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Is there Initial Upper Palaeolithic in Western Tian Shan? Example of an open-air site Katta Sai 2 (Uzbekistan)

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ABSTRACT

The paper presents the results of multidisciplinary studies on the open-air loess site Katta Sai 2 located in the western piedmonts of Tian Shan in Uzbekistan. Two archaeological horizons contain features associated with the Initial Upper Palaeolithic (IUP) - both Levallois and blade/bladelet volumetric technology, together with an Upper Palaeolithic toolkit. The cultural traits observed in Katta Sai 2 might have local roots dating back to MIS 5a and can be found in so-called Obirakhmatian technocomplex determined in several archaeological sites in the region. Thus, the obtained results question the hypothesis of non-local origins of IUP complexes associated with the early modern human migration from the Near East to Mongolia along the piedmonts of Pamir and Tian Shan. Until reliable anthropological and genetic data are obtained, it seems to be too early to conclude about the relationship between modern human migration and the appearance of IUP assemblages, at least across the western parts of Central Asia.

1. Introduction

Initial Upper Palaeolithic (IUP) is a widely used term indicating assemblages dated to 50-35ky BP combining some traits of both Levallois and volumetric technology, interpreted as an early stage of development of the Upper Palaeolithic technological traits among modern human groups (Kuhn et al., 1999; Hoffecker, 2011; Kuhn and Zwyns, 2014; Olszewski, 2017; Kuhn, 2019; Zwyns, 2021). The term was introduced in 1988 to describe the assemblage from the uppermost layer 4 in Boker Tachtit (Marks and Ferring, 1988). Recently it is used to describe a phenomenon identified in three separate geographical regions, i.e. Europe, Near East and Central Asia (Fig. 1).

- In the Near East, the IUP is best studied and divided into distinct facies (Goring-Morris and Belfer-Cohen, 2020; Bosch et al., 2015; Meignen, 2012; Kuhn et al., 2001). Their common features are: a predominance of Levallois or Levallois-like concept (recently identified as so-called 'along-axis cores', Leder, 2014, 2016) aimed at obtaining elongated blanks, but volumetric core reduction is also visible, e.g. in Boker Tachtit Level 4 or Ksar Akil Levels XXV-XX

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(Ohnuma, 1988, Leder, 2016). One can also observe a tendency to produce convergent, blade or even bladelet points, as well as an appearance of end scrapers and burins (Goring-Morris and Belfer-Cohen, 2020; Belfer-Cohen and Goring-Morris, 2003; Leder, 2018; Ohnuma, 1988; Schyle, 2015; Kadowaki et al., 2019).

- In Europe, IUP describes Levallois-based assemblages such as Stránská Skála or Bohunice accompanied by bifacial leaf points (Škrdla, 2003a, 2003b), as well as blade or even bladelet industries with Levallois component and UP toolkit (Bacho Kiro Cave, layer I, Temnata, layer VI, Ořechov IV – Kabáty- Ginter et al., 1996, 2000; Kozłowski, 1982, 2004; Tsanova, 2006, 2008; Fewlass et al., 2020; Demidenko et al., 2020).
- In Central Asia, IUP was recently used to describe Levallois-based assemblages with some traits of blade technology and a bladelet component accompanied by a specific toolkit consisting of truncated faceted pieces, burin-cores, burins, and single end scrapers (Shunkov et al., 2017; Rybin and Khatsenovich, 2020; Zwyns et al., 2012, 2019; Gladyshev and Tabarev, 2018; Zwyns, 2012, 2021; Anoikin et al., 2019).

The prevailing assumption is that IUP industries were produced by modern humans (Kuhn and Zwyns, 2014). The presence of IUP assemblages is treated as evidence for modern human migration toward Europe, as well as toward Central Asia. Such assumptions were recently proven for the European IUP assemblages by a discovery of modern human remains dated to 45,820–43,650 cal BP in Bacho Kiro Cave in Bulgaria in association with an extensive IUP assemblage (Fewlass et al., 2020; Hublin et al., 2020). The correlation of IUP industries with modern humans in the Near East is still a debatable topic due to the long-lasting cohabitation of both modern humans and Neanderthals in the region (Goring-Morris and Belfer-Cohen 2020; van de Loosdrecht et al., 2018; Hershkovitz et al., 2015, 2018).

The relation of so-called IUP industries from Central Asia with modern human migration is also still debatable because of the lack of human remains found in IUP archaeological contexts. Direct evidence of the presence of anatomically modern humans in Central Asia includes the discovery of human remains from Ust-Ishim directly dated to ~45 ky BP (Fu et al., 2014). Still, one should take into consideration the absolute lack of archaeological context of the finding. What is more, recently researchers identified IUP traits in layer 9 and 11 from Denisova Cave connected with either ancient modern human or Neanderthal at the site based on sedDNA analyses Zavala et al, 2021), which makes the discussion even more complicated.

The hypothesis of non-local origins of IUP complexes in Central Asia is based on an assumption that groups of anatomically modern humans migrated from the Near East to Mongolia (Zwyns et al., 2019; Fitzsimmons et al., 2017). The migration routes were heavily restricted by the local climatic and topographic conditions, including high mountainous areas. The best migration routes lead through the so-called Inner Asian Mountain Corridor along the piedmonts of Hindukush, Pamir, Tian Shan and Dzhungar, towards the Altai Mountains (Iovita et al., 2020).

In such a case, one should find traces of IUP assemblages everywhere along the possible migration route of modern humans. In this paper, we focus on the western part of Tian Shan piedmonts presenting new data, which can significantly improve the discussion of the IUP in Central Asia.

In previously studied sites, the Late Middle Palaeolithic period in the region was associated with the early development of blade industries called Obirakhmatian (Krivoshapkin et al., 2004, 2004b; Krivoshapkin, 2012; Pavlenok et al., 2018a, 2018b). The term "Levallois facies" or "Levallois-Mousterian facies" were described previously by V.A. Ranov (Ranov, 1965; Ranov and Nesmeyanov, 1973) on the basis of several archaeological sites in Uzbekistan and Tajikistan (e.g. Djar-Kutan, Kapchigai, Khodzekent 1 and 2). Still, such assemblages were determined only on the basis of typological features. What is more, the Levallois component rarely appears also in other Middle Palaeolithic sites of the region (Kuhsi, Obi-Rakhmat rock shelter, Kulbulak – Krivoshapkin, 2012; Krivoshapkin et al., 2004, 2004b; Kolobova et al., 2018; Tashkenbaev, 1967, 1972). However, the Levallois technology was never a dominant one, except for the new archaeological materials from the lowermost layers of the cultural sequence of the Kulbulak site (Pavlenok et al., 2018b) and some surface collections of uncertain homogeneity, e.g. Dzar Sai 2 (Anisutkin et al., 1995)

An assemblage with a predominance of Levallois technology in the Middle Palaeolithic of the western part of Central Asia was described for the first time in Katta Sai 1 (Kot et al., 2014; Krajcarz et al., 2016; Pavlenok et al., 2021). The site is located in the Dukent Sai valley near Yongiobod village in the Angren district, Uzbekistan. In the case of Katta Sai 1 the specific predetermined technology of the Levallois type is the only one used (Kot et al., 2020). Interestingly, intensive surveying of the

Fig. 1. Late Middle Palaeolithic and Initial Upper Palaeolithic sites mentioned in the text. 1 – Boker Tachtit; 2 – Stránská skála; 3 – Bohunice; 4 – Bacho Kiro; 5 – Temnata; 6 – Denisova Cave; 7 – Ust-Karakol; 8 – Kara-Bom; 9 – Kamenka; 10 –Tolbor 4; 11 – Tolbor 16; 12 – Tolbor 21; 13 – Moil'tyn-am; 14 – Kharganyn Gol 5; 15 – Djar-Kutan; 16 – Kapchigai; 17 – Khodzekent 1, 2; 18 – Obi-Rakhmat; 19 – Kulbulak; 20 – Katta Sai 1; 21 – Katta Sai 2; 22 – Hudji; 23 – Tossor; 24 –Utash Sai; 25 – Ak-Olon; 26 – Ushbulak.

whole valley brought several new surface sites containing mostly quite similar assemblages, which could also be ascribed by analogy to the Late Middle Palaeolithic (**Online Resources 1**). Among the newly discovered sites was Katta Sai 2, found in 1997 by K. I. Milutin, and systematically surveyed until 2009 (Milutin, 2012).

The site is located 1.3 km NW of Katta Sai 1, on the other side of the same crest, at the altitude of 1,440 m a.s.l. (41°07′10.2″N, 70°06′16.3″E) (Fig. 1**, Online Resources 1**). The site is facing North towards the mountains with a good overview of the Katta Sai gorge. It is located at the top of the crest, approximately 150 m above the bottom of the modern river valley.

In 2014 new artifacts were collected from the surface and two test trenches. They were opened along the road in the area where the surface finds were previously found, in order to verify the preservation of any strata containing archaeological material. Only in a trench located near to the top of the hill were artifacts found in stratigraphic position. The preliminary results of the positive verification were presented by Krajcarz et al. (2016).

During the next three seasons, the site was excavated in order to clarify the chronostratigraphic position of the artifacts. The first season revealed the presence of two distinct archaeological horizons in an unclear and sloping stratigraphic situation. Further research focused on determining the chronology of the strata and searching for undisturbed archaeological layers further up the slope.

389 artifacts were found so far, including 383 stone artifacts, 5 pieces of pottery, and a fragment of a metal knife. Apart from these artifacts, 310 mollusk shells, shell detritus, and very scarce vertebrate bones were found in the layers. Scarce human remains including several teeth were found in layer 2 "dark", which can be interpreted as a grave pit (Fig. 2). Human remains will be analysed in detail in a separate paper.

The main scope of this article is to discuss how the newly discovered site Katta Sai 2 and other similar assemblages in the region may change our way of understanding human migrations during the Middle/Upper Palaeolithic transition.

2. Methods & materials

2.1. Archaeological fieldworks and analyses

The archaeological excavations of the Katta Sai 2 site were conducted in a meter network system. In total, 30sqm were excavated. The exact location of the trenches is presented in Fig. 2. The archaeological material was collected during the excavation of the sediments in 10 cm thick mechanical layers. All the sediments were sieved with 5 mm mesh, and the chosen samples (15 L of sediment collected from each 20-cm thick interval from each square meter of the archaeological grid) were water sieved with 1 mm mesh. During the fieldworks, detailed documentation of the three-dimensional position of all the finds was conducted with the use of geodetic equipment, ensuring an accuracy of 10 mm. It also allowed us to establish their relative location in the geological layers, and their position in space.

Stone artifacts were found in two distinct horizons (Fig. 3). The upper horizon was located in layer 2a and the upper part of 2b, whereas the lower one was excavated from layer 3. The majority of the artifacts from the lower horizon were found near the border of sublayers 3a and 3b.Fig. 4.

Due to the postdepositional processes visible in the site, for the initial analyses we decided to take into account only the artifacts found in a clear stratigraphic position, and their refits.

For this reason, artifacts found either in layers 1, bioturbations, or near the border between layers 1 and 2a, were excluded from further analyses. For the same reason artifacts found at the border of layers 2b

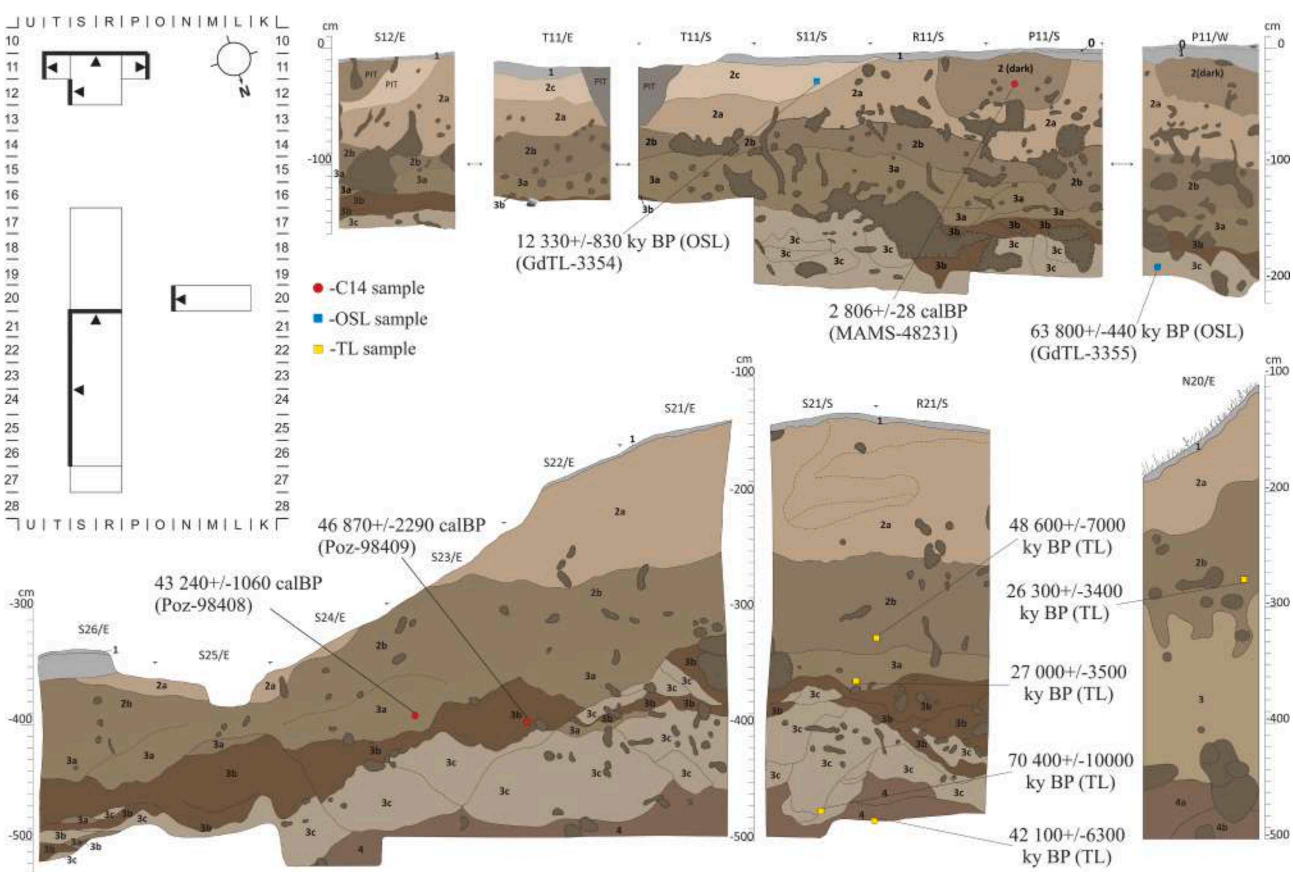

Fig. 2. Stratigraphy of Katta Sai 2 site with TL, OSL and C14 sampling places marked. The upper cross-section presents stratigraphy on the top of the hill, whereas the lower one shows the stratigraphy down the hill, where the slope erosion processes and erosional rills are more visible.

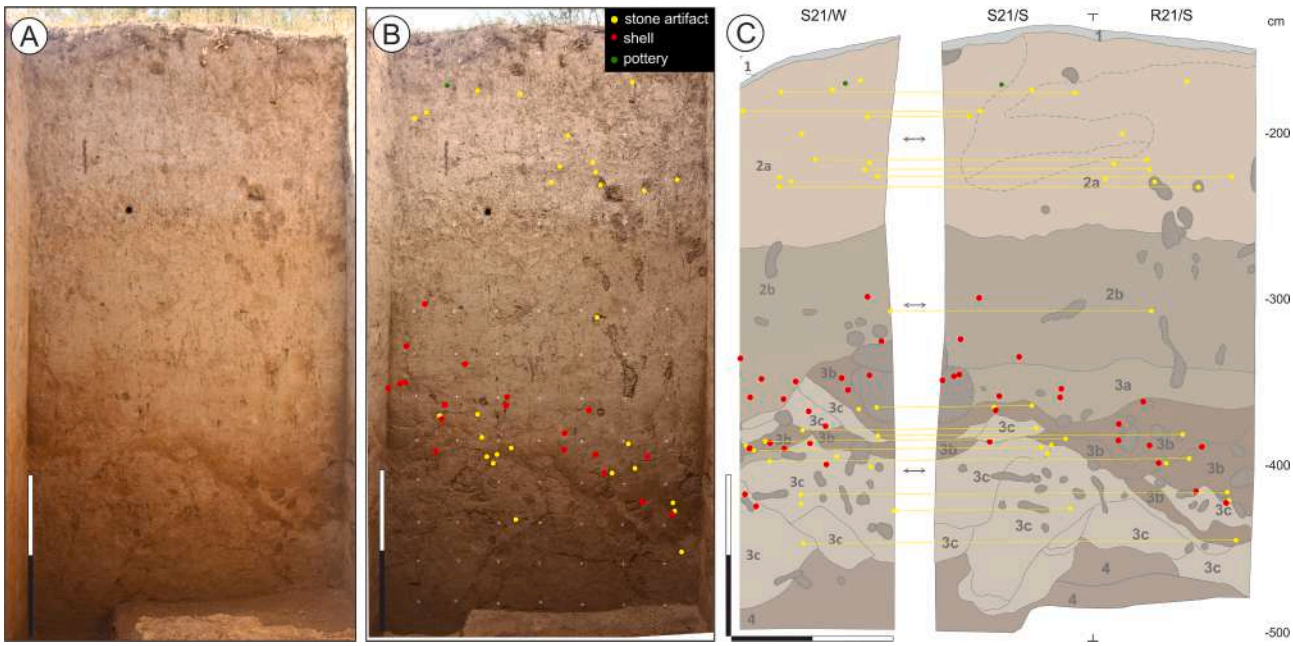

Fig. 3. Vertical distribution of the artifacts along the WE cross section of the site. Only artifacts found up to one meter from the section were plotted. A. Photo of the cross section along the WE axis; B. Distribution of artifacts and mollusks along the WE cross section; C. Distribution of artifacts and mollusks plotted onto cross section along WE and NS axis showing the inclination of findings in both the N and W directions.

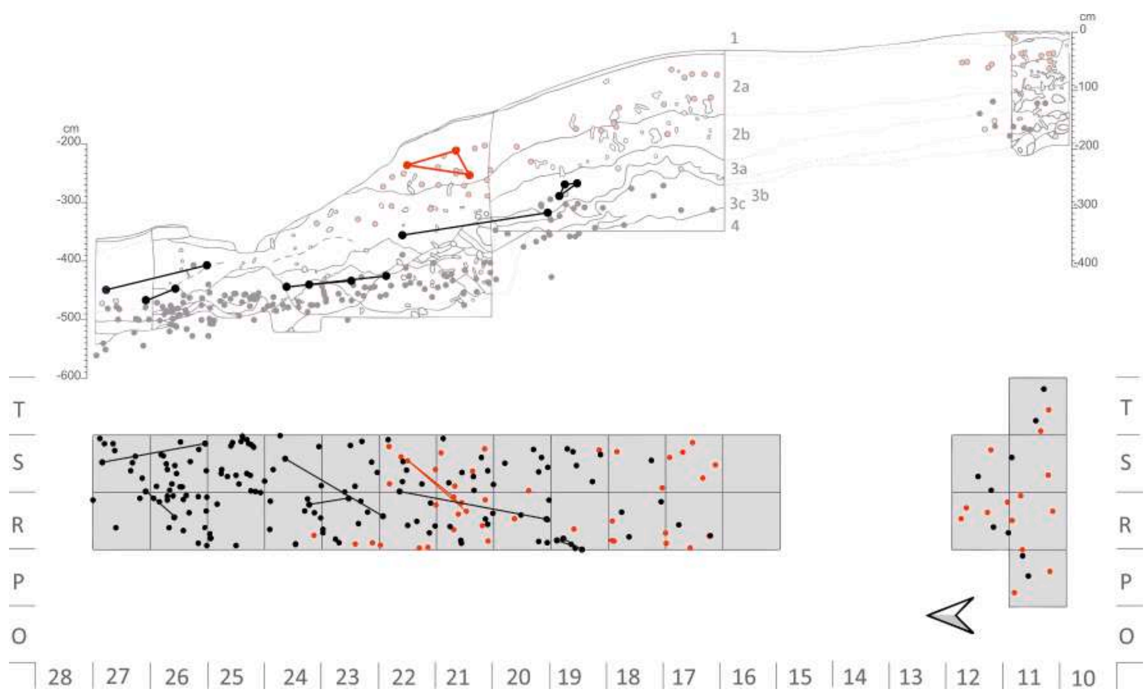

Fig. 4. Horizontal and vertical distribution of stone artifacts and their refittings. Black dots represent artifacts found in Lower archaeological level; Red dots represent stone artifacts found in the Upper archaeological level. Please note that all the artifacts from the Lower archaeological level were found in Sublayers 3a/3b, but due to the inclination of the layers in both NS and EW axis, they might mistakenly appear to belong to the Sublayers 3c and 4. A list and coordinates of the refitted artifacts can be found in **Online Resource 7**.

and 3a were also not taken into consideration. All these artifacts (n = 22) were treated as a mixed collection, together with a surface series found in the site (n = 76).

In consequence, the upper horizon assemblage consists of 77 stone artifacts, whereas the lower one consists of 208.

The stone artifacts were analysed with refitting and attribute analysis, in order to determine the operational chain. The raw material analysis of the assemblage was already presented in comparison to the Katta Sai 1 assemblage (Kot et al., 2020).

In total, 22 artifacts were successfully refitted, giving nine nodules. Three refittings constitute refits of broken artifacts, and were not subjected for further analyses. Technological analysis was conducted on six refitted nodules. A single one which included core with refitted debitage came from the upper cultural horizon. The other ones were found in the lower level.

The attribute analysis method (Chabai and Demidenko, 1998) was applied to the debitage. The attributes were divided into four general groups:

- general artifact morphology (the size, shape, state of preservation/ fragmentation, symmetry, cross-section, profile, the character of the distal part),
- the condition of the dorsal side (the direction of scars, cortex, interscar ridges, pecking, retouch),
- the condition of the ventral side (the bulbs, bulbar scars),
- the condition of the butt (the size, shape, profile, preparation).

Cores were submitted to detailed morpho-technological description based on the scar pattern analysis (working step analysis - Bar-Yosef and Van Peer, 2009), which is currently a standard method for the analysis of bifacial tool production and reduction processes. The method relies on the reconstruction of *chaîne opératoire* derived from evaluating the characteristics, spatial distribution and chronology of scar pattern visible on the tool (Pastoors et al., 2015; Pastoors and Schäfer, 1999; Richter 2001; Perreault et al., 2013; Shalagina et al., 2019).

The stone assemblage analyses aimed to determine the general purpose of the observed knapping schemes and identify the characteristic waste products from the planned and deliberate core reduction products. The term "blank" was used to describe such intentional core reduction products, even though they could be used for further tool production, but could be also used as tools without further retouching.

2.2. Geological investigation

Walls and bottoms of the archaeological trenches were accessible for geological investigation in the field. The visible sedimentary structures (such as boundaries of strata, bedding, lamination), as well as the post-sedimentary features (such as traces of bioturbation, cracks and fissures, discontinuity of sedimentary structures), were described, hand-drawn, and photographed. The basic lithological parameters were detailed, including color, soil texture, soil structure, reaction with 10% HCl. Layers (strata) were distinguished as archaeological excavation progressed, with basic field lithological criteria: changes in sedimentary structures, soil texture and structure, color, the intensity of bioturbation. The same was applied for additional trenches.

Most of the samples for dating were sediment samples collected in 2015 under dark conditions, and were intended to be analyzed by Thermoluminescence dating (TL), as a continuation of a TL dating program started in 2014 by S. Fedorowicz. However, after S. Fedorowicz's lab was closed, additional samples were collected in 2018 for optically stimulated luminescence dating (OSL) to supplement the TL series and to enable cross-verification of both methods. The only material from Katta Sai 2 appropriate for radiocarbon dating (^{14}C) was a collection of snail shells and human remains from a burial. We selected two of the shells from the Sublayer 3a/3b for dating, where the shells were the most abundant, and one human tooth from the grave backfill, Layer 2 „dark". We decided to use the different techniques (TL/OSL and radiocarbon) because they date different phenomena: the time since death of organisms (radiocarbon dating) and the age of the deposition of sediment (TL/OSL dating).

2.3. Dating

2.3.1. TL

Four standard TL sediment samples were collected from the S section of 2015 trench (Fig. 2). The annual dose was established with gamma spectrometry and performed on Polon-Izot gamma spectrometer with Mazar scintillation augment in the Institute of Geography, University of Gdansk. The equivalent dose was established on 63–80 μm polymineral fraction, after 10% HCl and 30% H_2O_2 washing and UV optical leaching (**Online Resource 2**). The samples were irradiated with 20 Gy, 50 Gy, 100 Gy, 200 Gy dozes from ^{60}Co gamma source, and heated in 140 °C for 3 h. The registration of curves was performed on RA'94 (produced by Mikrolab) thermoluminescence reader, coupled with EMI 9789 QA photomultiplier. The TL age was calculated, according to Frechen (1992).

2.3.2. OSL

Two sediment samples were collected from the S section of 2018 trench (Fig. 2). In the laboratory, both samples were dried. High-resolution gamma spectrometry using a HPGe detector manufactured by Canberra was carried out in order to determine the content of U, Th and K in the samples. Prior to measurement, the samples were stored for about 3 weeks to ensure equilibrium between gaseous ^{222}Rn and ^{226}Ra in the ^{238}U decay chain. Each measurement lasted for at least 24 h. The activities of the isotopes present in the sediment were determined using IAEA standards RGU, RGTh, RGK after subtraction of the detector background. Dose rates were calculated using the conversion factors of Guerin et al. (2011). For beta dose rate the cosmic ray dose-rate to the site was determined as described by Prescott and Stephan (1982). We assumed that the average water content was (18 $\pm$ 5)%. For further calculations a mean a-value of 0.08 for fine-grained quartz (Rees-Jones, 1995) was used. All necessary data for dose rate calculation are placed in Online Resource 3.

For OSL measurements, fine grains of quartz (4–11 μm) were extracted from the sediment samples. The first step was to obtain the fraction below 45 μm using sieves, next, sediments were treated by 20% hydrochloric acid (HCl) and 20% hydrogen peroxide (H_2O_2). Finally, material was etched by concentrated hydrofluorosilicic acid (34%, H2SiF6) for few days, after that grains were ready for gravitional separation.

All OSL measurements were made using an automated Risø TL/OSL DA-20 reader. The stimulation light source was a blue (470 $\pm$ 30 nm) light emitting diode (LED) array delivering 50 mW/cm2 at the sample (Bøtter-Jensen et al., 2000). Detection was through 7.5 mm of Hoya U-340 filter. Equivalent doses were determined using the single-aliquot regenerative-dose (SAR) protocol (Murray and Wintle, 2000). The final result was calculated using Central Age Model (CAM) (Galbraith et al., 1999) and the equivalent dose distributions (Berger, 2010) are presented in **Online Resource 3**. The obtained overdispersion was about 10%.

2.3.3. ^{14}C

In 2018, three human teeth and >10 unidentified small bone splinters were found in the oval pit structure filled with sediment called Layer 2 "dark", which was further interpreted as a human burial. A single human tooth belonging to adult individual was dated with the radiocarbon dating method at the Department of Human Evolution at the Max Planck Institute for Evolutionary Anthropology using the protocol described in Fewlass et al. (2019). Briefly, the sample was demineralised in 0.5 M HCl at 4 °C until no CO_2 effervescence was observed and the sample was soft. In order to remove any humic acid contamination, the sample was then treated with 0.1 M NaOH for 30 min at room temperature, and re-acidified in 0.5 M HCl. The sample was gelatinised in HCl pH 3 at 75 °C for 20 h, then filtered with an Ezee-filter (Elkay labs, UK: pre-cleaned by sonication in Milli-Q water for 20 min), and ultrafiltered (Sartorius Vivaspin Turbo 15 with a molecular weight cut off of 30 kDa, precleaned according to Brock et al., 2007). The > 30 kDa fraction was freeze-dried and then weighed to determine the collagen yield (as a % of the original dry bone weight). The yield was well above the generally required 1% minimum. ~0.5 mg collagen was analysed on a ThermoFinnigan Flash elemental analyser (EA) coupled to a Thermo Delta plus XP isotope ratio mass spectrometer (IRMS). Stable carbon isotope ratios were expressed relative to VPDB (Vienna PeeDee Belemnite) and stable nitrogen isotope ratios were measured relative to AIR (atmospheric N_2), using the delta notation (δ) in parts per thousand (‰).

Repeated analysis of both internal and international standards indicates an analytical error of 0.2‰ (1σ) for $\delta^{13}C$ and $\delta^{15}N$. The stable isotopic ($\delta^{13}C$ and $\delta^{15}N$) and elemental values (C%, N%, C:N) (Table 3) indicated the collagen was suitably well-preserved for ^{14}C dating (van Klinken, 1999). ~4 mg collagen was weighed into pre-cleaned tin cup and sent to the Curt-Engelhorn-Centre for Archaeometry Klaus-Tschira-AMS facility in Mannheim, Germany (lab code: MAMS) where the sample was combusted in an EA, then the CO_2 was converted catalytically to graphite and dated using the MICADAS-AMS (Kromer et al., 2013). Age and error calculation of unknown samples was performed using BATS software, using background collagen samples and standards measured in the same batch, with an added external error of 1‰ as per their standard practice. In order to monitor lab-based contamination, an aliquot of a > 50,000 BP cave bear bone (Korlević et al., 2018) was pretreated and dated alongside the sample.

Due to the lack of bone preservation in the artifact-bearing strata, the radiocarbon dating was conducted on mollusk shells. Two shells of *Fruticicola lantzi* (Lindholm, 1927) found in the main concentration at the border between layers 3a and 3b were dated. Despite some limitations in the application of shells in radiocarbon dating due to possible incorporation of dead carbon from the bedrock, bradybaenid snails (which *Fruticicola* belongs to) feeding on fresh and decaying plants (e.g. Brodie and Barker, 2012; Kuźnik-Kowalska et al., 2013; Wang et al., 2014) are expected to provide reliable ^{14}C ages (cf. Limondin-Lozouet and Preece, 2004; Pigati et al., 2010; and references therein).

The quality of the material was verified using the X-ray diffraction (XRD) method, which showed pure aragonite. This indicates that the carbonate material of the shells has not been affected by diagenetic alteration, which tends to produce calcite. The dating was performed in the Poznań Radiocarbon Laboratory in Poland.

2.4. Subfossil fauna

During the malacological analysis shells collected directly from the trenches in 2015 and 2018, as well as those acquired in the course of wet-sieving during the extraction of the artifacts were investigated. After maceration, all mollusk shells and their fragments were collected from dried residuum. Identification of the material was carried out under a stereoscopic microscope with magnifications up to 65 × with reference to taxonomic keys and catalogues (Sysoev and Schileyko, 2009; Schileyko and Rymzhanov, 2013). The entire shells, the apical or mouth fragments, as well as the shell fragments that could be assigned to a specific species were counted. Some damaged specimens and shell fragments were assigned to the level of genus or considered as unidentifiable. Nomenclature and ecological preferences followed Schileyko and Rymzhanov (2013) and Egorov (2008), respectively. The relatively low frequency of shell material from Katta Site 2 excluded quantitative methods used in standard malacological procedures (e.g. Ložek, 1964; Alexandrowicz and Alexandrowicz, 2011).

3. Results

3.1. Stratigraphy

The lowermost studied unit in the stratigraphic sequence of Katta Sai 2 is Layer 4 (Table 1). The lack of visible sedimentary structures within this unit suggests that this is an eolian deposit. However, the layer was uncovered in a limited area and at limited thickness during the excavation, and its lower boundary was not reached, therefore the interpretation of its origin is restricted. Above Layer 4, there is around 1.5 m thick colluvial series (Layer 3). This series comprises numerous erosional channels filled with silts and silty loams, some with aggregate

Table 1
Stratigraphic units recognized at Katta Sai 2.

Layer	Sublayer	Color	Texture	Sedimentary structures	Genetic interpretation
1		10YR 7/2 (dry) 10YR 4/2 (moist)	silty loam, strongly bioturbated by insect/worm burrowing and plant roots	unreadable due to post-depositional bioturbation	modern topsoil
2 (dark)		10YR 7/2 (dry) 10YR 4/3 (moist)	silty loam, porous, slightly bioturbated by insect/worm burrowing	sharp, erosional lower boundary, subvertical walls	anthropogenic feature (grave)
2		10YR 8/3 (dry) 10YR 6/4 (moist)		possibly originally massive	eolian deposits
	2c	as entire layer	silt/silty loam, soft in dry state, porous, strongly bioturbated by insect/worm burrowing	unreadable due to post-depositional bioturbation	loess (?), modified by post-sedimentary alterations
	2a	as entire layer	silt/silty loam, soft in dry state, porous, strongly bioturbated by insect/worm burrowing, with mollusk shells and lithics	unreadable due to post-depositional bioturbation	loess (?), modified by post-sedimentary alterations
	2b	as entire layer	silt/silty loam, soft in dry state, with dispersed fine aggregates visible in close view	massive (?)	loess (?), slightly modified by post-sedimentary alterations
3		variable		erosional channels	colluvial deposits
	3a	10YR 8/2 (dry) 10YR 7/3 (moist)	silt/silty loam, soft in dry state, more porous than Sublayer 2b, with dispersed fine aggregates visible in close view, with mollusk shells and lithics	massive in upper part; series of erosional channels at the bottom, the largest up to 30 cm deep and up to 120 cm wide	colluvial deposits mobilized by rill erosion and washed down the slope, possibly covered by loess
	3b	10YR 6/3 (dry) 10YR 5/4 (moist)	silt/silty loam, soft in dry state, brownish sediment, with abundant fine whitish carbonate clasts	series of erosional channels, the largest up to 40 cm deep and up to 100 cm wide	colluvial deposits mobilized by rill erosion and washed down the slope
	3c	10YR 8/2 (dry) 10YR 7/3 (moist)	silty loam, hard and compacted in dry state, with coarse aggregates	series of erosional channels, the largest up to 70 cm deep and up to 150 cm wide	colluvial deposits mobilized by rill erosion and washed down the slope
4		10YR 8/2 (dry) 10YR 7/3 (moist)	silt/silty loam, soft in dry state	massive	eolian deposit (?)

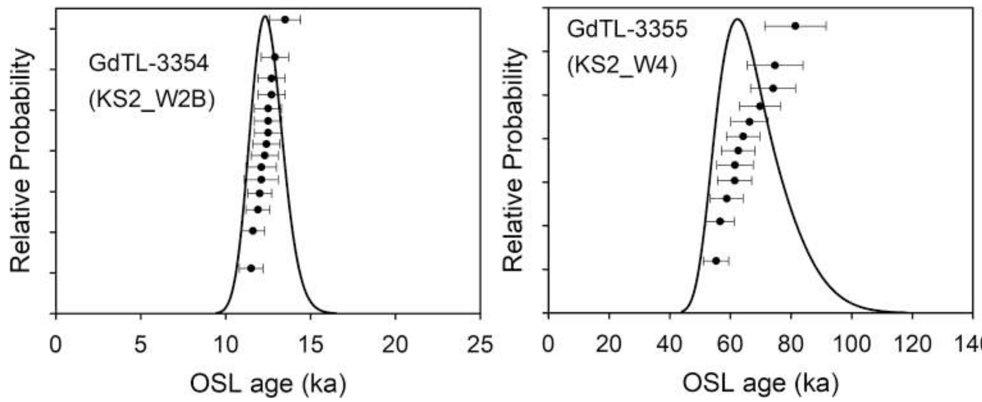

Fig. 5. Graph of the age distribution (Berger, 2010) for both investigated samples.

Table 2
Results of OSL and TL dating of sediments from Katta Sai 2.

Unit	Method	Lab code	Age (y BP), ± 1σ	Laboratory
Sublayer 2c	OSL	GdTL-3354	12330 ± 830	Gliwice Absolute Dating Methods Centre (Gliwice, Poland)
Sublayer 2b	TL	UG-7069	48600 ± 7000	Institute of Geography, University of Gdansk (Gdańsk, Poland)
Sublayer 3a	TL	UG-7068	27000 ± 3500	
Sublayer 3c	OSL	GdTL-3355	63800 ± 4400	Gliwice Absolute Dating Methods Centre (Gliwice, Poland)
Sublayer 3c	TL	UG-7070	70400 ± 10000	Institute of Geography, University of Gdansk (Gdańsk, Poland)
Layer 4	TL	UG-7071	42100 ± 6300	

texture. The material of infills of these channels can be subdivided into three lithological types, which were called Sublayers 3c, 3b, and 3a. Type 3c usually occurs in the lower part of the layer, type 3b in the middle, and type 3a in the upper part. However, this ordering of sublayers is not strict and in some cases the infills attributed to a given sublayer occur in other stratigraphic positions. This indicates that deposition of the entire series was a dynamic process, and the source of the material changed several times. Lithic artifacts and mollusk shells are sparse and unevenly distributed in the Sublayers 3b and 3c, but are numerous in the Sublayer 3a. Erosional channels are of similar size and morphology as the structures noticed at Katta Sai 1 (Krajcarz et al., 2016), where the channels appeared in one stratigraphic level and formed a single network, possibly linked with a single erosional event. But at Katta Sai 2 we have a series of channels, recording numerous erosional events and possibly a long-lasting period of geomorphological instability.

The colluvial series is covered by massive silty sediments (Layer 2), possibly representing the eolian accumulation of loess-like material. There is no clear boundary between units 3 and 2, so the upper unit is distinguished on the basis of indirect characteristics, such as lower porosity, different compactness, drying rate of the freshly exposed sediment, and lack of channels. The thickness of Layer 2 reaches over 2 m in the lower excavation zone, and around 1 m at the top of the crest. Sparse fine aggregates dispersed within this unit may record occasional re-deposition of material down the slope (washing), or periglacial alteration. This series contains the upper level of lithics and the mollusk shells, situated in the middle part of the unit. The layer (especially its Sublayer 2a) is strongly affected by bioturbation, so it is impossible to detect any original sedimentary structures here, so in consequence the interpretation on the origin of the layer is limited. This series is cut by several anthropogenic features, called "Layer 2 (dark)". Human remains were found in the backfill which indicates that at least some of these structures were graves. The sequence is topped with humiferous Layer 1, which is the modern topsoil.

Fossil macro-scale burrows are quite numerous in the whole sequence, especially in units 3 and 2b, and in the entire profile of the upper excavation zone. Their size suggests mid-size and large rodents, such as ground squirrels and marmots, but no identifiable remains of burrowing animals were preserved. The presence of burrows suggests that the original distribution of the artifacts and ecofacts might have been disturbed. In particular, bioturbation may be responsible for the observed irregularity in the distribution of the lithics, such as the occurrence of single artifacts outside the main concentration levels.

3.2. *Chronology*

The order of the obtained OSL, TL and radiocarbon dates is not consistent with the stratigraphic sequence. This was, however, expected due to the colluvial nature of the deposits. Nevertheless, detailed analysis of the date distributions and their relationships with the sediment facies allows the approximation of the chronology of geomorphic events at Katta Sai 2.

Both OSL age distributions (Berger, 2010) presented in Fig. 5 show unimodality with overdispersion parameters less than 10% which means that there is no clear evidence for partial bleaching or mixing grains with

Table 3
Results of radiocarbon dating from Katta Sai 2.

Unit	Material	Collagen yield (%)	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	%C	%N	C:N	Age (y BP)/Lab code	Calibrated age* (cal. y BP), 95.4% probability
Sublayer 2 (dark) [human burial]	Human bone (B8/2018)	7.8	−14.7	10.9	43.9	16.1	3.2	2710 ± 21/MAMS-48231	2851–2761 cal BP
Sublayer 3a/3b	Mollusk shell (B27/2015)							39000 ± 1500/Poz-98409	45840–41200 cal BP
Sublayer 3a/3b	Mollusk shell (B37/2015)							43000 ± 2000/Poz-98408	52330–42840 cal BP

* Dates were calibrated with IntCal20 using OxCal v4.4.2 (Bronk Ramsey, 2009; Reimer et al., 2020).

Table 4
Mollusks from Katta Sai 2; n_t – number of taxa, n_s – number of specimens, f – shell fragments. Ecological preferences based on Egorov (2008) and Schileyko and Rymzhanov (2013).

Layer/ sublayer	*Pseudonapaeus* cf. *albiplicatus* (Martens, 1874)	*Pseudonapaeus sogdianus* (Martens, 1874)	*Pseudonapaeus* sp.	*Fruticicola lantzi* (Lindholm, 1927)	*Leucozonella mesoleuca* (Martens, 1882)	n_t	n_s	**Unidentifiable**
1		1		4 + 3f		**2**	5 + 3f	5f
2a				6 + 9f		**1**	6 + 9f	9f
2a/2b	1			1f		**2**	1 + 1f	
2b	2	1	6 + 1f	10 + 19f	2 + 1f	**5**	21 + 21f	59f
2b/3a		6	5 + 2f	6 + 28f		**3**	17 + 30f	1 + 45f
3a	1 + 1f	20 + 5f	14 + 2f	59 + 174f	3	**5**	97 + 182f	1 + 139f
3a/3b	3	41 + 7f	33 + 23f	62 + 208f	21 + 10f	**5**	160 + 248f	5 + 195f
3c		1	1	1 + 3f		**3**	3 + 3f	1 + 5f
Total	**7 + 1f**	**70 + 12f**	**59 + 28f**	**148 + 445f**	**26 + 11f**	**5**	**310 + 497f**	**8 + 457f**
Ecology	Open habitats, among shrubs, in mountain slopes covered with bushes, also in mesophilous and hygrophilous conditions	Screes, shrubs, steppe foothills among grassy vegetation		Mountain meadows, open slopes with bushes and grasses, under rocks, screes, rock crevices, along banks of rivers and streams	Open slopes, in grasses and shrubs			

different luminescence ages.

Although the depositional context of Layer 4 is uncertain (this may be an eolian sediment preserved *in situ*, or re-deposited colluvial sediment), the TL date for this layer (Table 2) allows us to date the deposition or re-deposition of this layer's material to around 42.1 ± 6 ky BP. At the same time, this date sets a lower boundary for the chronological framework of the studied profile. Sublayer 3c is clearly of colluvial origin and yielded one TL date (70.4 ± 10 ky BP) and one OSL date (63.8 ± 0.4 ky BP) (Table 2**)** which overlap due to the large associated error of the TL date but pre-date the TL age from Layer 4. These dates likely indicate the original age of the main source material, while the re-depositional event should post-date these ages and the date for Layer 4, i.e., after 42.1 ± 6 ky BP.

The Palaeolithic artifact-bearing Sublayers 3a and 3b delivered two ^{14}C dates which overlap each other (52,330–42,840 cal BP and 45,840 – 41,200 cal BP – Table 3) and the TL date for Layer 4. These ^{14}C dates were obtained from snail shells but may represent the approximate age of the source material, which was silt rich in snail remains. The dates suggest that the source material could have been part of Layer 4, situated higher up the slope, but we cannot exclude that it was a sediment of other unknown strata. These dates do not represent the age of the Palaeolithic assemblage directly. However, due to the common co-occurrence of snail shells and Palaeolithic artifacts, these dates tentatively suggest an approximate age of the archaeological assemblage within the layer (see section 4.1 for wider discussion).

Another part of Sublayer 3a was dated with TL method to around 27.0 ± 3.5 ky BP (Fig. 2, Table 2). This date is notably similar to the TL age 26.3 ± 3.4 ky BP (Fig. 2) obtained for a similar stratigraphic position (Sublayer 2b) within the 2014 trench (Krajcarz et al., 2016). If we take into consideration that the sample from Sublayer 3b (2015 trench) was taken from the upper part of this unit (around 10 cm below its upper boundary), and the sample from Sublayer 2b (2014 trench) was taken from its lower part (around 20 cm over its lower boundary), and further, that the boundary between both units was unclear, we can conclude the both dates likely relate to the same depositional event. This event might represent loess accumulation or – a less likely but possible scenario – a resetting of the TL signal during a re-deposition event. Both these interpretations indicate that deposition or re-deposition of Sublayers 3a–2b took place, or at least ended, during the Last Glacial Maximum (LGM). The eolian interpretation seems more likely if we consider that the LGM was the main period of loess accumulation across Eurasia. The OSL date for the upper part of the Layer 2 (around 12.3 ± 0.8 ky BP, Table 2) marks the upper limit for this loess accumulation.

Thus, it seems that the loess accumulation at Katta Sai 2 was interrupted, possibly by a colluvial event, as indicated by the disordered dates. A TL date obtained for Sublayer 2b (48.6 ± 7 ky BP - Table 2) is clearly older than the TL date of LGM age in the lower deposits Sublayer 3a, but is similar to the ^{14}C dates from Sublayers 3a and 3b from the

Table 5
Composition of Katta Sai 2 assemblage. Numbers in brackets represent amount of blanks within certain typological categories.

	Katta Sai 2				
artifacts $^{(blanks)}$	Lower horizon (Layer 3a, 3a/b, 3c)	Upper horizon (Layer 2a, 2b)	Mixed material	Surface material	TOTAL
blades	$12^{(4)}$	$15^{(9)}$	$4^{(1)}$	$10^{(2)}$	$41^{(16)}$
bladelets	$2^{(0)}$	$4^{(1)}$	$0^{(0)}$	$1^{(0)}$	$7^{(1)}$
flakes	$116^{(18)}$	$47^{(2)}$	$10^{(1)}$	$50^{(9)}$	$223^{(30)}$
points	$18^{(13)}$	$2^{(1)}$	$0^{(0)}$	$3^{(3)}$	$23^{(17)}$
chips	25	1	4	0	30
chunks	31	8	4	12	55
cores/preforms	2	2	0	0	4
TOTAL	$208^{(35)}$	$77^{(13)}$	$22^{(2)}$	$76^{(14)}$	$383^{(64)}$

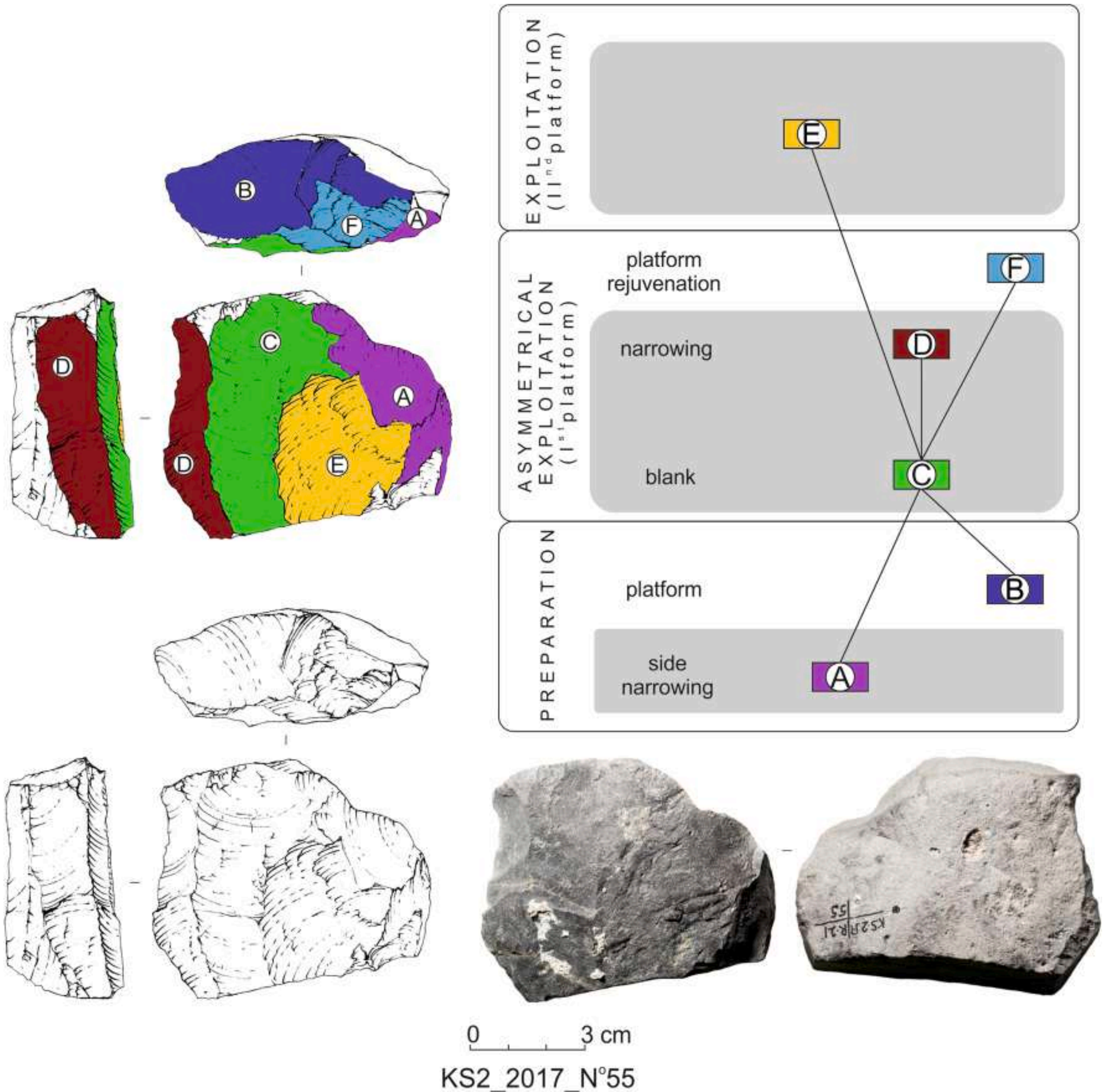

Fig. 6. Core from the Lower cultural horizon. Scar pattern analysis of the core representing asymmetrical knapping scheme.

shells. The LGM-aged TL date likely documents another colluvial event, difficult to identify by sedimentological structures, as the entire stratum is disturbed by later bioturbation. The sources of material for these colluvial processes were most probably the same sediments which served as a source for colluvial deposits of Sublayers 3a and 3b which is supported by similar dating, and also by the presence of shells and lithics in both levels.

3.3. Subfossil fauna

Mollusk remains in Katta Sai 2 were found in 8 deposit layers and/or sublayers. Altogether, five taxa of land snails, represented by 310 individuals and 497 shell fragments, were identified. Eight individual shells and 457 shell fragments were not identified (Table 4). The number of taxa in particular layers ranged from 1 to 5, whereas the number of individuals varied from a single shell and a shell fragment noted in Sublayer 2a/2b to 160 shells and 248 fragments in Sublayer 3a/3b. The most abundant and diversified fauna was found in Sublayers 3a, 3a/3b and 2b. In other layers usually a few shells and shell fragments occurred (Table 4).

The assemblage is dominated by *Fruticicola lantzi*, represented by 148 individuals and abundant shell detritus, and *Pseudonapaeus sogdianus* (Martens, 1874) represented by 70 individuals (Table 4). Many *Pseudonapaeus* shells were damaged and assigned to the genus level only. About seven of them may represent *Pseudonapaeus* cf. *albiplicatus* (Martens, 1874), but this identification is uncertain as it is based on incomplete and poorly preserved shells. *Leucozonella mesoleuca* (Martens, 1882) was quite numerous, with 21 out of 26 shells concentrated in Sublayer 3a/3b (Table 4).

All the recognised species are distributed in the mountain ranges of Central Asia, including Tian Shan, in recent times (Egorov, 2008; Sysoev and Schileyko, 2009; Schileyko and Rymzhanov, 2013).

3.4. Archaeological assemblage

3.4.1. Lower horizon

The collection from the lower horizon consists of 208 artifacts. Table 5 presents a composition of the assemblage.

In the assemblage, all the *chaîne opératoire* stages are present, starting from single opening flakes i.e. flakes covered with 100% with a cortex up to blanks and retouched tools. 30% of the assemblage consists of chips and chunks, which indicates that the lower archaeological horizon was only slightly decomposed by the erosional processes. This is additionally proved by the presence of technological refittings. 37% of the

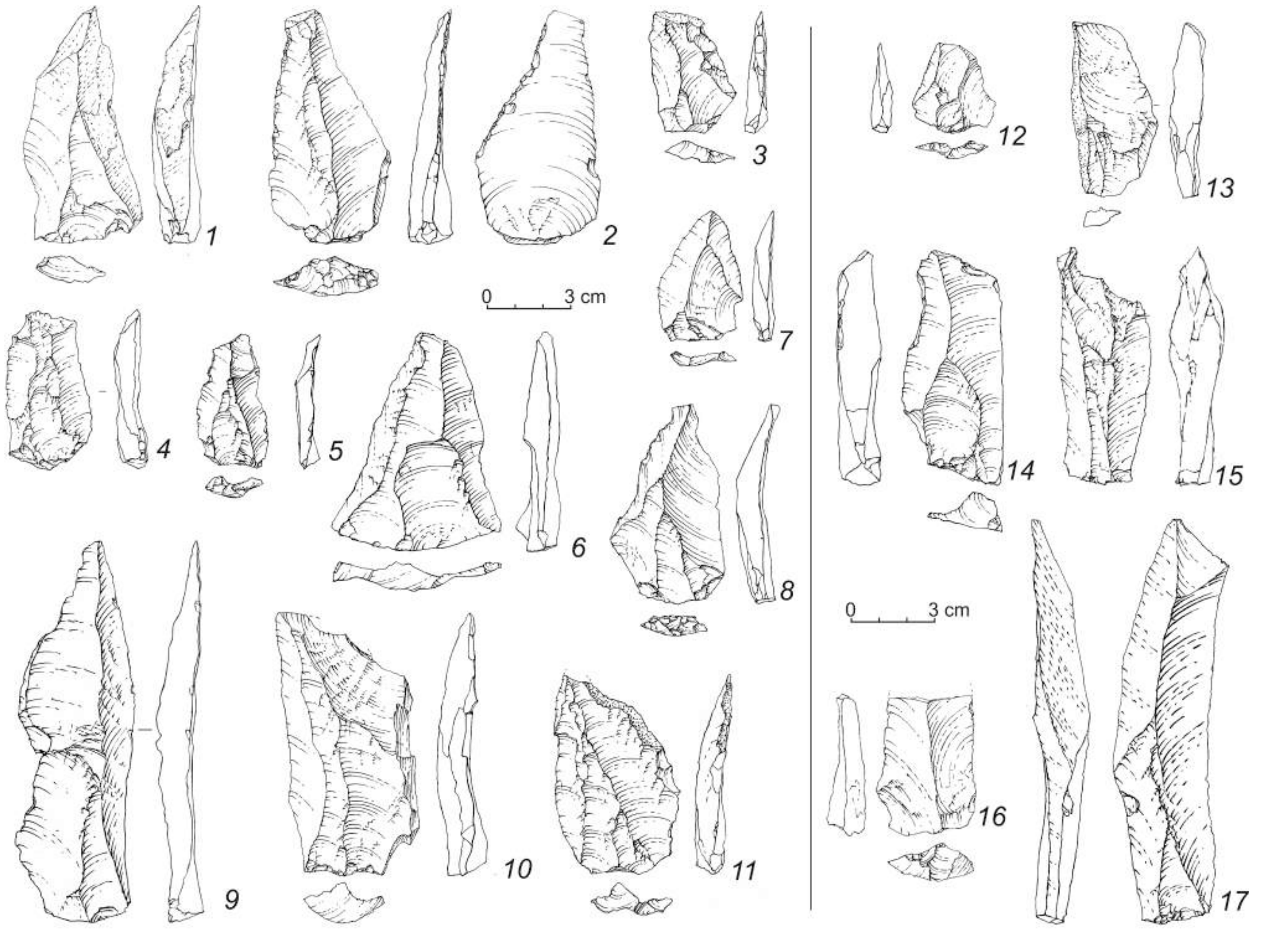

Fig. 7. Blanks (points and blades) from the Lower and Upper cultural horizon. 1–11 - Lower cultural horizon (layer 3a/3b), 12–18 - Upper cultural horizon (layer 2a and 2b). 1–12 – Levallois points; 13–15- Levallois blades; 16–17 - blades.

assemblage comes from the core preparation, whereas only 7% from the rejuvenation (**Online Resource 6**). 24% of the assemblage consists of blanks. What is more, only a single core and a single preform were found in the lower level. Such a significant amount of blanks might indicate a settlement character of the site.

The preform was prepared by splitting the pebble into two pieces and preparing the striking platform around the core by detachment of the big and thick, short flakes. The working surface was not worked on further (**Online Resource 4**).

The core was made on a flat angularly broken nodule (Fig. 6). It has a single flat striking platform located at an angle of 65° but single removals were also detached from a second unworked striking platform. The striking platform was prepared by several removals detached angularly from two sides of the core. Such a feature has not been noted before either in Katta Sai 1, nor Katta Sai 2. The core has two distinct flaking surfaces, the main one being located on the flat face of the core, and the second one on the narrow face. The narrow face was used at the end of the reduction process and was not involved in the initial phase, although the striking platform was prepared with a use of a removal detached from a side of a narrow surface. Blade reduction using a side of the flat working surface shows some similarities to the asymmetrical core reduction method specific for IUP assemblages in Central Asia (Zwyns, 2012, 2021).

The general knapping scheme aimed to obtain preferential blanks of Levallois type. Out of 35 blanks found in the assemblage, there are 18 flakes, 13 points, and 4 blades (Fig. 7). Although one can see the scarcity of blades, still, the tendency toward elongation might be seen among the pointed Levallois blanks (Fig. 7**:8,9**). This indicates that the scheme was focused on obtaining pointed blanks with convergent scar pattern. The majority of blanks contains linear plain butts. Only four of them are faceted (e.g. Fig. 7**:2,7)**. There are also single *chapeau de gendarme* butts (Fig. 7**:8).**

Among five retouched artifacts found in the lower horizon there are three which show irregular retouch along the edge, e.g. a Levallois point with alternate marginal retouch on both edges (Fig. 7**:2**). A thick flake reworked in a truncating-faceting manner might be described as an atypical truncated faceted tool (**Online Resources 5**). Additionally, a single atypical burin-core made on blade was found (Fig. 8). Its flaking surface is located along the edge and extends onto the ventral face. Small blade blanks are struck from two opposed platforms, which are located angularly towards each other (Fig. 8). Due to the presence of a retouched edge prepared at the very end of the reduction process (Fig. 8), one cannot exclude the use of this artifact more as a truncated faceted piece, similar to the ones known from Obi-Rakhmat (Shalagina et al., 2015).

One should also take into consideration that the knapping technology was limited by the use of a poor quality local raw material, which constrained the use of simplified knapping schemes (Kot et al., 2020). Still, the presence of multiple blanks made of various raw materials, including the exotic ones, indicates that the general knapping approach was focused on obtaining points of different morphology. The presence of two one-side crested blades (Fig. 9**:2**–**3**) might also indicate realizing a more volumetric concept in the assemblage. Still, one should also

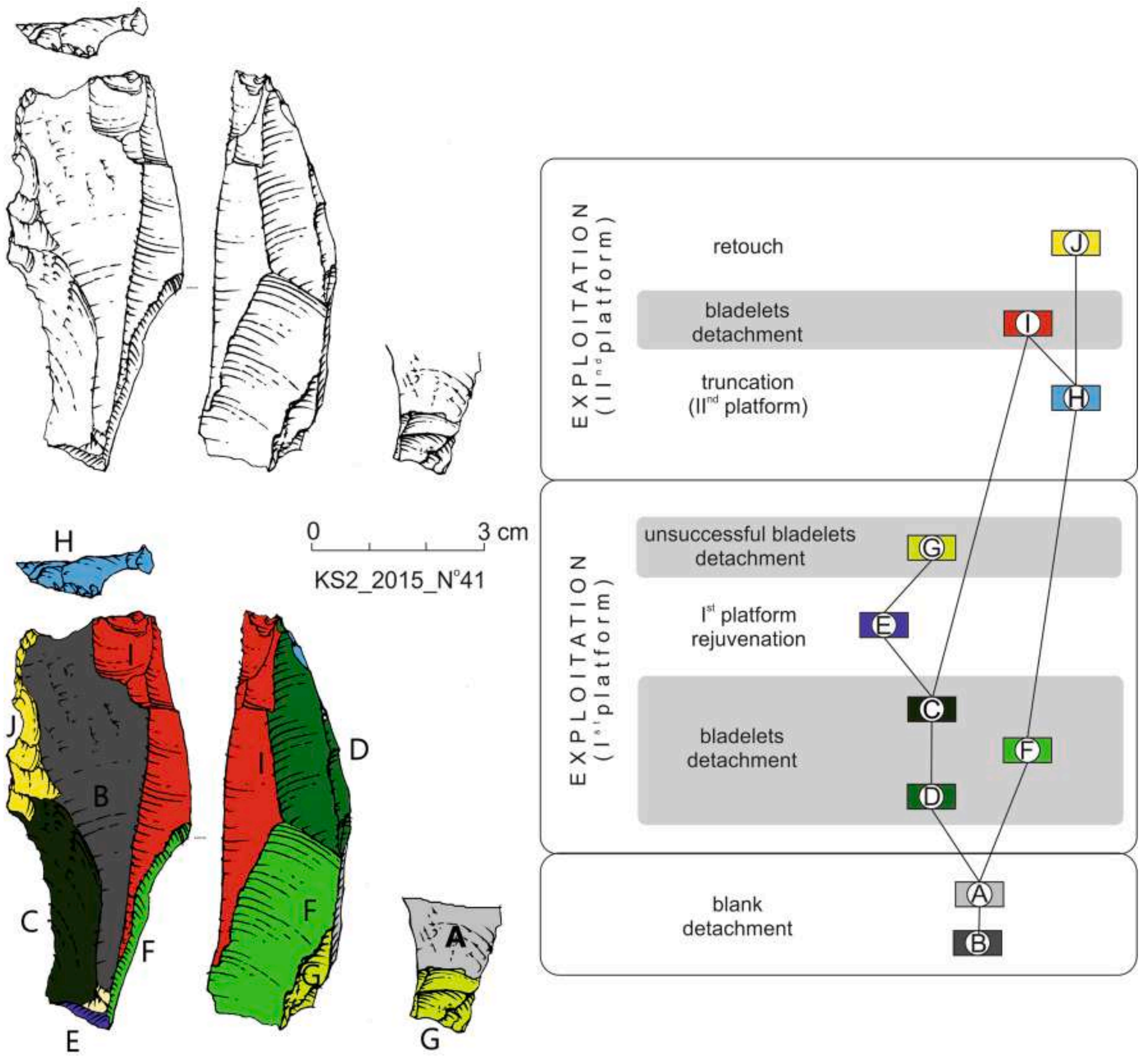

Fig. 8. Scar pattern analysis of the burin-core/truncated-faceted piece found in the Lower cultural horizon showing that the lower striking platform was prepared and exploited first, and only then the second platform was prepared (sequence H) and exploited (sequence I). The first striking platform shows also traces of rejuvenation (sequences E).

consider the possibility that they resemble part of asymmetrical core exploitation operational chain (Fig. 6), which is a characteristic core reduction scheme for IUP assemblages (Slavinsky et al., 2016; Škrdla, 2003c).

3.4.2. Upper horizon

The inventory from the Upper horizon consists of 77 stone artifacts (Table 5), including two cores. One of them was successfully refitted with four flakes.

The narrow-faced core aimed to obtain wide blades or elongated flakes (Fig. 10). The striking platform was prepared with transversal detachments. Refitting of the striking platform preparation flakes shows how the core was subsequently shortened during the exploitation. The knapping angle is 85°. The narrow face was worked by detaching removals located at the intersection of the front of the sides of the core. Only then the removal, which was probably a blank, was detached in the middle. The very last removals aimed at rejuvenating the working surface by repeating detachment of narrowing (*débordant)* removals located at the intersection of the front and the side of the core.

The second core presents a less regular knapping scheme due to its triangular shape (Fig. 11). It was reoriented several times. The last working surface was worked from two opposite striking platforms located angularly to each other. One can observe a tendency toward detaching narrowing (*débordant*) flakes on the side of a working surface, and the elongated blank in the middle, which is specific for Levallois concept. The first stages of core exploitation show some traces of asymmetrical reduction (Fig. 11).

The assemblage of the Upper horizon consists of 25% blanks. Among blanks one can see the presence of two distinct components. The predominant one consists of blades made with a unidirectional knapping scheme (Fig. 7). Blade blanks are thick (medium = 7.3 mm) and wide (medium = 25.4 mm) with a parallel or convergent scar pattern. The majority of them have biconvex prepared butts with traces of pecking. The width of the butts is smaller than the width of the blank in its proximal part (Fig. 9**:5,6,12**), which is opposite to the blank characteristic in the lower cultural horizon. The characteristic feature is the predominance of a lip accompanied in some artifacts with a small bulb without bulbar scar. This might indicate a use of soft, mineral hammer percussion.

The second component consists of flake, pointed blanks with triangular or trapezoid cross-section and a prepared linear butt. They resemble blanks found in the lower horizon (Fig. 7**:12,13**) but in general are substantially smaller.

Taking into consideration the small number of artifacts, and especially cores in the Upper horizon, together with the presence of two quite distinct knapping approaches, it is not possible to identify if the blades

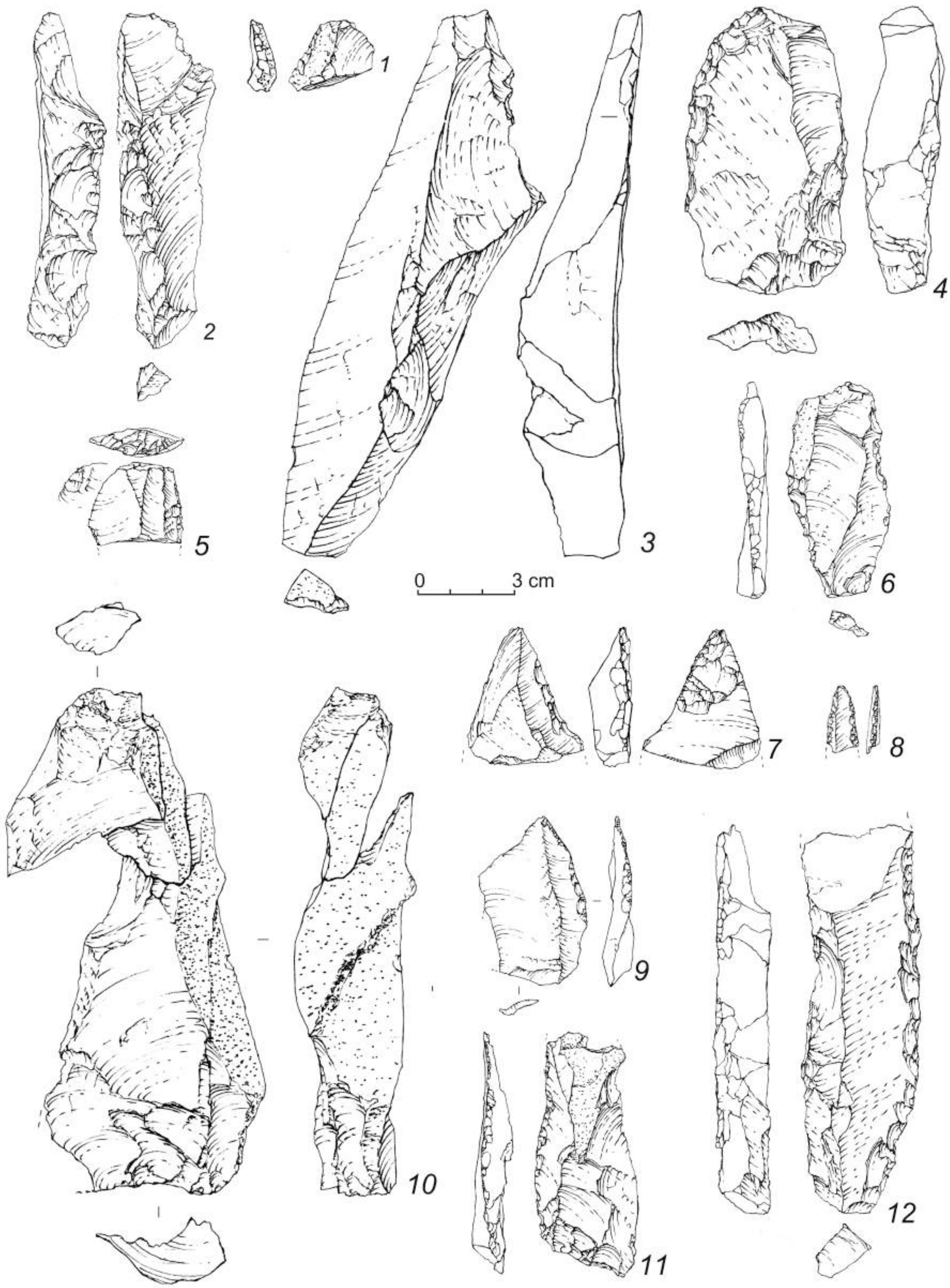

Fig. 9. Stone artifacts found in Lower (1–4), and Upper (5–12) cultural horizon. 1. Retouched flake, 2–3. Crested blades; 4. Retouched flake; 5. Blade blank with ventral marginal retouch; 6. Retouched flake; 7. Flake with ventral retouch; 8. Retouched bladelet; 9. Retouched flake; 10. Technological refitting from bidirectional core preparation stage; 11–12. Artifacts with retouched longitudinal edge.

themselves were obtained with the use of the Levallois concept or a volumetric knapping scheme.

Among 11 retouched artifacts found in the upper level, the retouched blades and bladelets predominate (n = 7). One can observe a tendency for retouching longitudinal edges (Fig. 9) with either marginal or extensive retouch. Additionally a single perforator made on the blade was found, as well as a single convergently retouched bladelet, made on exotic raw material (a silicified limestone [calcarenite] with shells). A single broken flake shows traces of bifacial reduction and ventral thinning (Fig. 9**:7**).

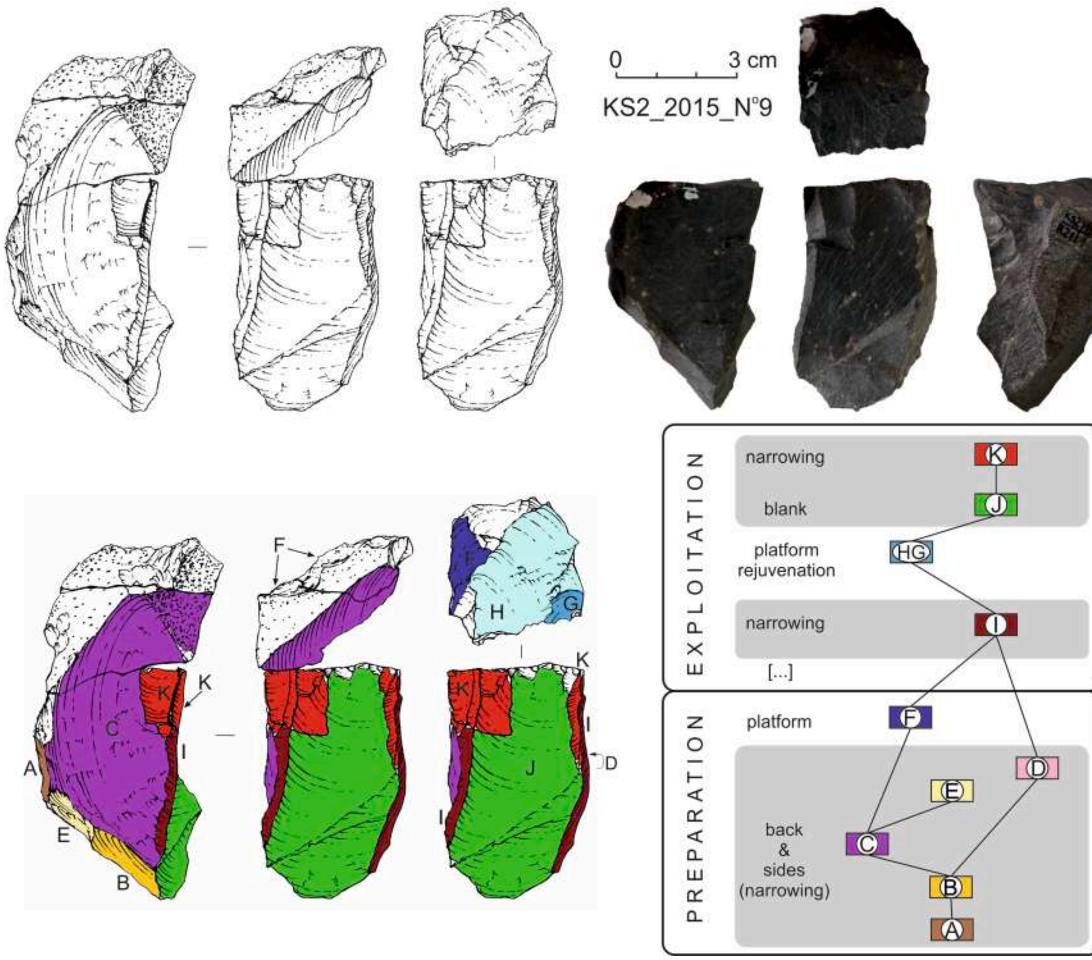

Fig. 10. Scar pattern analysis of the unidirectional core and its refits from the Upper cultural horizon.

4. Discussion

4.1. Palaeolithic site formation

Most of the Palaeolithic material at Katta Sai 2 occurs within two well-separated levels, each linked to a certain stratigraphic position. Only single artifacts occur outside these levels, and their positions do not follow any regular pattern. We may assume that those artifacts are post-depositionally dispersed, possibly by animal burrowing activity.

The Lower level is situated at the bottom of Sublayer 3a and in Sublayer 3b. Due to erosional characteristics of the bottom of this unit (see Table 1 and Fig. 2), the deposition of artifacts was possibly related to geological transport which followed an erosional event. However, all artifacts are situated at roughly the same level, which indicates that they were deposited together. Also, the lack of postdepositional damage along the artifact edges as well as the presence of several technological refits indicates rather short transportation of the artifacts from their primary location. It is noteworthy that the size and morphology of erosional channels at the bottom of Sublayer 3a resembles the characteristics of similar structures at Katta Sai 1 (Krajcarz et al., 2016). Likewise here, the stratigraphic position of the Palaeolithic artifacts was also at the bottom of the erosional channels. This similarity may suggest that the re-deposition of artifacts was connected at both sites with the same geomorphic event. Additional similarities include the texture of sediments and the co-occurrence of Palaeolithic artifacts and snail shells. The disorder of the dates, as mentioned above (Results: Chronology section), suggests that the artifacts together with numerous snail shells, are connected with colluvial re-depositions down the slope (Fig. 12). The obtained dates are not robust enough to conclude the exact age of the Lower level Palaeolithic-bearing sediments. What we can conclude about the age of this assemblage is that it is earlier than the age of the LGM eolian sedimentation of the layers above (around 26–27 ky BP), and contemporary or earlier than the youngest date which predates the re-deposition event (around 42 ± 6 ky BP).

The common co-occurrence of re-deposited Palaeolithic and mollusk assemblages within Sublayers 3a and 3a/3b suggests that they were originally situated in the same or similar stratigraphic positions. We cannot exclude the possibility that the shells and artifacts were initially deposited in two different locations and/or stratigraphic positions, and then re-deposited mutually and mixed together within one re-deposited layer. Such an interpretation would need, however, a very complex explanation, because shells and lithics have different mechanic parameters (density, shape, size), so their simultaneous accumulation is highly improbable due to expected segregation during geological transport. Therefore, their independent deposition at one level would need an accidental association of variable events of erosion, transport and accumulation. A much more likely explanation is that they were initially deposited together at the same location and stratigraphic position, and then re-deposited together by a cohesive or semi-cohesive flow (e.g. a mudflow), which did not segregate the material. The lack of segregation is also supported by numerous refittings. Thus, the age of the mollusk assemblage, established on the basis of two radiocarbon dates to between 52 and 41 ky cal BP (95% probability), may be considered as an approximate age for the Palaeolithic assemblage in the Lower level. A second possibility is that the Palaeolithic assemblage dates to between 70 and 60 ky, as indicated by the luminescence ages of the sediment

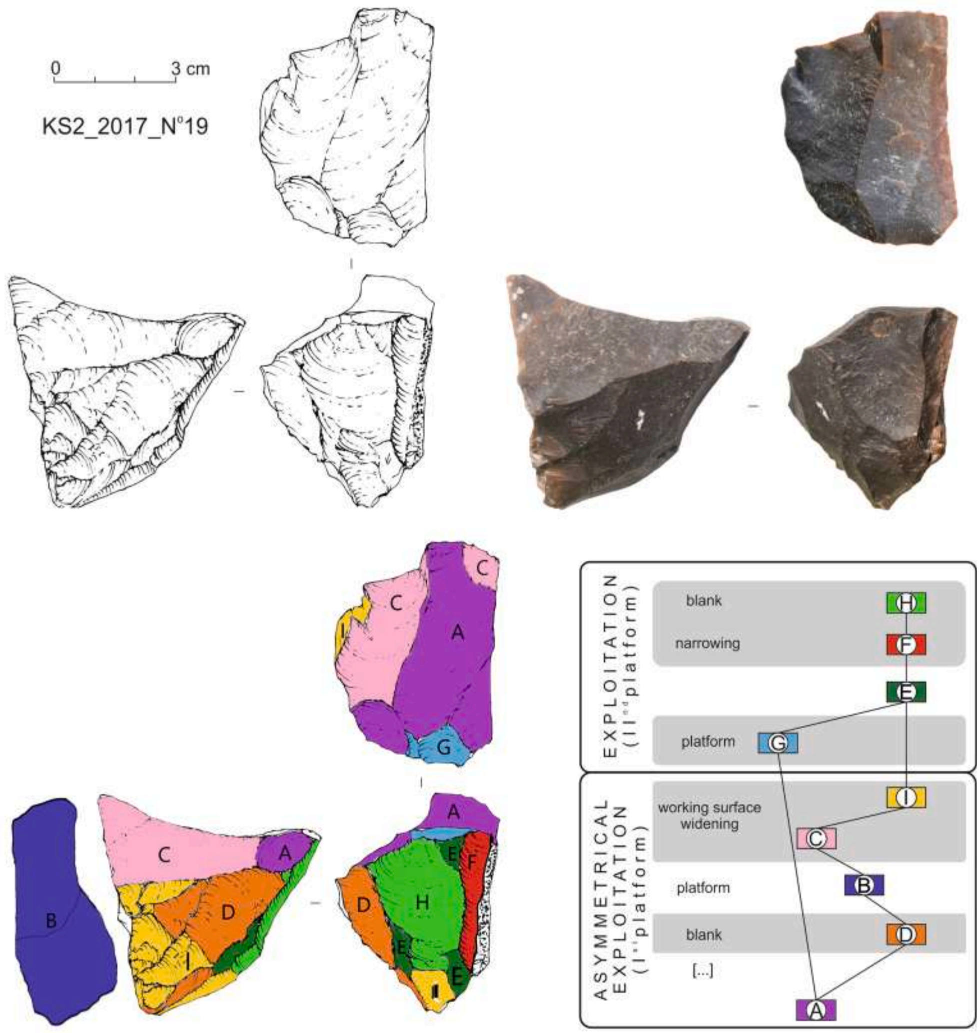

Fig. 11. Scar pattern analysis of the core knapped in asymmetrical scheme.

from Sublayer 3c. Determining which of these two scenarios is the case requires further chronological investigation.

The Upper level occurs within the middle part of Layer 2, mostly in the upper part of Sublayer 2b. We cannot conclude on the depositional conditions, because the original texture of the sediment has been damaged by later bioturbation, likewise the other sedimentary structures within the unit. The original age of the assemblage is uncertain. Two TL dates obtained for this stratum are different from each other (around 48.6 ± 6 and 26 ky BP) and most likely represent the age of source material (around 48 ky BP), re-deposited down the slope, and the age of either the re-deposition event or a simultaneous eolian deposition (around 26 ky BP). Such interpretation suggests an age of the Upper level to be around 48 ky BP, which is similar to that from the lower archaeological level.

Taking into consideration some similarities between both Palaeolithic levels at Katta Sai 2 (such as co-occurrence of the lithics and snail shells, the similarity of the taxonomic structures of snail assemblages, and occurrence within colluvial packets), we cannot exclude the same source material in both levels. The suggested age of the Upper level's primary deposition is similar to the age of the lower level, especially if we consider the wide sigma range of the TL date of the Upper level (which is ± 7,000 years). Further similarities to Katta Sai 1, both in terms of sedimentological characteristics and chronology, are noticeable.

In both cultural horizons in Katta Sai 2 one can find both Middle and Upper Palaeolithic features in the knapping technology used, but also some specific tools such as truncated faceted pieces (Table 6). In both horizons, the Levallois knapping scheme appears, but the morphology of blanks differs. In the Lower level, mostly Levallois points and pointed flakes are present, whereas in the Upper level, pointed blades but also flakes and small points are common (Fig. 7). However, these differences in size could be an effect of different capacities of geological transport responsible for two re-deposition events. In both horizons, elongated flakes and blades were found. However, blades from the Upper horizon are characterized by a detailed preparation of the striking point e.g. through pecking and regular scar pattern. On the other hand, the elongated flakes and blades found in the Lower horizon in most cases have an irregular scar pattern and show no regularity in butt preparation. They mostly represent debitage from the working surface preparation and working surface narrowing (*débordant*) stages of core preparation. The blades found in the Upper horizon due to their regularity can be described as blanks. Still, one should mention the presence of two one-side crested blades in the Lower horizon.

Both Lower and Upper cultural horizons in Katta Sai 2 have a similar age to the Katta Sai 1 site, located 1.3 km to the SW, though their technological and typological components are very different. In Katta Sai 1, one can observe several predetermined knapping schemes of Levallois type. One of them was focused on elongated blanks, which show proportions of elongated flakes rather than blades, which is in opposition to Katta Sai 2, where one can observe a focus on Levallois

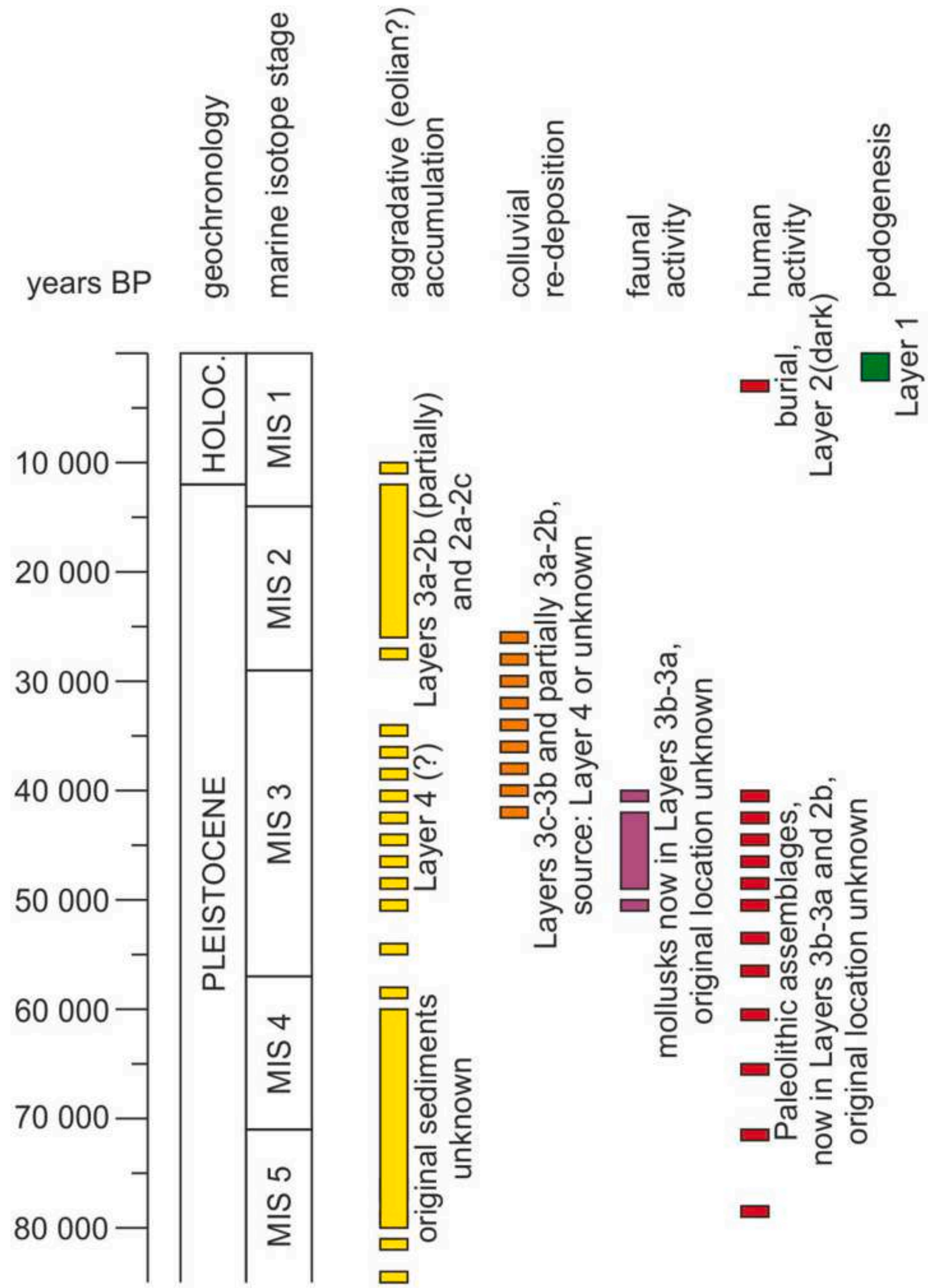

Fig. 12. Suggested reconstruction of the chronological order of geological processes, faunal and human activity at Katta Sai 2. The continuous bars represent the age of events based on chronometric dating, and discontinuous bars represent estimated ages of events.

points production. What is more, the knapping scheme aimed at the production of Levallois points seems to be also a feature of the Katta Sai 2 Upper-level assemblage.

4.2. Palaeoecological background

According to the dates obtained, both cultural horizons in Katta Sai 2 appear to correspond with MIS 3. Very scarce bones found in the sediments and the shell material extracted at 5 mm mesh hinder detailed palaeoecological interpretation. Routine malacological analysis requires wet-sieving on 0.5 mm mesh (Ložek, 1964; Alexandrowicz and Alexandrowicz, 2011). Thus, some depletion in the smallest snail species may be expected at Katta Sai 2. Despite these limitations, malacological records in the site may provide some valuable palaeoecological data. Mollusk assemblages are very uniform based on the ecological preferences of recognised species. The most frequent *Fruticicola lantzi* has the widest ecological tolerance, but its co-occurrence with *Pseudonapaeus sogdianus* and *Leucozonella mesoleuca* points to the predominance of open slopes covered with grassy and shrubby vegetation around the site (Table 4; Egorov, 2008; Schileyko and Rymzhanov, 2013). The most abundant mollusk material was found in Sublayers 3a, 3a/3b and 2b (Table 4), i.e., within two Palaeolithic levels. This irregular distribution within the sedimentary sequence was probably connected with colluvial re-deposition from the original source area, together with lithics. Similar mollusk composition in both levels may suggest similar palaeoecological conditions during the accumulation of both source assemblages, or – as suggested by the dating results – that both these levels are the result of a repeated re-deposition from the same source situated somewhere higher up the slope. Presumably, climate and environment could resemble modern conditions, which is suggested by

Table 6
Presence of Initial Upper Palaeolithic features among the western Tian Shan piedmonts assemblages.

		Katta Sai 1	Katta Sai 2		Hudji	Obi-Rakhmat
			Lower horizon	Upper horizon		
Middle Palaeolithic features	Predetermined technology (Levallois type)	++	++	+	+	+
	Blade/elongated Levallois blanks	+		++	+	+
	Levallois points		++	+	+	+
	Levallois flakes	++	+	+	+	+
	Middle Palaeolithic tool types	++	+	+	+	+
	Longitudinal scrapers	+	+	++	++	++
Upper Palaeolithic features	Bidirectional technology	+	+	+	+	+
	Blade technology		+	+	++	++
	Crested-blades		+		+	+
	Bladelets		+	+	+	++
	Bladelet tools			+		+
	Upper Palaeolithic toolkit				+	+
Specific features	Burin-cores		+		+	++
	Multiplied burin-cores				+	++
	Truncated faceted pieces	+	+		++	++

+ present feature; ++ dominant feature

the presence of all determined species in present-day Tian Shan.

4.3. Initial Upper Palaeolithic

None of the sites of similar age show a predominance of Levallois knapping scheme focused on Levallois point production. Single analogies might be found in the region but they represent either surface collections, Dzar Sai 2 (Anisutkin et al., 1995), or stratified sites of undetermined chronostratigraphy, e.g. Kuhsi open-air site (Tashkenbaev, 1967, 1972). Interestingly, the presence of multiple blanks made on either exotic raw material or raw material representing single pieces from the individual nodule in Katta Sai 2 (Kot et al., 2020), indicates that the lack of analogies in the nearest region is caused by insufficient surveying.

Beside the predominance of Levallois point production, as well as the elongated morphology of the blanks, one should also consider the presence of truncated faced pieces, which find multiple analogies in Central Asian IUP sites and seems to be a specific feature for this kind of assemblage (Zwyns et al., 2012; Shalagina et al., 2015; for further discussion see also Demidenko et al., 2020).

Similar features, especially in the knapping approach towards a blade production, might be found in the open-air site Hudji in Tajikistan, excavated in 1978 by V.A. Ranov (Ranov and Amosova, 1984). The archaeological assemblage (n = 8178) found in layer 2 in Hudji was dated to 38–43 ky cal BP (Ranov et al., 2015b). The blade component in the whole assemblage is well visible (30% of debitage), and bladelets are also present (Table 6). Parallel unidirectional cores with flat surface were used for both blade and flake production. Still, prismatic and narrowed face cores and elongated blank production were found. Burin cores, as well as truncated-faceted pieces, are also present in the assemblage. Tools are mostly made on the longitudinal edge of the elongated blanks. Longitudinal side scrapers, convergent points, as well as asymmetric convergent scrapers, predominate within the toolkit. Single end scrapers are also present (Ranov et al., 2015a).

Several undated stratified assemblages with similar characteristics are known in the region, i.e. Dzar-Kutan (Tajikistan - Ranov and Nesmeyanov, 1973; Ranov et al., 2015b), Khodzakent 1 and 2 (Uzbekistan – Okladnikov, 1961, 1963; Nasretdinov, 1962), Tossor (Ranov and Nesmeyanov, 1973; Ranov and Yunusaliev, 1975; Rybin et al., 2015), and Utash Sai (Kirgistan - Derevianko et al., 2003; Zenin et al., 2004), as well as surface collection from Ak-Olon (Kirgistan - Derevianko et al., 2002). Hudji, as well as other similar undated assemblages, were so far described as a late phase of the so-called Obirakhmatian technocomplex, named after a multilayer site Obi-Rakhmat (Krivoshapkin, 2012). In Obi-Rakhmat a sequence of strata is dated from 40 to 90 ky BP (Krivoshapkin et al., 2010; Skinner et al., 2007), although the new OSL dates indicate the possibility of an even older chronology at the site (Krivoshapkin et al., 2019). 21 cultural horizons contain a blade component accompanied by bladelet production connected with burin-cores (Table 6). Blade production is based on unipolar, bipolar and semi-tournee cores. Bladelet production was associated with burin-cores and multiplied burin-cores (nucleiform burins - Kolobova et al., 2014). Among tools, rectangular wide truncated-faceted pieces and convergent longitudinal scrapers and points predominate (Shalagina et al., 2015). Single atypical end scrapers, as well as burins, appear in that assemblage. Several cores with Levallois morphology are present, as well as short, intensively retouched points (Krivoshapkin, 2012). Still, one should take into consideration that the majority of the assemblage was made on excellent-quality raw material appearing in a shape of rectangular nodules, which simplified the blade production. The affinities between Obirakhmatian and IUP industries were recently suggested by Krivoshapkin (2003, 2006; Krivoshapkin et al., 2004, 2004b; Wrinn et al., 2004).

What is more, similar traits in blank elongation can be found even further into the lowlands in Kuturbulak in the Zaravshan Valley which was dated to >32.91 ky BP (U/Th) (Szymczak and Gretchkina, 2000). The assemblage was also characterised by the presence of both Upper and Middle Palaeolithic tool types. We believe that only further technological analyses would enable detailed comparisons between Obi-Rakhmat, Kuturbulak and the Katta Sai 1 & 2 assemblages.

In a broader perspective, one can see that the presented techno-typological features are present also in some MIS 3 contexts dated to 45–35 ky BP in the Altai and eastern parts of Central Asia, such as Denisova Cave (Shunkov et al., 2020), Kara-Bom (Belousova et al., 2019), Ust-Karakol (Shunkov and Belousova, 2015), Kamenka, Tolbor 4, 16, 21, Moil'tyn-am, Kharganyn Gol 5 (Khatsenovich et al., 2017; Zwyns et al., 2019; Rybin and Khatsenovich, 2020) and Ushbulak (Anoikin et al., 2019). Such complexes have been recently described as IUP. Their predominant feature is the presence of blade technology accompanied by or made with Levallois knapping schemes, together with the presence of burin-cores connected with bladelet production. Taking into account the presented features, the similarity of the Katta Sai 2 assemblages with the Initial Upper Palaeolithic technocomplex is visible (Table 6).

Therefore the presented complex of the Pamir and Tian Shan sites could be considered as part of the IUP. Still, one should take into consideration that all the presented features, which are vital elements in the IUP, appear in the Obi-Rakhmat industry as early as MIS 5a (Krivoshapkin, 2012; Krivoshapkin et al., 2019). Additionally, taking into consideration the anthropological records from Obi-Rakhmat (Glantz et al., 2004), the state of research shows a much more complex picture than previously supposed (Kuhn and Zwyns, 2014; Kuhn, 2019).

5. Conclusions

Recent studies show a link between the occurrence of IUP technocomplexes in the eastern parts of Central Asia with *Homo sapiens* dispersal (Kuhn and Zwyns, 2014; Kuhn, 2019). Other researchers have recently documented IUP features in layer 9 and 11 in Denisova cave, potentially associated with both Neanderthals and Ancient modern human (Zavala et al., 2021). The recent results obtained in Katta Sai 2 indicate that all the features associated with IUP are present also in the western parts of Central Asia.

Due to the complex character of depositional events at Katta Sai 2, the age of both Palaeolithic assemblages cannot be precisely determined. Taking into consideration stratigraphic premises, the dating results and our interpretation of the site formation, we identify two possible chronological ranges for the stone assemblages and human occupation at the site. Radiocarbon dating of mollusk shells from the vicinity of the stone artifacts may indicate they date to the middle part of MIS 3 from 52 to 41 ky BP. However, due to the erosional character of the sediments and the obtained OLS dates we cannot exclude an earlier chronology for the assemblage of 60–70 ky BP. The earlier chronology fits with the technological and typological similarities with the Obi-Rakhmat assemblage. However, the younger MIS 3 chronological range would agree with direct analogies in the region (e.g. in Hudji). Detailed site formation analysis of both horizons is forthcoming with micromorphological studies. The Malacological record also offers some perspective for palaeoenvironmental reconstruction during the human occupation of the site. Presumably, the studied area was dominated by open and grassy habitats, with some shrubs.

Due to the presented comparisons, one can see that both assemblages found in Katta Sai 2 share some specific Middle Palaeolithic, as well as Upper Palaeolithic features, and this co-occurrence of characteristics might be found in several other sites in the region (e.g Obi Rakhmat). What is more, the blade and bladelet technology based on Levallois, burin-cores and truncated faceted knapping schemes has local roots dated up to MIS 5a (Krivoshapkin, 2012; Krivoshapkin et al., 2019) and may be connected with local Middle Palaeolithic industries based on Levallois technology. For this reason, it seems to be too early to conclude about the migration of Initial Upper Palaeolithic typo-technological features together with a modern human dispersal in Asia.

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7. Availability of data and material

All data will be provided on request.

8. Code availability

N/A.

Authors contributions

Material preparation, data collection and analysis were performed by Małgorzata Kot, Galina Pavlenok, Maciej T. Krajcarz, Marcin Szymanek, Stanisław Fedorowicz, Piotr Moska, Sahra Talamo, Helen Fewlass, Michał Leloch, and Sergey Kogai. The first draft of the manuscript was written by Małgorzata Kot, Konstantin Pavlenok, Maciej T. Krajcarz, Marcin Szymanek and Piotr Moska and all authors commented on previous versions of the manuscript. Mukhiddin Khudjanazarov, Karol Szymczak and Konstantin Pavlenok supervised the project. All authors read and approved the final manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jaa.2021.101391.

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