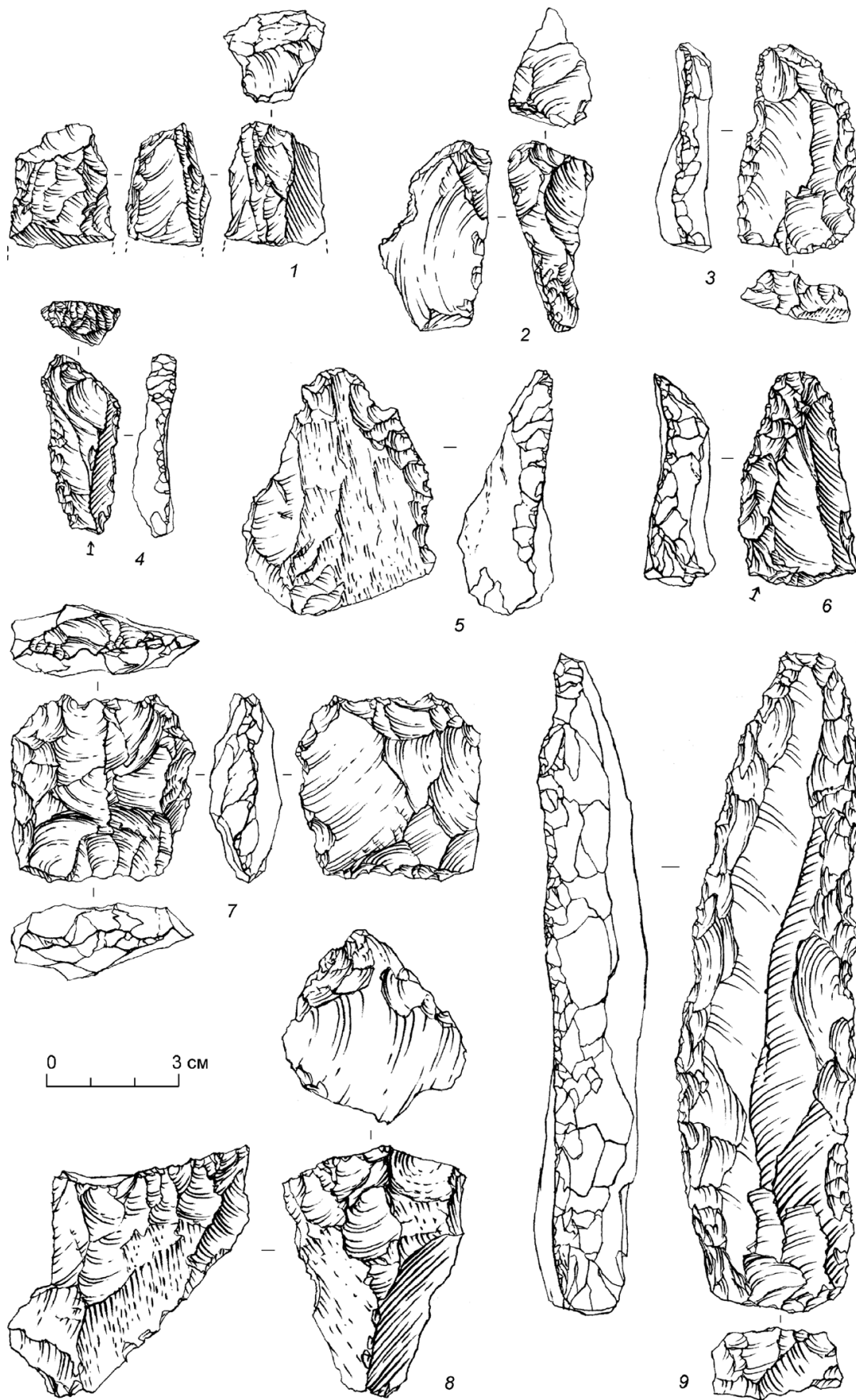


Figure 129: Kulbulak, layer 23 (excavation of 2007-2010). 1-2: narrow-face cores; 3: sidescraper; 4, 6: endscraper; 5: knife; 7: flat-face core/truncated-faceted piece; 8: prismatic core; 9: retouched blade (Kolobova et al., 2016).

The Levallois component of this industry demonstrates a production of elongated blanks, triangular and subtriangular, from parallel and unidirectional convergent cores, with a high faceting index. Most of the Levallois cores present a production of blades and bladelets from the narrow face (Krivoshapkin *et al.*, 2006), as can be seen in other “transitional” industries like Kara-Bom, or in the Levant (*e.g.* in Boker-Tachtit or Ksar-Akil).

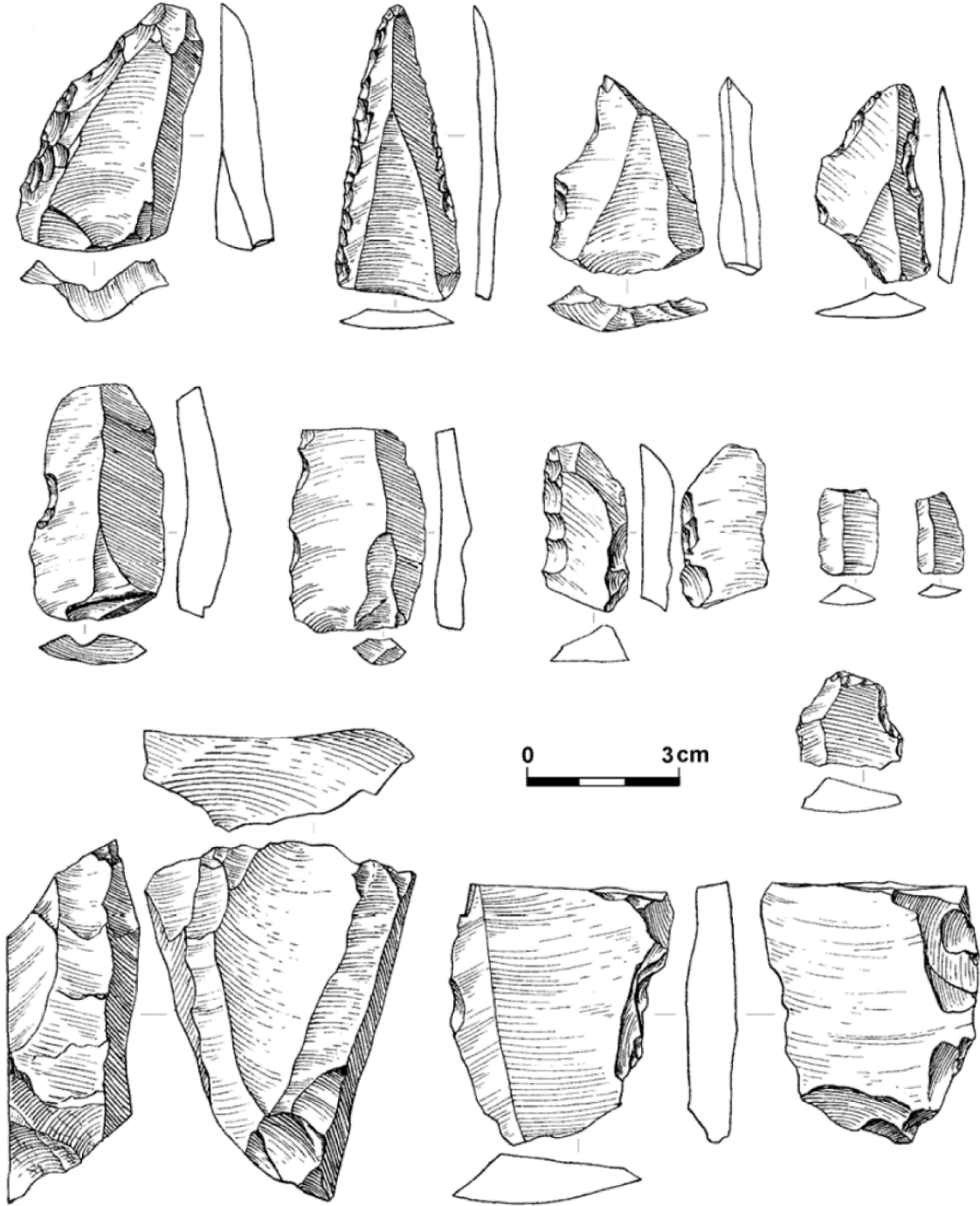


Figure 130: Obi-Rakhmat. Material from Unit 3 (Krivoshapkin *et al.*, 2006).

5.2.1.3 *Kyrgyzstan*

A few Middle Palaeolithic sites have been described in Kyrgyzstan. Georgievskiy Bugor, on the Chuy River in Bishkek, is said to belong to the Mousterian of Soan tradition defined by Ranov (1968). It is characterized by a pebble-tool industry, with choppers and chopping-tool and a low frequency of Levallois. Tossor, on the left bank of the Issyk-Kul Lake, yielded a Levallois-Mousterian industry, with a dominant Levallois production, with tendency to elongation and even a blade production, possibly Levallois (Ranov, 1968; Ranov and Davis, 1979).

Sel'Ungur Cave, in the Sokh river valley of the Fergana depression, is a large cave opening in the south-east, about 1900 m asl. It was discovered in the 1950's, and test pits began as soon as 1956 by A.P. Okladnikov; the cave was subsequently excavated by Islamov in 1980, then 1988-1990. New excavations of the cave began in 2014 and are still ongoing, directed by A.I. Krivoshapkin and B. Viola. The lithic assemblage is unique in the region, distinct from the Middle Palaeolithic variability of Central Asia (Krivoshapkin *et al.*, 2018). The Levallois technology is absolutely absent, the production is based on radial, orthogonal and unidirectional cores, in order to obtain short and wide flakes; planoconvex bifacial tools, Tayaci an points and Mousterian tranchets are also present.

5.2.1.4 *Tajikistan*

In the Tajik Depression in southern Tajikistan, massive accumulations of loess have been correlated with sections from northern China, resulting in high-resolution sequences. They yielded important Lower Palaeolithic material, notably Kul'dara (in pedo-complexes – PC – 12 and 11, dated around 800-900 ka), Karatau I (in PC6, correlated with MIS 15) and Lakhuti (in PC5, correlated with MIS 13). Kul'dara and Karatau represent the “Karatau pebble culture”; Lakhuti presents some hints of Levallois technology, with flat-faced cores that could be Levallois (Figure 131) and some possible Levallois blades (Ranov and Davis, 1979; Ranov, 1995; Ranov *et al.*, 1995; Vishnyatsky, 1999). It would thus be the first expression of the Levallois technology in the region around MIS 13. A similar industry was found in Obi-Mazar PC4, correlated with MIS 11, at the transition between Lower and Middle Palaeolithic (Schäfer *et al.*, 2003).

The first Middle Palaeolithic industry occurs at Khonako III and IV in PC2 (MIS 7), at more than 2000 m asl in the Khovaling region. The raw material is the same than in Lakhuti and Obi-Mazar. Blades are well represented in the assemblage (around 20%), and are produced on prismatic, volumetric cores (Schäfer *et al.*, 1998). Levallois flakes are also present, but no

mention nor drawing of Levallois cores has been found in the publications (Schäfer *et al.*, 1998; Ranov and Schäfer, 2000). A small assemblage was recovered in PC1 (around 70 ka), with a production of Levallois flakes.

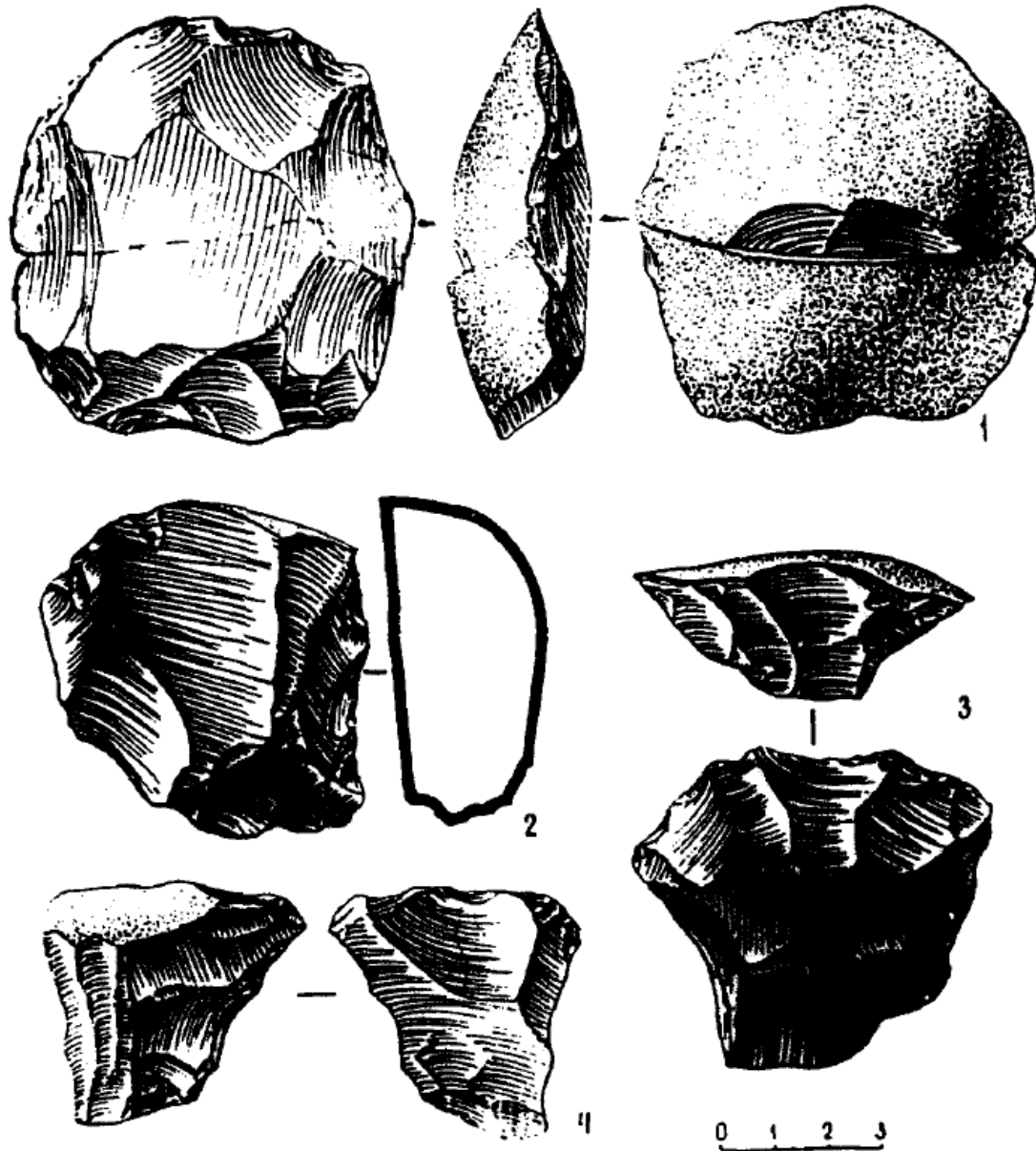


Figure 131: Lakhuti I. "Levallois" cores (Ranov, 1995).

Khudji is an open-air site, located about 40 km west of Dushanbe. Three combustion structures have been found, around which most of the material was concentrated (Ranov and Amosova, 1984). A radiocarbon date of $38,900 \pm 700$ BP (GIN-2905) has been obtained on a charcoal, and has been confirmed by a series of new determinations, from 36 to 42 ka BP (Ranov and Laukhin, 2000). The raw material consists in local good quality sandstone and aleurolite, but also in exogenous flint and slate (Vishnyatsky, 1999). Blades outnumber flakes, and are the

main support for retouched tools. The cores however are mostly non-diagnostic, and seem to show low degrees of predetermination. The assemblage has been attributed to the Levallois-Mousterian facies due to the high number of blades, but the Levallois technology seems absent.

Ogzi-Kichik cave in the Dangara valley has yielded a similar assemblage (Ranov *et al.*, 1973; Ranov, 1980; 1984), but no cultural layer has been recognized, and the material is likely mixed (Abramova, 1984; Vishnyatsky, 1999). Interestingly, the remains of at least 1200 tortoises were found burned, next to identified hearths, as they were probably roasted whole.

The Tajik Depression also yielded some surface finds, like Kara-Bura or Ak-Dzhar (Ranov, 1965). The production is dominated by flakes, choppers and chopping-tools, and are attributed to Ranov's Mousterian of Soan tradition.

Along the Syr-Darya, some open-air sites yielded rich collections, like Kairak-Kum (Ranov, 1971). The Levallois technology dominates the assemblage, with a high faceting index and numerous scrapers. Unfortunately no dates are available.

5.2.1.5 Afghanistan

The Upper Amu-Darya Basin, in northern Afghanistan, is not geographically distinct from the rest of Central Asia, as it is situated on the northern versant of the Hindu Kush. We thus decided to include it in our study.

The cave of Darra-i-Kur is located in the Badakhshan Province. The site was excavated in 1966 by a team directed by L. Dupree in three trenches. The lithic industry was implemented on local poor quality black flint (Dupree and Davis, 1972). Over 800 artefacts were identified, and the Levallois technology dominates the assemblage, with numerous Levallois flakes and points. Levallois cores are mentioned, but not drawn, and their mode is not described.

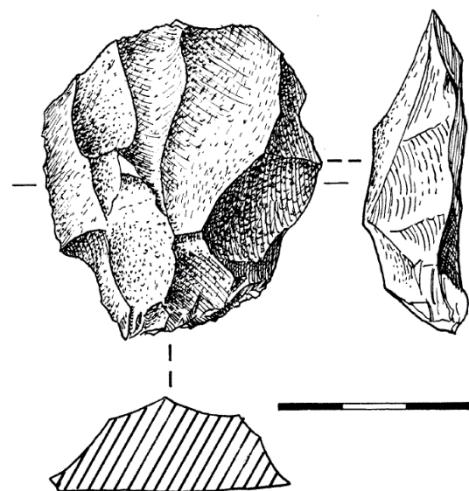


Figure 132: Darra-i-Kur. Levallois flake (Dupree and Davis, 1972).

A temporal bone had been found in the excavation, morphologically attributed to AMH (Angel, 1972). A recent DNA sampling of the bone confirms that it belonged to a male AMH, but it was a Neolithic individual, and was associated with the Mousterian assemblage because of taphonomic activity (Douka *et al.*, 2017).

The cave of Ghar-i-Mordeh Gusfand, a limestone rockshelter located near Gurziwan, was discovered and excavated in 1969 by a team led by L. Dupree (Dupree *et al.*, 1970). It yielded a similar assemblage to Darra-i-Kur, but the raw material mainly consists of siliceous limestone. The represented Levallois cores show a management of the lateral and distal convexities, but seem to be lacking the preparation of the striking platform.

5.2.2 Siberia

5.2.2.1 *Western Siberia*

The plain of Western Siberia, bordered by the Ural range, the Kazakhstan steppe and the Yenisei River, includes a smaller number of Palaeolithic sites than its bordering regions. This could be explained by the activation of periglacial and gelifluction processes during the MIS 3, which would have limited the conservation of previous open-air Middle Palaeolithic sites (Chlachula, 2017). It is assumed that the warm Last Interglacial stages of MIS 5e, c and a were the most favourable for a Middle Palaeolithic dispersal in the region.

In the Trans-Ural, some scattered artefacts have been found next to raw material outcrops (Serikov, 2000; Serikov and Chlachula, 2013). Galyanskaya in the Leba valley yielded cores, scrapers, bifaces, Levallois blades and points. The neighbouring site of Golyy Kamen' Hill is interpreted as a Middle Palaeolithic workshop, with partially cortical flakes, partly prepared cores and bifacial tools. Beregovaya III is a multi-layered site of the Leba valley, and its small collection includes crude Levallois cores. In the upper Tura and Neiva River basin, small open-air sites yielded Middle Palaeolithic artefacts like Levallois cores (in Garevaya II). Two carefully manufactured bifaces have been found in two localities of the Salda River basin, Prokop'evskaya Salda IV and Nizhnaya Salda.

Some Middle Palaeolithic sites have been reported in the Northern Altai Plain, but no detailed information is available yet (Kungurov, 2002).

Aryshevskoe 1, in the Chulym basin, is described as a workshop, with “Discoid, orthogonal, convergent and parallel” debitage, sidescrapers, denticulates and notches (Zenin, 2002). It is the only multi-layered site of the region with Voronino-Yaya, which yielded a few non-diagnostic artefacts.

5.2.2.2 *The Yenisei Basin*

The Yenisei basin is particularly rich in Upper Palaeolithic sites, however it is not very documented for the precedent periods. Hints of Middle Palaeolithic occupations can be found in some localities, but it only consists in small assemblages or isolated pieces, mostly cores or

choppers (Derevianko *et al.*, 1992a). Levallois elements have been identified in Kamenniy Log II (unidirectional convergent core for the production of points, lineal core), in Berezhekovo, Verkhniy Kamen (Drozdov *et al.*, 1999). In Kurtak, surface finds include Levallois points, Levallois blade cores, Discoid cores, scrapers and denticulates (Derevianko *et al.*, 1992a; Davis, 1998). Downstream on the Yenisei from Kurtak, Ust'-Izhul site has yielded mammoth bones associated with Discoid cores and Levallois flakes, and is dated *c.* 125 ka (Ovodov and Tomilova, 1998; Chlachula *et al.*, 2003).

5.2.2.3 The Sayan Range

Dvugalzka Cave, in Khakassia, was discovered in 1974 by Z. Abramova (Abramova, 1981). The small lithic assemblage consists in Levallois points, a Levallois uni- or bidirectional parallel core, Discoid cores, denticulates and notches (Abramova, 1989; Davis, 1998).

5.2.3 Mongolia

5.2.3.1 Western Mongolia

In the Mongolian Altai, the Middle Palaeolithic is represented by numerous sites; however, they only consist in surface collections (Okladnikov *et al.*, 1994). In 1995, an inventory of the sites of the Hovd Aymak already signalled by Russian-Mongolian missions confirmed the Middle Palaeolithic attribution of these localities (Jaubert *et al.*, 1997). Levallois elements are noted in Hoit Tsenkher Gol A (a bidirectional parallel Levallois core) and B (a Levallois flake), Takhiltiin Hotgor (2 bidirectional parallel Levallois cores, 3 Levallois flakes), Zakh Bulag (a unidirectional Levallois core), and Tsakhiriin Uzuur (a Levallois flake). In all cases, the raw material procurement is local, and the debitage is aimed towards the production of flakes.

The Great Lakes Depression

Prospections in the Great Lakes Depression revealed numerous surface finds (Derevianko and Petrin, 1990). In Barlagin-Gol I, “tortoise-shell cores” are recorded, mostly for the production of flakes, but also for blades and points. Two cores are centripetal, the others are parallel. In Naryn-Gol 17, “proto-Levallois” traits have been identified in assemblage A, and a fully Levallois debitage (“tortoise-like”) in assemblage B. Levallois cores heavily dominate the assemblages of Orog-Nuur I and II; they produced flakes, points and blades, and are comparable to the Chikhen Agui collection (Derevianko *et al.*, 2001b).

5.2.3.2 Northern Mongolia

In the Khangai Mountains, numerous surface sites have yielded elements of Levallois technology, for example in Arts-Bogdo, with a unidirectional convergent Levallois reduction sequence for the production of points (Derevianko and Petrin, 1995).

In the Orkhon valley, important Middle Palaeolithic sites have been excavated. In Mojl'tyn-Am, discovered by Okladnikov in 1949, different reduction sequences are represented: Discoid and Levallois, but also blade and bladelet productions (the latter includes the Yubetsu method). However, the integrity of the assemblage is problematic, as the geological analysis showed cyoturbations, lamellar structures and solifluction processes (Bertran *et al.*, 1998; Jaubert, 2015). New excavations in 2018 yielded two retouched Levallois points obtained by the unidirectional convergent method (Khatsenovich *et al.*, 2019). The neighbouring sites of Orkhon 1 and 7 are multi-layered and correlated (Derevianko *et al.*, 2010b). Among the 1028 artefacts collected, 20 are Levallois cores (10 for flakes production, 3 for points and 7 for blades), and 238 are Levallois products, dominated by blades. In Orkhon 1, the Levallois recurrent centripetal method dominates, followed by the bidirectional parallel method (Rybin and Khatsenovich, 2018). No datable material was found associated, but on the overlaying level in Orkhon 1, provides a *terminus ante quem* at 38,600 ± 800 BP (RIDDLE-716).

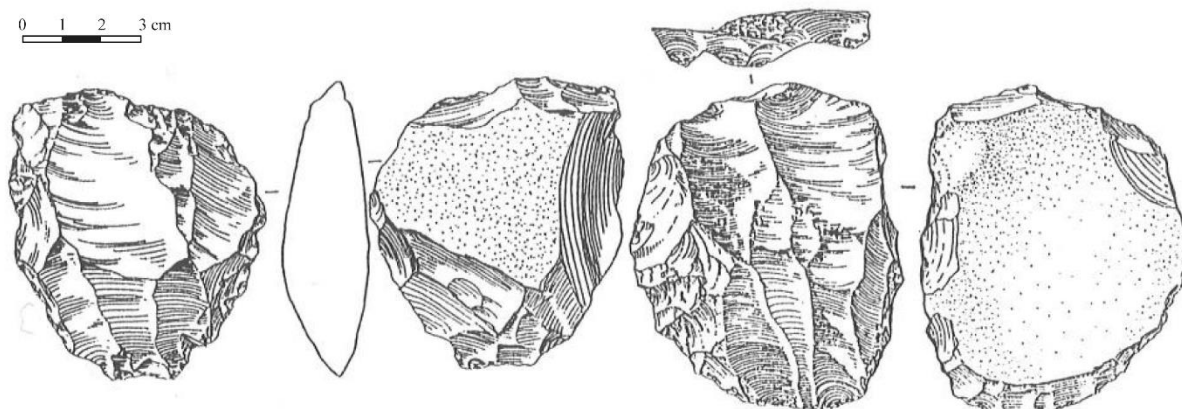


Figure 133: Orkhon I. Levallois cores (Derevianko and Petrin, 1995).

A small assemblage from the lowermost layer – layer 7 – of Kharganyn Gol 5 contains a possible Levallois component in the form of flakes obtained by a centripetal reduction, with faceted striking platforms (Khatsenovich *et al.*, 2017). It is associated with a blade reduction. In layer 6, Levallois convergent unidirectional and bidirectional blades with faceted platforms are identified. In both layers, Levallois blades are produced by parallel and convergent methods, and débordant flakes document the management of the convexities (Rybin and Khatsenovich, 2018). A series of refits demonstrates the production of elongated flakes (or points) from flat-

cores (Rybin *et al.*, *ibid.*). Large bidirectional blades (typical of the IUP) are also present in the assemblage. Radiocarbon dates have been obtained on layer 6, at $46,180 \pm 1100$ BP and $43,340 \pm 790$ BP (Khatsenovich *et al.*, 2017; Rybin and Khatsenovich, 2018).

5.2.3.3 Gobi desert

Tsagaan Agui Cave has been discovered in 1987 by a joint Soviet-Mongolian team and excavated in the 1990's (Derevianko *et al.*, 1996; 1998b). The lowermost layer – first cycle of sedimentation – yielded a flake-based assemblage that seems to be produced from low degree of predetermination reduction sequences (Derevianko *et al.*, 2000c). It is attributed to the Lower Palaeolithic, and has yielded an RTL date of 520 ± 130 ka (MIS 12 to 14). In the second cycle of sedimentation, RTL dates of 450 ± 123 ka and 470 ± 117 ka (MIS 11 to 14) were obtained. The archaeological layers once more yielded a low degree of predetermination assemblage, but Levallois cores and flakes, as well as a few rough prismatic blade cores, have also been identified. This material was attributed to a Levallois-Acheulean industry, and compared to surface finds of the region (Tsakhiurtyn Hondi in the Flint Valley, Mount Yarkh, Otstonmaint and Gurvan-Sikhan in the Southern Gobi). According to Derevianko *et al.* (2000), they could illustrate an eastward migration from the Balkash Lake region in Kazakhstan around 500-400 ka.

The archaeological sequence of Chikhen Agui Cave consist in a Holocene and a terminal Pleistocene horizons, each divided into two cultural layers (Derevianko *et al.*, 2001b; 2008b). In the Pleistocene horizon, the assemblage is dominated by the Levallois reduction, with Levallois-like cores for flakes, blades and points, with a clear management of the lateral and distal convexities with prepared platforms (Figure 134). An associated subprismatic core for blade production is also noted, as well as a “wedge-shaped” core on a blank (Figure 134, right side, 1), and a microblade core. In the products, typical Levallois points with faceted platforms are present, as well as what is described as “transitional” points, between Levallois and Upper-Palaeolithic types points (Derevianko *et al.*, 2001b). The authors attributed this assemblage to a late Middle to Upper Palaeolithic transition.

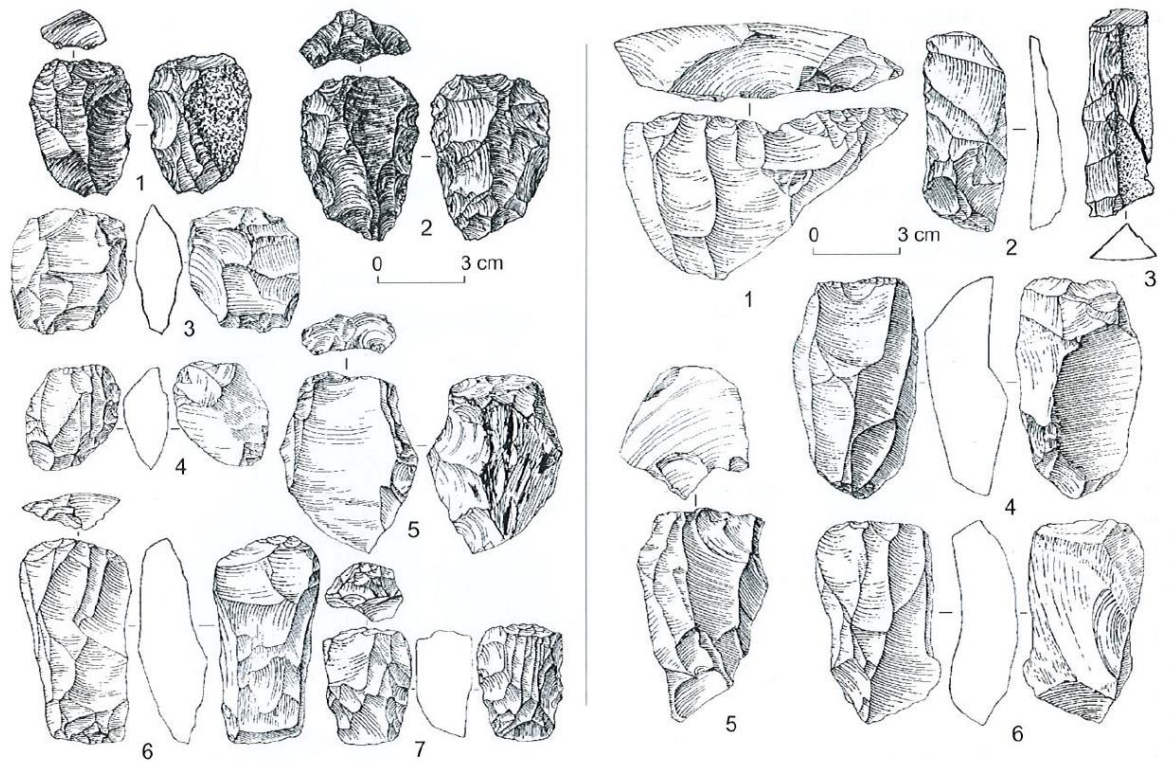


Figure 134: Chikhen Agui. Lithic material from the Pleistocene horizon (Derevianko *et al.*, 2001b).

5.2.4 China

The Levallois concept was said to be absent in China until recently, when it has been identified in at least three sites: Shuidonggou and Jinsitai in the North, and Guanyindong in the South.

The Shuidonggou complex is situated in the Ningxia Hui Autonomous Region, 10 km east of the Yellow River, and has been discovered and excavated in 1923 (Licent and de Chardin, 1925). It has since regularly been studied by Chinese and international teams. It covers a large area, and comprises 10 localities, which date from the end of the Pleistocene to the Holocene; the oldest archaeological layers comes from SDG1 (layers 7 and 8), between 46 ± 3 ka and 33 ± 3 ka (Nian *et al.*, 2014; Li *et al.*, 2019). The artefacts were buried by the fluvial-lacustrine sediments of the Biangou River.

SDG1 layers 7 and 8 yielded two associated reduction systems, both implemented on siliceous limestone and quartzite (Boëda *et al.*, 2013; Peng *et al.*, 2014):

- A dominant Levallois bidirectional parallel reduction for the production of flakes and blades, a part of which were subsequently retouched in different tools, notably endscrapers and denticulates on blades;

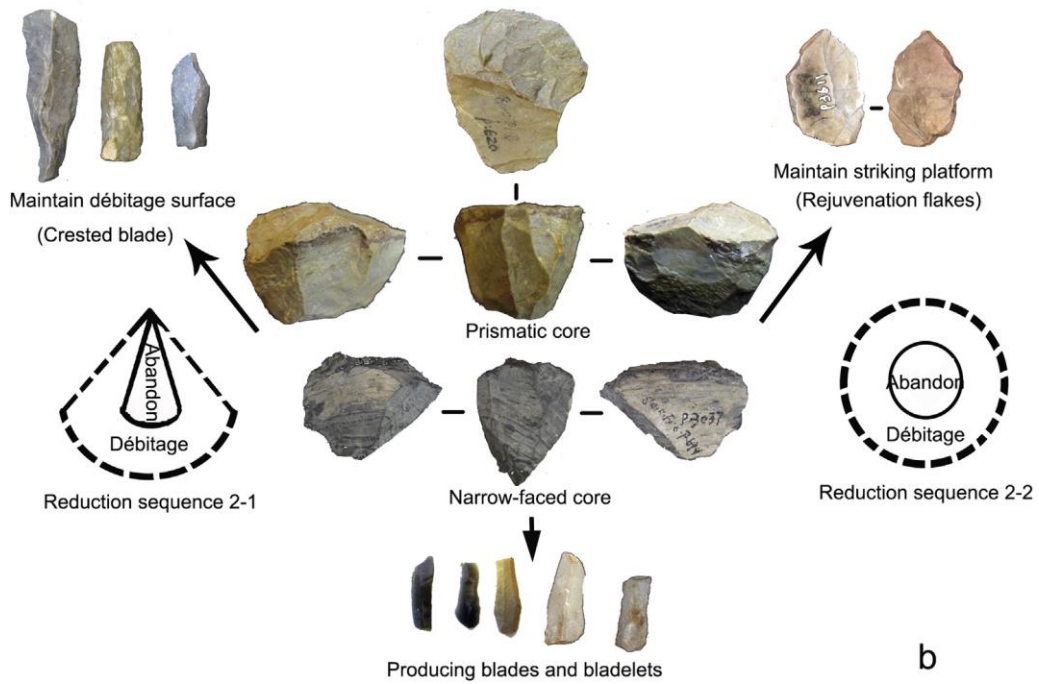
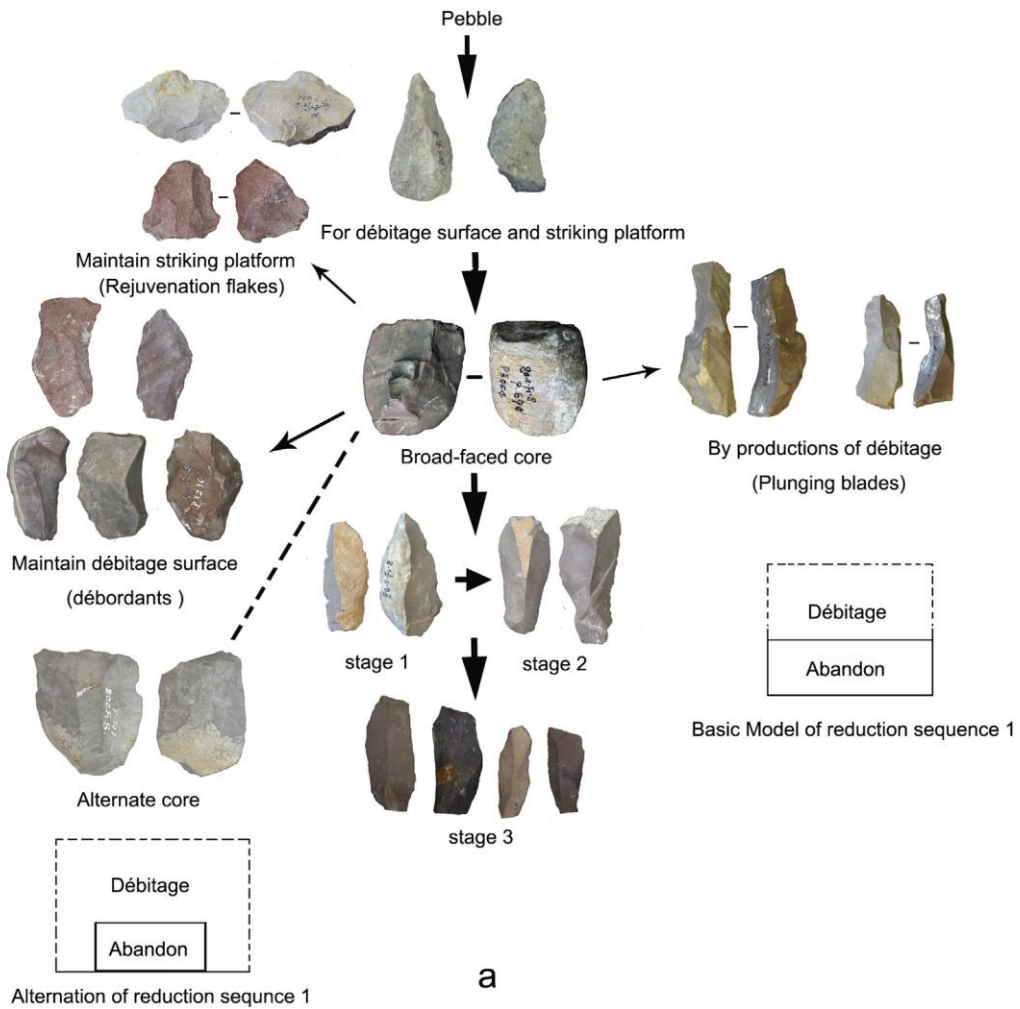


Figure 135: Shuidonggou SDG 1. Two blade reduction sequences (Peng et al., 2014).

- And a “type D2” (volumetric; Boëda, 1997) production of blades and elongated flakes, partly transformed into burins, scrapers or notches.

It has been suggested that this blade industry appeared as a result of a technological diffusion or hominin dispersal from Mongolia and/or the Altai (Peng *et al.*, 2014; Li *et al.*, 2016; 2019). Prospections in the Ningxia Hui in 2002-2003 have led to the discovery of similar types of assemblages in Shijiayao and Zhangjiayao in the Lingwu District and Ling'er in Pengyang County (Gao *et al.*, 2004).

Jinsitai Cave is located 20 km south of the Mongolian-Chinese border, on the foothills of the Donghaierhan Mountains. It was first excavated in 2000-2001 (Wang *et al.*, 2010), but most of the material and knowledge comes from the 2012-2013 reinvestigation. Nine geological layers have been identified, 8 of which bearing cultural horizons. The Middle Palaeolithic assemblage comes from layers 7 and 8. Radiocarbon dates on layer 8 have given various results, but the dates of $45,377 \pm 1,657$ cal BP and $43,298 \pm 991$ cal BP are accepted (Li *et al.*, 2018).

The assemblage was produced on chert, volcanic rocks (basalt, andesite and tuff) and quartz that mostly comes from local pebbles. The flake-based assemblage is dominated by Discoid core reduction, but the Levallois debitage is represented by one atypical core, as well as Levallois flakes and points. Other Levallois cores and flakes are present in the 2000-2001 assemblage (Figure 136). Tools are dominated by scrapers, with some notches and denticulates.

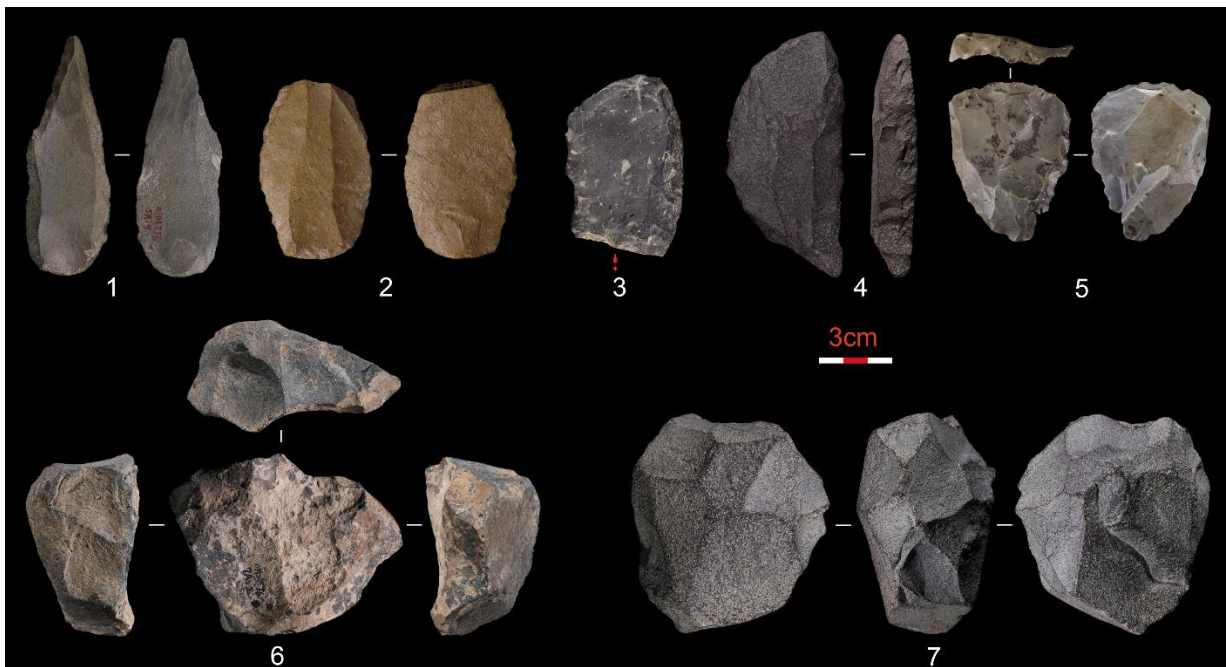


Figure 136: Jinsitai, 2000-2001 material. 1, Levallois point; 2, Levallois flake; 3,4, Sidescrapers; 5,6, Levallois cores; 7, Discoid core (Li *et al.*, 2018)

Guanyindong Cave is located on the Yungui Plateau in the Guizhou Province, in southwest China, and was discovered in 1964 and excavated in four campaigns until 1973. Unfortunately, most of the collection do not have a clear stratigraphic attribution, still the researchers were able to associate a small number of Levallois artefacts to stratigraphic groups A and B (Hu *et al.*, 2018). Group A has yielded OSL dates around 90-80 ka (MIS 5a-b) and group B around 170-160 ka (MIS 6).

The lithic assemblage is predominantly made on chert. Out of the 2273 studied lithic artefacts, the Levallois component is represented by 11 cores and 34 flakes, 4 of which bear retouch (Figure 137). Seven of the cores are recurrent centripetal, and three are preferential. Most of the Levallois flakes present a faceted platform. According to Hu *et al.* (2018), the Levallois concept appeared in the group B in the MIS 6, and thus represents the earliest expression of high degree of predetermination concepts in East Asia.

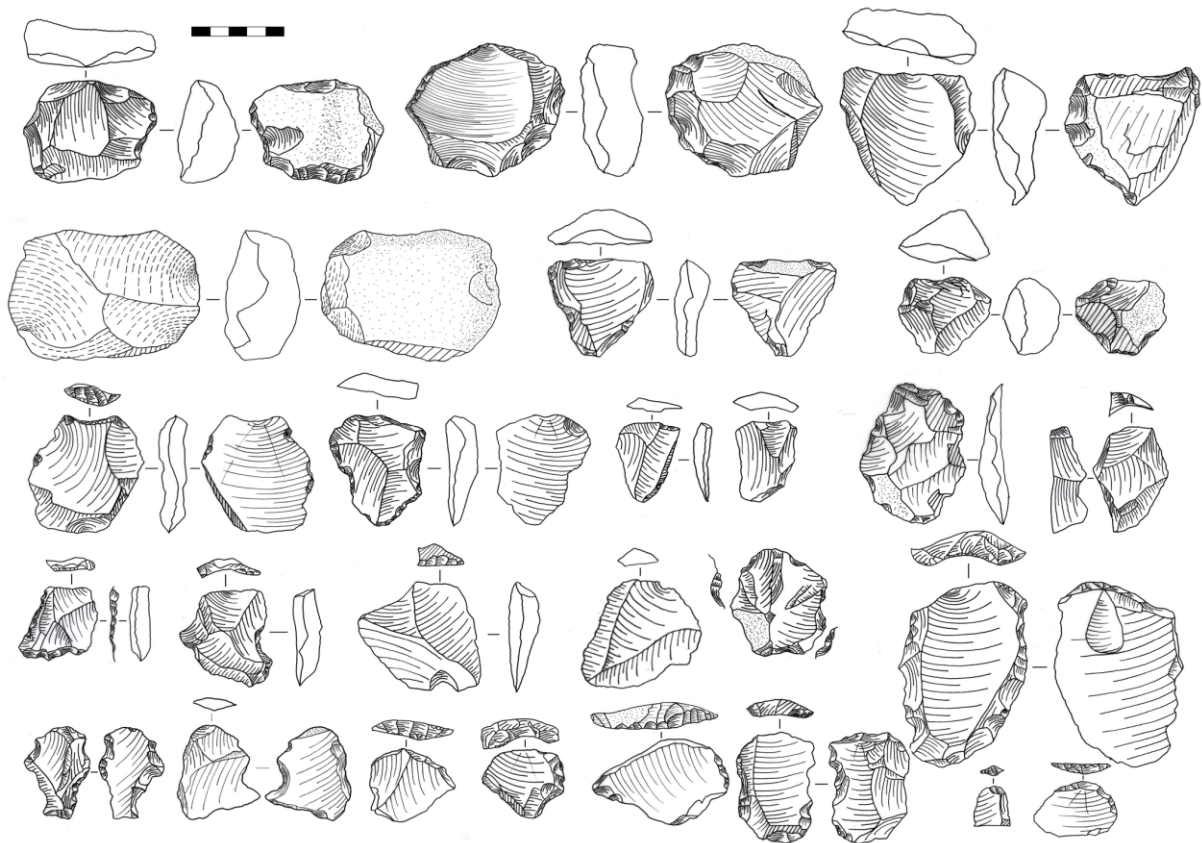


Figure 137: Guanyindong. a, d, f: Levallois recurrent cores; b, c, e: Levallois preferential cores; g-k, n: Levallois flakes; l: débordant; o, p: Pseudo-Levallois points; m, q-s: tools on Levallois blanks; t-z: flakes with prepared platforms (Hu *et al.*, 2018)

5.2.5 Summary

As we saw in this section, the Levallois concept is widely represented in Central Asia, but less in Siberia, Mongolia and China.

A long chronology for the appearance of the Levallois concept seems plausible. The loessic Palaeolithic in Tajikistan yielded the earliest well dated evidence of Levallois elements, with the sequences of Lakhuti correlated with MIS 13, and Obi-Mazar PC4, correlated with MIS 11. They are roughly contemporaneous to the first Levallois occurrences in northern France – Cagny-Cimetière in MIS 12 and Cagny-la-Garenne and Saint-Acheul in MIS 12/11 (Tuffreau, 1982; Antoine *et al.*, 2007; Bahain *et al.*, 2007) – and in the United Kingdom – Rickson’s Pit, Swanscombe and Boyn Hills in MIS 11 (White *et al.*, 2006). At the same time, we find some Levallois elements in Tsagaan Agui Cave in the Gobi desert. No directly dated evidence relates to MIS 10 to 8. In MIS 7, the record is marked by the productions of Khonako III and IV, with an important blade reduction. The only assemblage associated with MIS 6 is group B of Guanyindong Cave in southwestern China. In Siberia, Ust’-Izhul attests of an occupation during the Last Interglacial (MIS 5e). Evidences of occupations are more numerous for the Recent Middle Palaeolithic in most regions, with sites such as Teshik-Tash, Anghilak, Obi-Rakhmat and Khudji in Central Asia, Kharganyyn Gol 5, Orkhon and Chikhen Agui in Mongolia, and Guanyindong, Jinsitai and Shuidonggou in China. The Levallois concept seems to persist into Initial Upper Palaeolithic assemblages, but in a specific form: Levallois flakes and points obtained by bidirectional parallel reduction (Rybin and Khatsenovich, 2018).

Due to the lack of multi-layered, well-dated sites, it is difficult to draw a comprehensive picture of the evolution of the Middle Palaeolithic in those regions. It seems that the Levallois concept appears with “proto-Levallois” forms, with a management of the convexities to produce invasive blanks, and maybe some blades (Lakhuti, Obi-Mazar). It develops into a fully Levallois reduction sequence, that leads to the production of flakes, blades and points, most sites yielding all three types. Except for specific industries like Koshgurgan “small tools” industry, the Levallois production is generally turned towards obtaining elongated blanks (blades, elongated points, elongated flakes that do not answer fully to the blade definition), as we saw in Altai, and sometimes coexists with volumetric blade productions (notably in Khonako, Obi-Rakhmat, Tossor, Kharganyyn Gol 5, Tsagaan Agui, Chikhen Agui, and Shuidonggou). This association is frequent in late assemblages, and can indicate a mix or the beginning of the Upper Palaeolithic with the association of MP and UP traits, like in the IUP. But assemblages like Khonako and Obi-Rakhmat demonstrate that this type of association is not limited to the Final Middle Palaeolithic, and can be present as soon as MIS 7. In Altai, this association is present as soon as MIS 5c, with Ust’-Karakol layer 18. Besides, the Levallois assemblages seem to always be associated with a lower degree of predetermination scheme of production, usually quite expedient, as we could see in all the Altai collections.

Raw material procurement seems to be local, as no specific case of middle- or long-distance transportation has been demonstrated, except in Khudji where exogenous flint and slate have been worked. The occupations are often situated directly on outcrops of knappable material, or next to rivers that could provide pebbles. In the case of surface finds, this could also be a result of the decision to prospect around known outcrops, as it is more likely to provide information.

Only a few Middle Palaeolithic sites in Central Asia seem to not have yielded any type of Levallois product, the two most important being Kulbulak and Sel'Ungur; in Anghilak and Teshik-Tash, the Levallois debitage is anecdotal. In Altai, only Chagyrskaya Cave present an industry that doesn't include elements of a Levallois reduction sequence. On the contrary, in China the Levallois concept is represented only in three sites, two of them yielding very recent dates, while most of the Middle Palaeolithic assemblages are dominated by small flakes production from Discoid cores (*e.g.* in Wulanmulun, Zhoukoudian, Salawusu, Huanglongdong) (Chen *et al.*, 2014; Shen *et al.*, 2016). Conversely, these standardized productions based on short flakes produced on Discoid cores are not documented in Central Asia or Mongolia. What are the reasons of this geographical and cultural shift? There is probably a strong constraint of the available raw material (poor quality quartz and quartzite in Zhoukoudian for example), but it is also likely the result of a combination of environmental and behavioural patterns.

5.3 CONCLUSION

The Altai range, at the border between Central and Northern Asia, has a rich anthropological and archaeological history. It is strategically located on the northern Asian dispersal route, and offers a mosaic of environments that constituted a real hominin refugium in the different climatic periods of its occupation. This study fits into the continuity of the research on the cultural material of the region, to better understand the settlement patterns during the Middle Palaeolithic, when it was home to at least two different hominins, Neanderthals and Denisovans.

For this study, we selected two cave sites and two open-air sites that all yielded a multi-layered stratigraphy and were excavated recently, to try to avoid most of the problems met with scattered surface finds or ancient excavations; namely, Ust'-Kanskaya Cave, Denisova Cave, Ust'-Karakol and Kara-Bom. However, for most of the sites, the integrity of at least part of the assemblages could be questioned, which is a limit to our results. Despite this, we were able to come to multiple conclusions.

First, the Levallois concept is fully represented in Altai, and both the recurrent and the lineal modes have been implemented, according to different methods: uni- or bidirectional parallel, bidirectional orthogonal, unidirectional convergent, and centripetal. The predetermined products are varied and comprise blades, flakes and points. A general tendency towards elongation has been noted in all the assemblages.

Then, we found that, in the assemblages, the elements of the Levallois reduction sequence were often associated with a production of volumetric blades from prismatic cores with a hard hammer. This association of Levallois and laminar reduction sequences is known for numerous sites in Western Europe and the Levant, but also in Central Asia. The Altai assemblages fit in this general scheme.

Anthropological data are unfortunately limited to only one site of our study, which did not allow us to conclude on the identity of the Levallois producers in the Altai. Based on the available data in Denisova Cave, the most parsimonious hypothesis would be that Neanderthals were the first to implement the Levallois reduction system in Altai.

The Altai Middle Palaeolithic Levallois assemblages demonstrate a common set of homogenous features, and seem to have developed within the same cultural tradition (Shunkov, 2005). When compared to the surrounding regions, they show numerous common traits, especially with the Tien-Shan region in Central Asia, towards which the Altai is connected by the Inner Asian Mountain Corridor, a major dispersal route. We can assume that exchanges

between the Altai and the Tien-Shan were recurrent, as they both constitute climatic refugia during cold and arid periods such as Stadials (Beeton *et al.*, 2014; Glantz *et al.*, 2018).

However, the lack of multi-layered, directly dated assemblages in Altai and the neighbouring regions constitutes a serious limit to cultural and behavioural interpretations. Numerous inventoried Palaeolithic sites are actually scattered surface finds without context, and the other ones that offer a stratigraphy sometimes present mixed assemblages that prevent any chrono-cultural conclusion. Numerous dating campaigns have recently been launched in Altai to precise the chrono-cultural models, and they already yield very interesting results. Campaigns of the same scale in the neighbouring region would allow us to better understand how the Altai compare to its surroundings, and to trace the directions and dispersal routes of the Middle Palaeolithic hominins.

On a final note, let us not forget that the Palaeolithic people were not only stone tool-makers. Because of the better preservation of the stone artefacts compared to other materials, an archaeological bias of prehistorians is to think that they carry the most important cultural information. But in the absence of other data, the weight of the lithic technology is not that significant. For example, Ust'-Kanskaya Cave has yielded numerous bones with burns or cutmarks, that were accumulated by hominins. A detailed zooarchaeological study would probably bring important insights on the cultural behaviour of the prehistoric occupants of the cave, and precise the stratigraphical data.

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Table of figures

Figure 1: Location of the Altai range (modified after zoom.earth)	18
Figure 2: Palaeolithic sites in the northwestern Altai; stars are cave sites, dots open-air sites. 1: Strashnaya cave; 2: Chagyrskaya cave; 3: Okladnikov Cave; 4: Iskra cave; 5: Karama; 6: Anuy; 7: Denisova cave; 8: Kamminaya cave; 9: Ust'-Karakol; 10: Ust'-Kanskaya cave; 11: Kara-Bom; 12: Tiimechin; 13: Maloyalomanskaya cave; 14: Kara-Tenesh; 15: Biyka caves; 16: Ulalinka (Zwyns, 2012).....	19
Figure 3: General illustration of the Levallois criteria.....	28
Figure 4: Comparison of technical criteria for the volumetric construction of Levallois and Discoid cores (Boëda, 1993)	38
Figure 5: Principles of core volume management (after Delagnes <i>et al.</i> , 2007, modified).....	40
Figure 6: Characterization of type I (1), type II (2) and type III (3) blanks, in a recurrent unipolar parallel Levallois reduction (Soriano, 2000, after Boëda, 1994).	41
Figure 7: Theoretical blades, obtained by Levallois (1) or volumetric (2) reduction sequences.	42
Figure 8: Example of a core recording on FileMaker™.	43
Figure 9: Core measurements.	44
Figure 10: Example of a product recording in Filemaker™.	45
Figure 11: Morphology of the retouched section.	47
Figure 12: Topographic map of Ust'-Kanskaya Cave area (modified after Derevianko, 2000)	51
Figure 13: Ust'-Kanskaya cave, view from the south.....	52
Figure 14: Ust'-Kanskaya, map of the excavation (modified after Postnov, 2008)	53
Figure 15: Ust'-Kanskaya. Hearth in square 8/26 and 8/27, layer 10 (modified after Derevianko, 2000).....	54
Figure 16: View of the cave at the end of the excavation (Postnov, 2008).....	55
Figure 17: Ust'-Kanskaya, stratigraphy, northern wall (modified after Derevianko, 2000)	57
Figure 18: Ust'-Kanskaya. Artefacts from Rudenko's excavation (Rudenko, 1961).....	60
Figure 19: Topographic map of Denisova and Ust-Karakol area (redrawn after Derevianko <i>et al.</i> , 2003).....	61
Figure 20: Denisova cave.....	62
Figure 21: Denisova, map of the excavation (modified after Ulianov <i>et al.</i> , 2017).....	63
Figure 22: Denisova cave, entrance zone, stratigraphic profile (Derevianko <i>et al.</i> , 2003).....	64

Figure 23: Denisova Cave, central chamber, stratigraphic profile (Derevianko <i>et al.</i> , 2003)..	68
Figure 24: Denisova Cave, Eastern Gallery, stratigraphic profile (Ulianov <i>et al.</i> , 2017).....	69
Figure 25: Denisova cave, Central chamber. Bayesian model of optical ages (Jacobs <i>et al.</i> , 2019).....	72
Figure 26: Denisova cave, Central chamber. Radiocarbon age determinations. B: bone points; P: pendant; *: bone sample; ^: charcoal sample (modified after Douka <i>et al.</i> , 2019).....	73
Figure 27: Denisova cave, Eastern gallery. Radiocarbon age determinations. B: bone points; P: pendant; *: bone sample; ^: charcoal sample (modified after Douka <i>et al.</i> , 2019).....	75
Figure 28: Denisova cave, Eastern gallery. Bayesian model of optical ages (Jacobs <i>et al.</i> , 2019).	76
Figure 29: Denisova Cave, hominin DNA along the stratigraphy of the Eastern Gallery (modified after Slon <i>et al.</i> , 2017b)	84
Figure 30: Ust'-Karakol 1-2 (photo J. Jaubert).....	92
Figure 31: Ust'-Karakol, general reconstruction of the excavation areas (Zwyns, 2012)	93
Figure 32: Ust'-Karakol 1-1, stratigraphic profile (Zwyns, 2012)	94
Figure 33: Ust'-Karakol 1-2, stratigraphic profile (Derevianko and Postnov, 2004)	98
Figure 34: UK1-2. Metacarpus of <i>Capra siberica</i> (dorsal and palmar view) with cutmarks (Derevianko <i>et al.</i> , 2003).....	101
Figure 35: UK1-2. Refit of a Levallois core and a selection of associated artefacts (Postnov, 1999).....	103
Figure 36: Topographic map of Kara-Bom area. 1: Kara-Bom site; 2: spring; 3: amphitheatre; 4: absolute elevation asl (Derevianko and Rybin, 2003).....	104
Figure 37: Kara-Bom (J. Jaubert).....	105
Figure 38: Kara-Bom, map of the excavation areas (Belousova <i>et al.</i> , 2018)	106
Figure 39: Kara-Bom. Stratigraphic profile on the line I (modified after Belousova and Rybin, 2013).....	108
Figure 40: Kara-Bom. Burin cores from OH 5 and 6 (Zwyns <i>et al.</i> , 2012).....	113
Figure 41: Kara-Bom. Refit of a Levallois core from MP2 (Slavinsky and Rybin, 2007)	114
Figure 42: Kara-Bom. Refit of a blade core from OH5 (Slavinsky and Rybin, 2007)	115
Figure 43: Ust'-Kanskaya. Raw materials distribution according to the identified type of reduction.	120
Figure 44: Ust'-Kanskaya, layer 10. Fragmented, retouched Levallois product (1), Levallois laminar blank (2).	121
Figure 45: Ust'-Kanskaya, layer 10. Mean measurements of the products.	122

Figure 46: Ust'-Kanskaya, layer 9. UK06.8/31.482.9 (drawing J. Galfi).....	125
Figure 47: Ust'-Kanskaya, layer 9. Mean measurements of the products.	126
Figure 48: Ust'-Kanskaya, layer 8. Laminar blanks (1, 3), Levallois flake (2), volumetric blade core (4) (from Postnov, 2006).	130
Figure 49: Ust'-Kanskaya, layer 8. UK05.8/30.571.8 (outlines C. Lesage; shading J. Galfi).	131
Figure 50: Ust'-Kanskaya, layer 8. Mean measurements of the products.	132
Figure 51: Ust'-Kanskaya, layer 8. Levallois point (1) and elongated point (3), Levallois flakes (2, 4).	133
Figure 52: Ust'-Kanskaya, layer 7. UK04.8/31.284.7 (drawing J. Galfi).....	136
Figure 53: Ust'-Kanskaya, layer 7. UK04.8/31.288.7 (drawing J. Galfi).....	137
Figure 54: Ust'-Kanskaya, layer 7. Levallois flakes (1, 2), blade (3) and oblique débordant flake (4; from Postnov, 2006).....	138
Figure 55: Ust'-Kanskaya, layer 7. Mean measurements of the products.	139
Figure 56: Ust'-Kanskaya, layer 7. Burin.	142
Figure 57: Ust'-Kanskaya, layer 6. UK02.10/29.18.6a.	143
Figure 58: Ust'-Kanskaya, layer 6. Levallois points (2, 3, 4), elongated point (6), and Levallois flakes (1, 5).....	145
Figure 59: Ust'-Kanskaya, layer 6. Mean measurements of the products.	146
Figure 60: Ust'-Kanskaya, layer 5. Low predetermination cores (drawings J. Galfi).	150
Figure 61: Ust'-Kanskaya, layer 5. Lamellar core.....	151
Figure 62: Ust'-Kanskaya, layer 5. UK06.8/32.471.5d.	152
Figure 63: Ust'-Kanskaya, layer 5. UK00.8/31.262.5c (outlines C. Lesage; shading J. Galfi)	153
Figure 64: Ust'-Kanskaya, layer 5. UK06.8/32.681.5b (from Postnov, 2006).....	154
Figure 65: Ust'-Kanskaya, layer 5. UK07.8/31.486.5e (from Postnov, 2008).	155
Figure 66: Ust'-Kanskaya, layer 5. UK07.9/32.447.5e (from Postnov, 2008).	156
Figure 67: Ust'-Kanskaya, layer 5. Débordant flakes.....	156
Figure 68: Ust'-Kanskaya, layer 5. Mean measurements of the products.	157
Figure 69: Ust'-Kanskaya, layer 5. Levallois points (1, 2), Levallois flakes (4, 6), Levallois blades (3, 5).	158
Figure 70: Ust'-Kanskaya, layer 5. Mousterian point (1), retouched blade (2).	162
Figure 71: Ust'-Kanskaya, layer 4. Discoid core (from Postnov, 2006).	163
Figure 72: Ust'-Kanskaya, layer 4. Low predetermination cores (from Postnov, 2005).	164

Figure 73: Ust'-Kanskaya, layer 4. Levallois points (1, 2, 4), Levallois flake (3).	165
Figure 74: Ust'-Kanskaya, layer 4. Levallois flake (1), blade (2).	166
Figure 75: Ust'-Kanskaya, layer 4. Mean measurements of the products.	167
Figure 76: Ust'-Kanskaya, layer 3. Lamellar core.....	170
Figure 77: Ust'-Kanskaya, layer 3. UK99.7/30.23.3c.	171
Figure 78: Ust'-Kanskaya, layer 3. Levallois points.	172
Figure 79: Ust'-Kanskaya, layer 3. Levallois flakes (1, 2), Levallois blades (3, 4, 5).	173
Figure 80: Ust'-Kanskaya, layer 3. Mean measurements of the products.	174
Figure 81: Ust'-Kanskaya, layer 3. Burin.	177
Figure 82: Ust'-Kanskaya, layer 2. Levallois flakes (1, 3), blades (2, 4).	179
Figure 83: Ust'-Kanskaya, layer 2. Mean measurements of the products.	180
Figure 84: Ust'-Kanskaya, layer 1. Mean measurements of the products.	183
Figure 85: Ust'-Kanskaya. Repartition of the cores according to their length and width.	186
Figure 86: Ust'-Kanskaya, layer 5. Repartition of the Levallois products according to their size class and scar patterns.	188
Figure 87: Ust'-Kanskaya, layer 5. Repartition of the Levallois products scar patterns by classes of percentage of cortex.	188
Figure 88: Ust'-Kanskaya. Levallois reduction sequences of layers 5 and 3.	190
Figure 89: Denisova, layer 22CC. Débordant flakes.....	194
Figure 90: Denisova, layer 20CC. Centripetal Levallois core.....	195
Figure 91: Denisova, layer 20CC. Blade.....	196
Figure 92: Denisova, layer 20CC. Mean measurements of the products.	197
Figure 93: Denisova, layer 20CC. Levallois point (3), fragments of Levallois products (1, 2, 4, 5).....	199
Figure 94: Denisova, layer 14EG. Débordant flakes.....	200
Figure 95: Denisova, layer 14EG. Mean measurements of the products.	201
Figure 96: Ust'-Karakol, layer 19. Levallois blades with an oblique back (1, 2), proximal fragment of a blade (3), proximal fragment of Levallois product (4).	206
Figure 97: Ust'-Karakol, layer 19. Mean measurements of the products.	207
Figure 98: Ust'-Karakol, layer 18. UK-I.96.18/3.52.18B.....	210
Figure 99: Ust'-Karakol; layer 18. Elongated points (1, 2), Levallois flakes (3,4)	211
Figure 100: Ust'-Karakol, layer 18. Levallois flake (1) and débordant flake (2).	212
Figure 101: Ust'-Karakol, layer 18. Mean measurements of the products.	213
Figure 102: Ust'-Karakol, layer 18. Levallois points (1, 2, 3) and elongated point (4).	214

Figure 103: Ust'-Karakol, layer 17. Mean measurements of the products.	217
Figure 104: Ust'-Karakol, layer 16, Levallois flake.	220
Figure 105: Ust'-Karakol, layer 16. Mean measurements of the products.	220
Figure 106: Ust'-Karakol, layer 15. Levallois flake.	223
Figure 107: Ust'-Karakol, layer 15. Mean measurements of the products.	224
Figure 108: Ust'-Karakol, layer 14. Levallois flake.	227
Figure 109: Ust'-Karakol, layer 14. Mean measurements of the products.	228
Figure 110: Ust'-Karakol, layer 13. Mean measurements of the products.	231
Figure 111: Kara-Bom, layer MP2. KB92.M2.I12.2.2073.	236
Figure 112: Kara-Bom, layer MP2. KB93.M2.I7.7.4167.	237
Figure 113: Kara-Bom, layer MP2. KB93.M2.3/7.4056 (Derevianko <i>et al.</i> , 1998).....	238
Figure 114: Kara-Bom, layer MP2. KB93.M2.E10/13.4142 (Derevianko <i>et al.</i> , 1998).....	238
Figure 115: Kara-Bom, layer MP2. KB92.M2.2456.	239
Figure 116: Kara-Bom, layer MP2. B93.M2.J10.27.4140.	240
Figure 117: Kara-Bom, layer MP2. KB93.M2.J10.4.4083 (Derevianko <i>et al.</i> , 1998).....	241
Figure 118: Kara-Bom, layer MP2. KB93.M2.I9/4.4178 (Derevianko <i>et al.</i> , 1998).....	241
Figure 119: Kara-Bom, layer MP2. Levallois points.	243
Figure 120: Kara-Bom, layer MP2. Levallois blades.....	244
Figure 121: Kara-Bom, layer MP2. Mean measurements of the products.	244
Figure 122: Kara-Bom, layer MP2. Burin (1), scrapers (2, 3), truncated flake (4).....	247
Figure 123: Comparison of petrographical differences in pebble materials (A) and the Palaeolithic assemblages (B). 1: limestones; 2: volcanic rocks; 3: aleurolites; 4: sandstones; 5: gravelites; 6: hornfels; 7: slates; 8: quartz; 9: granite; 10: dyke rocks (Anoikin and Postnov, 2005).....	256
Figure 124: Petrographic composition of the Charysh river pebble assemblage (on the left) and Ust'-Kanskaya lithic assemblage (on the right; Kulik, 2014).....	256
Figure 125: Ust'-Kanskaya, layer 5. Two scrapers on thick flakes (Postnov, 2006).....	258
Figure 126: Ust'-Kanskaya, layer 5. Chopping tool.	259
Figure 127: Kuk-ayaz 1, Levallois core (Sayfullaev and Cauche, 2004).....	264
Figure 128: Teshik-Tash, layer I. Preferential Levallois flake (Okladnikov, 1949).	265
Figure 129: Kulbulak, layer 23 (excavation of 2007-2010). 1-2: narrow-face cores; 3: sidescraper; 4, 6: endscraper; 5: knife; 7: flat-face core/truncated-facetted piece; 8: prismatic core; 9: retouched blade (Kolobova <i>et al.</i> , 2016).....	267
Figure 130: Obi-Rakhmat. Material from Unit 3 (Krivoshapkin <i>et al.</i> , 2006).....	268

Figure 131: Lakhuti I. "Levallois" cores (Ranov, 1995).....	270
Figure 132: Darra-i-Kur. Levallois flake (Dupree and Davis, 1972).....	271
Figure 133: Orkhon I. Levallois cores (Derevianko and Petrin, 1995).....	274
Figure 134: Chikhen Agui. Lithic material from the Pleistocene horizon (Derevianko <i>et al.</i> , 2001b).....	276
Figure 135: Shuidonggou SDG 1. Two blade reduction sequences (Peng <i>et al.</i> , 2014).....	277
Figure 136: Jinsitai, 2000-2001 material. 1, Levallois point; 2, Levallois flake; 3,4, Sidescrapers; 5,6, Levallois cores; 7, Discoid core (Li <i>et al.</i> , 2018).....	278
Figure 137: Guanyindong. a, d, f: Levallois recurrent cores; b, c, e: Levallois preferential cores; g-k, n: Levallois flakes; l: débordant; o, p: Pseudo-Levallois points; m, q-s: tools on Levallois blanks; t-z: flakes with prepared platforms (Hu <i>et al.</i> , 2018).....	279

List of tables

Table 1: Correlation of the main chrono-stratigraphic sequences; interglacials are in italics (Astakhov, 2013)	23
Table 2: Fauna from Ust'-Kanskaya first excavation (Rudenko, 1961, modified)	59
Table 3: Denisova Cave, Central chamber, RTL dates (Derevianko <i>et al.</i> , 1998a)	71
Table 4: Denisova Cave, East Gallery, radiocarbon dates (Reich <i>et al.</i> , 2010)	74
Table 5: Denisova Cave, East gallery, radiocarbon dates (after Douka <i>et al.</i> , 2015).....	74
Table 6: Denisova cave, Eastern gallery. Faunal remains. d*: deformed part of layer 11 (after Vasil'ev <i>et al.</i> 2017)	81
Table 7: Denisova cave. Summary of the lithic assemblage attributions (modified after Derevianko <i>et al.</i> , 2001)	85
Table 8: Mammal species from 1993-1997 excavations (Derevianko <i>et al.</i> , 2003).....	100
Table 9: faunal representation in Kara-Bom, data from S.K. Vasiliev (in Derevianko <i>et al.</i> , 2000).....	110
Table 10: Ust-Kanskaya. Repartition of the artefacts.	120
Table 11: Ust'-Kanskaya, layer 10. Breakage.	122
Table 12: Ust'-Kanskaya, layer 10. Dorsal scar pattern.	123
Table 13: Ust'-Kanskaya, layer 10. Platform preparation.	123
Table 14: Ust'-Kanskaya, layer 10. Product shape.	123
Table 15: Ust'-Kanskaya, layer 10. Product profile.	124
Table 16: Ust'-Kanskaya, layer 10. Product cross-section.	124
Table 17: Ust'-Kanskaya, layer 10. Types of tools.....	124
Table 18: Ust'-Kanskaya, layer 9. Breakage.	126
Table 19: Ust'-Kanskaya, layer 9. Dorsal scar patterns.....	127
Table 20: Ust'-Kanskaya, layer 9. Platform preparation.	127
Table 21: Ust'-Kanskaya, layer 9. Product shape.	128
Table 22: Ust'-Kanskaya, layer 9. Product profile.	128
Table 23: Ust'-Kanskaya, layer 9. Product cross-section.	128
Table 24: Ust'-Kanskaya, layer 9. Types of tools.....	128
Table 25: Ust'-Kanskaya, layer 8. Cores.	129
Table 26: Ust'-Kanskaya, layer 8. Breakage.	131
Table 27: Ust'-Kanskaya, layer 8. Dorsal scars patterns.	132
Table 28: Ust'-Kanskaya, layer 8. Platform preparation.	134

Table 29: Ust'-Kanskaya, layer 8. Product shape.....	134
Table 30: Ust'-Kanskaya, layer 8. Product profile.	134
Table 31: Ust'-Kanskaya, layer 8. Product cross-section.	135
Table 32: Ust'-Kanskaya, layer 8. Types of tools.....	135
Table 33: Ust'-Kanskaya, layer 7. Cores.	136
Table 34: Ust'-Kanskaya, layer 7. Breakage.	139
Table 35: Ust'-Kanskaya, layer 7. Dorsal scar pattern.	140
Table 36: Ust'-Kanskaya, layer 7. Platform preparation.	140
Table 37: Ust'-Kanskaya, layer 7. Product shape.	141
Table 38: Ust'-Kanskaya, layer 7. Product profile.	141
Table 39: Ust'-Kanskaya, layer 7. Product cross-section.	141
Table 40: Ust'-Kanskaya, layer 7. Types of tools.....	142
Table 41: Ust'-Kanskaya, layer 6. Cores.	143
Table 42: Ust'-Kanskaya, layer 6. Breakage.	144
Table 43: Ust'-Kanskaya, layer 6. Dorsal scar pattern.	146
Table 44: Ust'-Kanskaya, layer 6. Platform preparation.	147
Table 45: Ust'-Kanskaya, layer 6. Product shape.	147
Table 46: Ust'-Kanskaya, layer 6. Product profile.	148
Table 47: Ust'-Kanskaya, layer 6. Product cross-section.	148
Table 48: Ust'-Kanskaya, layer 6. Types of tools.....	148
Table 49: Ust'-Kanskaya, layer 5. Cores.	149
Table 50: Ust'-Kanskaya, layer 5. Breakage.	157
Table 51: Ust'-Kanskaya, layer 5. Dorsal scar pattern.	159
Table 52: Ust'-Kanskaya, layer 5. Platform preparation.	159
Table 53: Ust'-Kanskaya, layer 5. Product shape.	160
Table 54: Ust'-Kanskaya, layer 5. Product profile.	160
Table 55: Ust'-Kanskaya, layer 5. Product cross-section.	160
Table 56: Ust'-Kanskaya, layer 5. Types of tools.....	161
Table 57: Ust'-Kanskaya, layer 4. Cores.	162
Table 58: Ust'-Kanskaya, layer 4. Breakage.	166
Table 59: Ust'-Kanskaya, layer 4. Dorsal scar pattern.	167
Table 60: Ust'-Kanskaya, layer 4. Platform preparation.	168
Table 61: Ust'-Kanskaya, layer 4. Product shape.	168
Table 62: Ust'-Kanskaya, layer 4. Product profile.	168

Table 63: Ust'-Kanskaya, layer 4. Product cross-section.	169
Table 64: Ust'-Kanskaya, layer 4. Types of tools.....	169
Table 65: Ust'-Kanskaya, layer 3. Cores.	170
Table 66: Ust'-Kanskaya, layer 3. Breakage.	174
Table 67: Ust'-Kanskaya, layer 3. Dorsal scar pattern.	175
Table 68: Ust'-Kanskaya, layer 3. Platform preparation.	175
Table 69: Ust'-Kanskaya, layer 3. Product shape.	176
Table 70: Ust'-Kanskaya, layer 3. Product profile.	176
Table 71: Ust'-Kanskaya, layer 3. Product cross-section.	176
Table 72: Ust'-Kanskaya, layer 3. Types of tools.....	177
Table 73: Ust'-Kanskaya, layer 2. Breakage.	178
Table 74: Ust'-Kanskaya, layer 2. Dorsal scar pattern.	180
Table 75: Ust'-Kanskaya, layer 2. Platform preparation.	181
Table 76: Ust'-Kanskaya, layer 2. Product shape.	181
Table 77: Ust'-Kanskaya, layer 2. Product profile.	181
Table 78: Ust'-Kanskaya, layer 2. Product cross-section.	182
Table 79: Ust'-Kanskaya, layer 2. Types of tools.....	182
Table 80: Ust'-Kanskaya, layer 1. Breakage.	183
Table 81: Ust'-Kanskaya, layer 1. Dorsal scar pattern.	184
Table 82: Ust'-Kanskaya, layer 1. Platform preparation.	184
Table 83: Ust'-Kanskaya, layer 1. Product shape.	184
Table 84: Ust'-Kanskaya, layer 1. Product profile.	185
Table 85: Ust'-Kanskaya, layer 1. Product cross-section.	185
Table 86: Ust'-Kanskaya. Mean, standard derivation and coefficient of variation of the measurements of the cores.	186
Table 87: Denisova. Composition of the assemblage. Between brackets, count coming from Derevianko <i>et al.</i> , 2003 for the Central chamber (CC) and from Kozlikin, 2017 for the Eastern gallery (EG). * The total includes only the artefacts selected for this study.	194
Table 88: Denisova, layer 20CC. Breakage.	196
Table 89: Denisova, layer 20CC. Dorsal scar pattern.	197
Table 90: Denisova, layer 20CC. Platform preparation.	198
Table 91: Denisova, layer 20CC. Product shape.	198
Table 92: Denisova, layer 20CC. Product profile.	198
Table 93: Denisova, layer 20CC. Product cross-section.	198

Table 94: Denisova, layer 20CC. Tool types.	200
Table 95: Denisova, layer 14EG. Breakage.	201
Table 96: Denisova, layer 14EG. Dorsal scar pattern.	201
Table 97: Denisova, layer 14EG. Platform preparation.	202
Table 98: Denisova, layer 14EG. Product shape.	202
Table 99: Denisova, layer 14EG. Product profile.	202
Table 100: Denisova, layer 14EG. Product cross-section.	202
Table 101: Ust'-Karakol. Composition of the assemblage	205
Table 102: Ust'-Karakol, layer 19. Breakage.	205
Table 103: Ust'-Karakol, layer 19. Dorsal scar pattern.	207
Table 104: Ust'-Karakol, layer 19. Platform preparation.	208
Table 105: Ust'-Karakol, layer 19. Product shape.	208
Table 106: Ust'-Karakol, layer 19. Product profile.	208
Table 107: Ust'-Karakol, layer 19. Product cross-sections.	208
Table 108: Ust'-Karakol, layer 19. Types of tools.	209
Table 109: Ust'-Karakol, layer 18. Cores.	209
Table 110: Ust'-Karakol, layer 18. Breakage.	212
Table 111: Ust'-Karakol, layer 18. Dorsal scar pattern.	213
Table 112: Ust'-Karakol, layer 18. Platform preparation.	215
Table 113: Ust'-Karakol, layer 18. Product shape.	215
Table 114: Ust'-Karakol, layer 18. Product profile.	216
Table 115: Ust'-Karakol, layer 18. Product cross-section.	216
Table 116: Ust'-Karakol, layer 18. Tool types.	216
Table 117: Ust'-Karakol, layer 17. Breakage.	217
Table 118: Ust'-Karakol, layer 17. Dorsal scar pattern.	217
Table 119: Ust'-Karakol, layer 17. Platform preparation.	218
Table 120: Ust'-Karakol, layer 17. Product shape.	218
Table 121: Ust'-Karakol, layer 17. Product profile.	218
Table 122: Ust'-Karakol, layer 17. Product cross-section.	219
Table 123: Ust'-Karakol, layer 16. Breakage.	219
Table 124: Ust'-Karakol, layer 16. Dorsal scar pattern.	221
Table 125: Ust'-Karakol, layer 16. Platform preparation.	221
Table 126: Ust'-Karakol, layer 16. Product shape.	222
Table 127: Ust'-Karakol, layer 16. Product profile.	222

Table 128: Ust'-Karakol, layer 16. Product cross-section.	222
Table 129: Ust'-Karakol, layer 16. Types of tools.	222
Table 130: Ust'-Karakol, layer 15. Breakage.	223
Table 131: Ust'-Karakol, layer 15. Dorsal scar pattern.	224
Table 132: Ust'-Karakol, layer 15. Platform preparation.	225
Table 133: Ust'-Karakol, layer 15. Product shape.	225
Table 134: Ust'-Karakol, layer 15. Product profile.	225
Table 135: Ust'-Karakol, layer 15. Product cross-section.	225
Table 136: Ust'-Karakol, layer 15. Types of tools.	226
Table 137: Ust'-Karakol, layer 14. Cores.	226
Table 138: Ust'-Karakol, layer 14. Breakage.	227
Table 139: Ust'-Karakol, layer 14. Dorsal scar pattern.	228
Table 140: Ust'-Karakol, layer 14. Platform preparation.	229
Table 141: Ust'-Karakol, layer 14. Product shape.	229
Table 142: Ust'-Karakol, layer 14. Product profile.	229
Table 143: Ust'-Karakol, layer 14. Product cross-section.	230
Table 144: Ust'-Karakol, layer 14. Types of tools.	230
Table 145: Ust'-Karakol, layer 13. Breakage.	231
Table 146: Ust'-Karakol, layer 13. Dorsal scar pattern.	231
Table 147: Ust'-Karakol, layer 13. Platform preparation.	232
Table 148: Ust'-Karakol, layer 13. Product shape.	232
Table 149: Ust'-Karakol, layer 13. Product profile.	232
Table 150: Ust'-Karakol, layer 13. Product cross-section.	232
Table 151: Ust'-Karakol, layer 13. Types of tools.	233
Table 152: Kara-Bom. Repartition of the artefacts.	234
Table 153: Kara-Bom, layer MP2. Cores.	235
Table 154: Kara-Bom, layer MP2. Breakage.	242
Table 155: Kara-Bom, layer MP2. Dorsal scar pattern.	245
Table 156: Kara-Bom, layer MP2. Platform preparation.	245
Table 157: Kara-Bom, layer MP2. Product shape.	246
Table 158: Kara-Bom, layer MP2. Product profile.	246
Table 159: Kara-Bom, layer MP2. Product cross-section.	246
Table 160: Kara-Bom, layer MP2. Types of tools.	248
Table 161: The Levallois concept in the studied assemblages.	253

Résumé en français

Introduction

L'Altaï est une chaîne de montagnes située à la frontière de la Russie, le Kazakhstan, la Mongolie et la Chine. La moyenne montagne (entre 800 et 2000 m d'altitude) constitue environ la moitié du territoire, le reste étant formé de hauts plateaux et de hauts reliefs escarpés. Les sites paléolithiques, qu'ils soient en grotte ou en plein air, sont situés dans la moyenne montagne, généralement entre 300 et 1000 m d'altitude.

Les recherches archéologiques dans la région ont commencé dès 1913, mais c'est surtout après la Seconde Guerre Mondiale que l'Altaï a été plus largement étudié, d'abord par S.I. Rudenko puis par A.P. Okladnikov. La grotte d'Ust'-Kanskaya est la première à avoir livré du matériel attribué au Paléolithique moyen (dont des pièces Levallois), en 1954. À la fin des années 1950, de nombreux autres sites avaient été mis au jour, mais tous attribués au Paléolithique supérieur. La découverte rapprochée des sites de Strashnaya, Denisova, Okladnikov (nommée Sibiryachikha lors de sa découverte), Kara-Bom et Tiumechin, à la fin des années 1960/début des années 1970, relance l'intérêt pour le Paléolithique moyen et plus spécifiquement pour la technologie Levallois. Dans les années 2000, des critiques sur l'application de la typologie bordienne en Altaï sont émises, et A.P. Derevianko, le successeur d'Okladnikov à l'institut d'Archéologie et d'Ethnographie de Novossibirsk, conclut que le Paléolithique moyen de la région est représenté par une seule tradition culturelle, divisée en deux principales variantes qui sont dues à une variabilité fonctionnelle et environnementale : la variante Kara-Bom, ou Levallois, et la variante Denisova, ou Moustérienne. La première présente une forte proportion de produits Levallois, associés à des outils de type « Paléolithique supérieur », alors que la seconde est représentée par une technologie plus expédiente, avec des nucléus à enlèvements centripètes et parallèles, ainsi qu'avec des outils « Paléolithique moyen » et principalement des racloirs. La découverte de la grotte de Chagyrskaya, qui a livré une industrie très distincte de celle des autres sites de l'Altaï, à l'exception d'Okladnikov, avec une production d'éclats très épais, déjetés, retouchés en racloirs, a entraîné la création d'un nouveau faciès du Paléolithique moyen de la région : le « faciès Sibiryachikha », associé à des restes de Néandertaliens.

En effet, des restes humains de différentes espèces ont été découverts en Altaï : des Néandertaliens, des Denisoviens et des Hommes Anatomiquement Modernes (HAM). L'analyse ADN des restes Néandertaliens découverts à Okladnikov et Chagyrskaya montre qu'ils sont liés avec les Néandertaliens européens, alors qu'une phalange trouvée à Denisova a

livré un ADN de Néandertalien dit « asiatique », distinct des Néandertaliens européens. La grotte de Denisova est le seul site à avoir livré des restes humains de différentes espèces, Néandertaliens et Dénisoviens, ainsi qu'un hybride Néandertalien-Dénisovien.

Objectifs

Le concept Levallois inclut une grande variabilité de modalités, et couvre une large aire géographique et chronologique. Raisonner en termes de sa présence/absence dans un ensemble donné ne permet pas d'établir de modèles régionaux et inter-régionaux, et particulièrement dans une région avec une histoire de peuplement aussi complexe que l'Altaï. Il est donc nécessaire de revenir sur les collections et d'établir quelles chaînes opératoires Levallois qui ont été mises en œuvre dans la région, afin de définir leurs caractéristiques et variabilités, la signification de cette variabilité ou homogénéité, et leur cadre chronologique.

Matériel et méthodes

Nous avons sélectionné des ensembles soit principalement Levallois, soit où la présence de pièces Levallois avait été mentionnée lors d'études précédentes. Ils proviennent de deux grottes, Ust'-Kanskaya et Denisova, et deux sites de plein air, Ust'-Karakol et Kara-Bom.

Nous avons utilisé le concept de chaîne opératoire, notamment initié en archéologie préhistorique par A. Leroi-Gourhan (1964), puis largement théorisé. Il regroupe toutes les étapes de production de l'outil (ici lithique) jusqu'à son abandon, à travers trois phases principales : l'acquisition de la matière première, la transformation de cette matière, et l'utilisation de l'objet obtenu. L'outil fini n'est alors plus étudié hors de tout contexte, mais résulte d'un processus complexe dans lequel il est réintégré.

Présentation des sites

Ust'-Kanskaya

La grotte d'Ust'-Kanskaya est située sur la rive nord de la rivière Charysh, dans la république de l'Altaï. Elle a d'abord été fouillée en 1954 par S.I. Rudenko, qui estime qu'il n'y a qu'un niveau archéologique, qu'il attribue au Paléolithique moyen sur la base de l'étude lithique. Les campagnes de fouilles reprennent entre 1999 et 2007, dirigées par A.V Postnov. Cette fois, la stratigraphie est divisée en dix couches archéologiques, qui vont du Paléolithique moyen (couches 10 à 6), jusqu'au Paléolithique supérieur (couches 3 à 1), incluant des niveaux attribués à la transition Paléolithique moyen/supérieur (couches 5 et 4). Une étude archéozoologique a montré qu'en comparaison avec les autres sites en grotte de la région

(Strashnaya, Denisova), les restes fauniques d'Ust'-Kanskaya portent peu de traces de carnivores, et plus de traces d'activités humaines (cutmarks et os brûlés).

Denisova

La grotte de Denisova est située sur la rive nord de la rivière Anuy, dans le kraï de l'Altaï. Elle a d'abord fait l'objet d'une campagne de fouilles en 1977, dirigée par N.D. Ovodov, puis par une série de campagnes depuis 1982 jusqu'à nos jours, d'abord sous la direction d'A.P. Derevianko puis de M.V. Shunkov. La grotte est divisée en quatre secteurs, la zone d'entrée, les galeries Sud et Est, et la chambre centrale. Les stratigraphies des différents secteurs n'ont pas été formellement corrélées, mais elles présentent toutes plusieurs niveaux qui vont du Paléolithique moyen ancien jusqu'à l'Holocène. De nombreuses campagnes de datation, notamment dans la chambre centrale et la galerie Est, permettent de caler chronologiquement ces stratigraphies. La grotte a livré d'importants ensembles lithiques et osseux. La spécificité principale de la grotte de Denisova est la très bonne conservation de l'ADN et du collagène dans les restes osseux, ce qui a permis d'identifier plusieurs fossiles humains, appartenant soit aux Néandertaliens, soit aux Denisoviens, ainsi qu'un hybride.

Ust'-Karakol

Ust'-Karakol est un site de plein air, localisé à la confluence des rivières Anuy et Karakol, 2 km en amont de Denisova. Le site a été découvert par A.P. Derevianko en 1984, et fouillé d'abord en 1986 sur le secteur UK1-1 par S.V. Markin, puis un deuxième secteur, UK1-2, a été fouillé sous la direction d'A.V. Postnov de 1993 à 1997. UK1-1 a livré un matériel attribué au début du Paléolithique supérieur, incluant de l'IUP (Initial Upper Palaeolithic) et de l'EUP (Early Upper Palaeolithic). UK1-2 présente une séquence plus longue, couvrant du Paléolithique moyen ancien jusqu'à la fin du Paléolithique supérieur.

Kara-Bom

Kara-Bom est un abri sous roche situé dans le bassin versant de la rivière Ursul dans la république de l'Altaï. La première campagne de fouille a eu lieu en 1980 sous la direction d'A.P. Okladnikov, suivie d'une campagne plus extensive entre 1987 et 1993 dirigée par A.P. Derevianko et V.T. Petrin. La stratigraphie est divisée en onze niveaux lithologiques, avec huit horizons culturels, deux attribués au Paléolithique moyen (MP1 et MP2), et six au Paléolithique supérieur (OH1 à OH6).

Résultats

Ust'-Kanskaya

Les matières premières sont très diverses, et locales, provenant de la rivière Charysh. Malgré leur diversité, elles présentent les mêmes caractéristiques élastiques dues à l'histoire géologique de la région. Nous avons cependant remarqué un certain type de sélection des matières premières : le jaspe a été sélectionné à plus de 70 % pour des productions nécessitant un fort degré de prédétermination (FDP) ; le grès, le chert, et la siltite sont sélectionnés à plus de 40% pour ces productions à FDP ; un troisième groupe réunit les roches qui ne montrent pas de schéma spécifique de sélection (les roches porphyriques et aphyriques, le tuf et la rhyolite) ; enfin, le quartz et le schiste ont été sélectionnés uniquement pour les méthodes expédientes.

Nous avons identifié des productions à FDP comme le Levallois, le laminaire volumétrique ainsi que les productions lamellaires, ainsi que des productions expédientes, sur 1 à 4 surfaces de débitage. Quelques productions Discoïdes ont également été notées.

Différentes modalités Levallois ont été identifiées, sur les nucléus ainsi que sur les produits. Malgré quelques légères différences entre les couches archéologiques, l'ensemble du matériel lithique présente une grande homogénéité, avec la présence dominante des modes récurrents parallèles et convergents, suivis du mode récurrent centripète.

Le débitage laminaire volumétrique est attesté par la présence de lames qui dont la morphologie ne correspond qu'à ce mode de débitage. Malheureusement aucun éclat technique n'a été retrouvé, et un seul nucléus potentiel a été identifié ; il est malheureusement fragmentaire.

Deux nucléus à lamelles ont été identifiés, dans les couches 5 et 3. Ils sont tous les deux produits sur des fragments épais d'éclats, et débités de manière expédiente. Quelques lamelles typologiques ont été identifiées le long de la séquence.

Dans tous les niveaux, nous avons identifiés des caractéristiques associées au Paléolithique moyen. La présence de quelques outils de type Paléolithique supérieur, en l'absence d'autres indices, ne permet pas à notre avis de conclure à l'attribution des niveaux 3 et supérieurs au Paléolithique supérieur. De plus, ces outils se trouvent également dans les niveaux inférieurs, et peuvent témoigner soit d'une caractéristique spécifique du Paléolithique moyen d'Ust'-Kanskaya, soit de l'intrusion de matériel plus récent via des processus taphonomiques.

Denisova

L'étude concernait uniquement les niveaux les plus anciens de Denisova. Comme à Ust'-Kanskaya, les matières premières sont variées et locales, provenant de la rivière Anuy. Très peu d'artefacts ont pu être reliés à la chaîne opératoire Levallois. Le plus ancien niveau, la couche 22 de la Chambre centrale, était censé démontrer la première présence de la technologie Levallois en Altaï ; cependant, nous n'avons pu trouver aucune preuve de la présence de Levallois avant le niveau 20 de la Chambre centrale, où une petite sélection d'artefacts indique une production Levallois certaine. Dans la Galerie est, quelques pièces pourraient être liées à une chaîne opératoire Levallois dans la couche 14 ; elles sont cependant peu diagnostiques, et nous ne nous avançons pas sur la présence de Levallois dans ce niveau.

Ust'-Karakol

De même que pour les sites précédents, les matières premières utilisées à Ust'-Karakol sont variées, et proviennent des rivières locales, l'Anuy et la Karakol.

Les niveaux Paléolithique moyen d'Ust'-Karakol ont livré un matériel homogène d'un point de vue technologique, dominé par la présence du concept Levallois, et la production de pièces allongées, qu'elles soient lames, éclats ou pointes. Le niveau le plus ancien (19), associé au MIS5e, présente un matériel rare et très roulé, mais qui démontre de la présence claire de productions Levallois allongées. Le niveau le plus informatif est le niveau 18, car il réunit plus des deux tiers du matériel lithique Paléolithique moyen du site. Les produits Levallois démontrent d'une recherche importante d'élongation, étant en moyenne plus de deux fois plus longs que ceux issus de chaînes opératoires plus expédientes.

Kara-Bom

À Kara-Bom, presque 98 % du matériel est produit sur une roche effusive cryptocristalline d'excellente qualité clastique, qui provient des alluvions de rivières locales.

La production du niveau Paléolithique moyen étudié (niveau MP2) est tournée presque intégralement vers le concept Levallois, avec une présence sporadique de nucléus et éclats provenant de méthodes à faible degré de prédétermination. Les modalités Levallois sont variées, récurrentes et préférentielles ; des lames sont présentes, produites selon le concept Levallois ou le concept volumétrique (un nucléus laminaire volumétrique a été identifié, mais aucun autre élément technologique).

Discussion et conclusion

Le concept Levallois en Altaï

Le concept Levallois est largement représenté en Altaï, avec un seul site qui n'a livré aucun élément Levallois, la grotte de Chagyrskaya ; cependant la proportion de la production Levallois diffère selon le site et le niveau. Les méthodes récurrentes sont toujours les plus représentées, principalement unipolaire parallèle et unipolaire convergent. C'est à Kara-Bom que le Levallois prend la place la plus importante au sein de la production. Les premiers éléments Levallois ont été notés dans la couche 20 de la Chambre centrale de Denisova, datée entre 250 ± 44 ka et 170 ± 19 ka. Les produits prédéterminés qui ont été identifiés dans ce niveau présentent toutes les caractéristiques d'une chaîne opératoire Levallois développée, et non d'un concept « typo-Levallois » ou « proto-Levallois ». Il semble donc que le concept Levallois soit arrivé en Altaï déjà entièrement développé, et aucun élément ne permet d'indiquer une émergence *in situ*, en l'absence d'une fondation culturelle adéquate lors des périodes précédentes.

Il est difficile de statuer sur l'auteur du Levallois dans la région, car un seul site a livré des restes humains associés aux restes lithiques : la grotte de Denisova. Selon les données actuelles, il semblerait que les Néandertaliens soient les premiers à avoir mis en œuvre cette méthode, mais il est fort probable que les Denisoviens l'aient aussi implémenté.

Comparaisons inter-régionales

Lorsque nous comparons les industries de l'Altaï avec les régions avoisinantes (reste de la Sibérie, Kazakhstan, Ouzbékistan, Kirghizistan, Tadjikistan, nord de l'Afghanistan, Mongolie et Chine), nous voyons que le Levallois est très présent en Asie centrale, au sud de l'Altaï, mais moins à l'ouest, au nord et à l'est. Les premiers éléments Levallois ont été livrés par les sites tadjiks de Lakhuti et Obi-Mazar, corrélés respectivement avec le MIS 13 et le MIS 11, donc contemporains des premiers éléments Levallois dans le nord de la France et en Grande-Bretagne. Pour le Paléolithique moyen ancien, antérieur au MIS5e, peu de sites sont recensés (Khonako au Tadjikistan, Guanyindong en Chine ; Ust'-Izhul, en Sibérie, est daté du MIS 5e) ; ils sont beaucoup plus nombreux au Paléolithique moyen récent. Malheureusement, la plupart des sites n'est pas datée, beaucoup d'entre eux étant des trouvailles de surface, ou étant fouillés trop anciennement. Il existe également peu de sites stratifiés, ce qui rend les interprétations sur la culture régionale difficiles.

Comme en Altaï, les productions Levallois sont tournées vers l'obtention de produits allongés, qu'ils soient éclats, lames ou pointes. De même, elles coexistent souvent avec la production laminaire volumétrique, dès le MIS 7, ainsi qu'avec des productions à faible degré de prédétermination. L'approvisionnement en matière premières est principalement local, les sites étant situés sur les gîtes secondaires. Ainsi, nous voyons que le concept Levallois en Altaï s'inscrit pleinement dans son contexte régional et inter-régional.

Levallois productions in Altai: identification, appearance, variability

Abstract: The Altai range, in southern Russia, has yielded an important series of prehistoric assemblages in various contexts (caves, shelters and open-air sites). Recent anthropological and archaeological studies have established the significance of this area, with complex peopling events involving at least three different human species, Neanderthals, Modern Humans and Denisovans, the latter being exclusively associated with Altai assemblages. The cultural background of these hominins' occupation is already well defined for the beginning of the Upper Palaeolithic. This study aims to better characterize the previous period's productions, through one of its important cultural features, the Levallois technology.

To address this issue, we have undertaken a review of material coming from some of the key Altai sequences, while trying to reconstruct the different chaînes opératoires implemented for the production of the desired products that had been previously recognized as Levallois. The analysed artefacts cover a large time span, from Early Middle Palaeolithic (Denisova, stratum 22 of the Central Chamber, RTL dated to 220-280 ky) to layers associated with Upper Palaeolithic (Ust'-Kanskaya, strata 3 to 1), and come from both caves and open-air sites. This allowed us to establish a chronological comparison, as well as regional. Results have shown that the Levallois assemblages of the region are quite homogenous; also, that Levallois technology may not have been present in Altai as early as it has been previously claimed, with a difference of ~100.000 years; and finally, that it is mostly analogous to what we can find in neighbouring regions. These extra-regional common features probably express contacts and exchanges to and from the Altai region.

Keywords: Levallois technical system, Middle Palaeolithic, lithic technology, Neanderthal, *chaîne opératoire*, Altai Mountains (Siberia)

Les productions Levallois en Altaï : identification, émergence, variabilité

Résumé : Les montagnes de l'Altaï, au sud de la Russie, ont livré de nombreuses séries paléolithiques dans divers contextes (grottes, abris et sites de plein air). Des études anthropologiques et archéologiques récentes ont établi l'importance de cette zone, qui témoigne de mouvements de populations complexes concernant au moins trois espèces humaines, les Néandertaliens, les Hommes modernes et les Denisoviens, ces derniers étant exclusivement associés aux ensembles de l'Altaï. Le contexte culturel de l'occupation de ces hominines est déjà bien défini pour le début du Paléolithique supérieur. Cette étude vise à mieux caractériser les productions du Paléolithique moyen, à travers l'une de ses caractéristiques culturelles les plus importantes, la technologie Levallois.

À cette fin, nous avons entrepris une révision du matériel provenant de certaines séquences clés de l'Altaï, en essayant de reconstruire les différentes chaînes opératoires mises en place pour la production des produits désirés, précédemment reconnus comme Levallois. Les séries analysées couvrent une longue période chronologique, du Paléolithique moyen ancien (Denisova, couche 22 de la Salle centrale, datée par RTL à 220-280 ka), aux niveaux associés au Paléolithique supérieur (Ust'-Kanskaya, couches 3 à 1), et proviennent de grottes et de sites de plein air, ce qui nous permet d'établir une comparaison chronologique et régionale. Nos résultats montrent que les ensembles Levallois de la région sont assez homogènes ; que la technologie Levallois est apparue en Altaï plus tard que ce qui avait été avancé précédemment, avec une différence d'environ 100 000 ans ; et enfin, qu'elle est comparable à ce qui a été découvert dans les régions voisines. Ces traits communs expriment probablement des contacts et échanges depuis/vers la région de l'Altaï.

Mots-clés : Système de débitage Levallois, Paléolithique moyen, technologie lithique, Néandertal, chaîne opératoire, Altaï (Sibérie)