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Early geometric microlith technology in Central Asia

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Abstract
Until recently, every industry with geometric microliths in Central Asia has been classified as Mesolithic solely on the basis that this technology appeared quite late in the region. The situation was further complicated by the absence of absolute dates for Upper Paleolithic and Mesolithic sites from this region. Recent research has proved a clear association between the earliest geometric microliths in Central Asia and the Upper Paleolithic Kulbulakian culture (Shugnou, layer 1; Kulbulak, layer 2.1). The most comprehensive archeological collection in Central Asia that documents the shift from the production of non-geometric microliths (backed bladelet, Arzheneh points) to geometric microliths (scalene triangles) in a very early chronological context is Dodekatym-2 site. The main morphometric characteristics of the Central Asian Upper Paleolithic geometric microliths correspond to the development of the Upper Paleolithic and Epipaleolithic of the Near East (Masraquan cultures) and the Middle East (Zarzian culture). The absolute dates available for the Dodecatym-2 site are older than presently known ones for the early Epipaleolithic Levantine industries with geometric microliths, thus making it possible to conclude that Central Asia was at least one of the microlitization origin centers.

Keywords Central Asia · Microlitization · Geometric microliths · Non-geometric microliths · Scalene triangles

Introduction

Geometric microliths are not important as a tool type per se, but because their appearance and development clearly illustrate significant changes in the subsistence strategies of ancient human populations (Lewis 2017; Robinson, Sellet 2018). This is a reference to the invention of long-range projectile weaponry for small-game exploitation (Nuzhnyy 2000; Munro 2009), which is what makes the investigation of early microlithization events, even as early as MSA-2 in Africa, so popular and productive in different parts of Eurasia (Brown et al. 2012; Petraglia et al. 2009). At the same time, the available data indicates that the earliest geometric microliths were episodic, often without any continuation and, as such, may be better explained in terms of a flickering pattern (Monigal 2004; Ziegler et al. 2013; Wilkins et al. 2017). The systematic manifestation of the geometric microlith technology and its continued exploitation in different parts of Eurasia is associated with the LGM (Nuzhnyy 2000; Belfer-Cohen and Gorring-Morris 2014).

Whether the near-simultaneous appearance of geometric microliths was a reflection of the increased mobility of human groups, the result of increased social complexity or the consequence of convergent technological development, resulting from similar environmental challenges during and after the LGM, is an issue crucial to contemporary Paleolithic studies.

Until recently, geometric microliths in archeological collections from the western regions of Central Asia were regarded as markers of the Mesolithic age (Davis and Ranov 1999; Ranov and Karimova 2005). The Mesolithic technocomplexes of this region provided evidence of the direct migration of human populations with geometric microliths and backed tool traditions from the Iranian Plateau (Davis and Ranov 1999). The local Upper Paleolithic industries were described as archaic traditions with Middle Paleolithic features in stone assemblages and were not regarded as a possible basis for the development of Mesolithic industries.

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Formerly, researchers of the Central Asian Upper Paleolithic had stressed the sheer absence of not only the backing technique and geometric microliths but also of the technology for bladelet production in that region (Davis and Ranov 1999). Archeological studies that have been carried out in that region since 1998 provide new information about the local Upper Paleolithic and prove the early appearance of geometric microliths and the backing technique in Central Asian Upper Paleolithic.

Research results over the last decade have made it possible to refute this assumption and prove the comparatively early appearance of bladelet technologies in the context of the Upper Paleolithic Kulbulakian culture (Fig. 1). In the Kulbulakian assemblages, we can trace some of the main trends of the development of Upper Paleolithic in western Central Asia, including the trend towards the backing type of microlitization. This trend has a strong connection to the spread of carinated pieces and its further replacement by prismatic cores (Fig. 2). On the basis of the available absolute dates, the time span of the Kulbulakian is estimated at 39–23 kyr BP (Kolobova et al. 2011; Vandenberghe et al. 2014).

Materials and methods

The lithic industries mentioned here come from Pamiro-Tian-Shan region and include key assemblages from Dodekatym-2, Kulbulak, layer 2.1, Shugnou, layer 1. Special importance is attached to the combination of typological and attribute analysis of geometric and non-geometric microliths. In order to find the main technological concept of the scalene triangles, we applied scar pattern or working stage/step analysis method (Pastoors 2000; Kot 2017) on the geometric microlith.

In accordance with Tixier's definition, a geometric microlith is regarded as tool with a geometric shape made from bladelets, with no trace of the butt on the ventral surface (Tixier 1963). The scalene triangle represents a type of geometric microlith that is fashioned mainly on the distal part of the bladelet through the backing of long and transverse sides. A scalene triangle is characterized by three edges unequal in length. Scalene triangles have obtuse angle between the backed sides. The third side is usually unretouched; some artifacts show utilization retouching.

The region's earliest geometric microliths have been identified in the Middle Kulbulakian assemblages. The first early geometric microlith (Fig. 3, *2*) was recovered from layer 2.1 at the Kulbulak site in Uzbekistan (Fig. 1 and Tables 1 and 2). Initially, this unique finding seemed doubtful as it was discovered close to the exposed excavation surface (Flas et al. 2010). However, a re-examination of the Upper Paleolithic collection of the 1980s revealed another scalene triangle (Fig. 3, *3*), which was regarded as evidence that geometric microliths representing an essential part of the Kulbulak tool kit. In this context, it should be noted that no overlying layers with more recent Stone Age industry have been found on the site. Geometric microliths were discovered inside the bladelet industry, with a significant proportion of carinated pieces. The

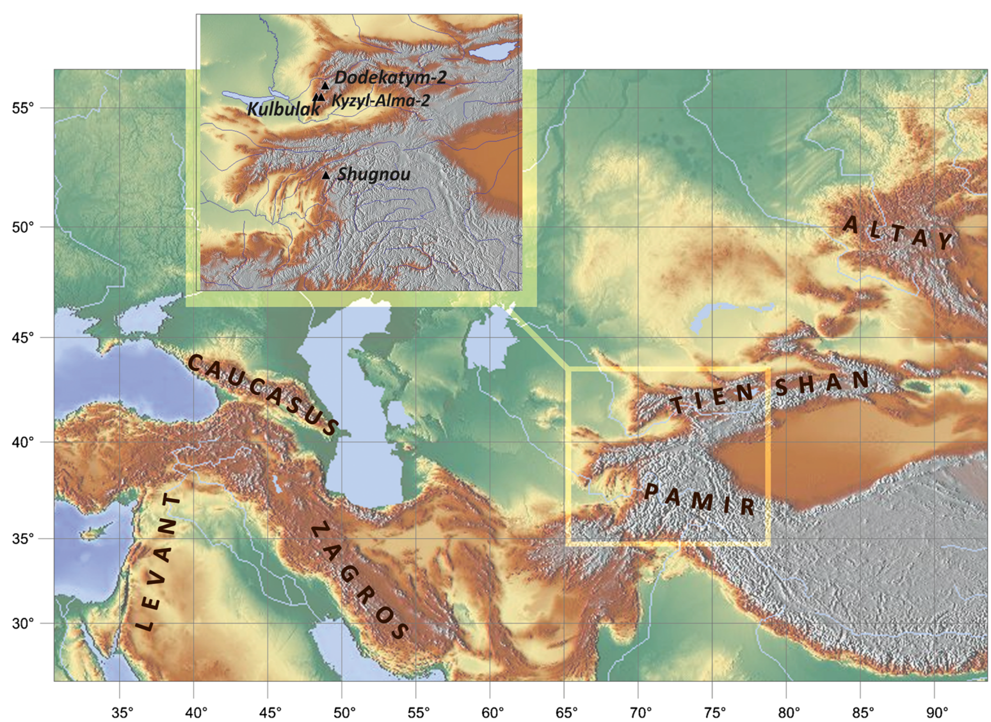

Fig. 1 Location of Kulbulakian sites in the western Central Asia

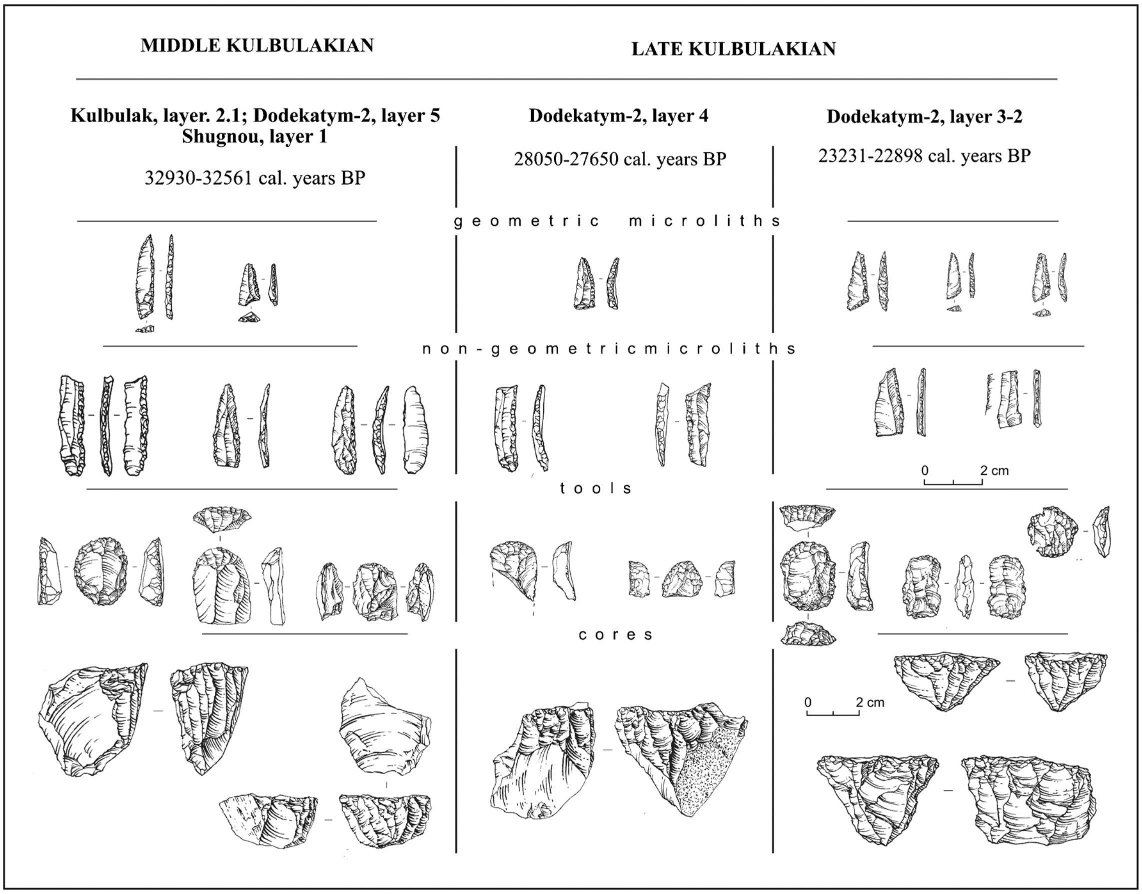

Fig. 2 Comparison of the Middle and Late Kulbulakian assemblages

tool kit includes retouched bladelets; Dufour bladelets; backed bladelets; and various end-scrapers, including thumbnail varieties and splintered pieces. The only OSL date of 39 ± 4 kyr BP (GLL-080316) obtained for the same lithological layer 2 of the Kulbulak site 6 m from the main excavation area (Vandenberghe et al. 2014) can be considered as the maximum age for the archeological layer 2.2.

Another scalene triangle has been found in the lithic collection from layer 1 at Shugnou in Tajikistan excavated in the 1970s (Ranov et al. 2012) (Tables 1 and 2). The Shugnou assemblage is characterized by the predominance of carinated flaking for the production of curved bladelets. The tool kits consist of various end-scrapers, Arzheneh points, and retouched and backed bladelets. Using "Arzheneh point," we follow the definition of Leroi-Gourhan (1988). The geometric microlith has been determined as an elongated scalene triangle variant (Fig. 3, *1*). No overlying layers with more recent Stone Age industry have been found in the Shugnou excavation area where the geometric microliths have been found. We have found some marked samples of bones and charcoal from the old excavations of layer 1 and, fortunately, were able to get the appropriate results. The charcoal sample has been dated at 28,633 ± 83 (UGAMS-23056: 32,930–32,561 cal. years BP at 68.2%). The animal bone sample has been dated at 27,057 ± 73 (UGAMS-23057: 31,301–31,134 cal. years BP at 68.2%). All dates were modeled in OxCal v.4.2, using IntCal13 calibration curve (Bronk Ramsey 2009; Reimer et al. 2013).

The largest collection of geometric microliths was found within the assemblage from Dodekatym-2 (Figs. 3, *4–26*, and 4 and Tables 1 and 2). The site of Dodekatym-2 (Uzbekistan) contains four cultural layers (layers 5–2). The assemblage of layer 5 is attributed to Middle Kulbulakian, whereas the assemblages of layers 4–2 are defined as Late Kulbulakian. The distinctive feature of the industry of the layer 5 is the predominance of carinated cores for the production of curved bladelets. Tool kit comprises of various end-scrapers, Arzheneh points, and retouched and backed bladelets. Archeological materials from the upper layers (4–2) clearly demonstrate the technological and typological development of the layer 5 techno-complex. The animal bone sample from the lower part of layer 4 has been dated at 23,600 ± 330 BP (AA-69075: 28,050–27,450 cal. years BP at 68.2%). The charcoal samples from the lower part of layer 4 have been dated at 23,800 ± 190 BP (AA-69073: 28,050–27,650 cal. years BP at 68.2%) and 21,850 ± 180 BP (AA-69074: 26,250–25,850 cal. years BP at 68.2%) (Kolobova

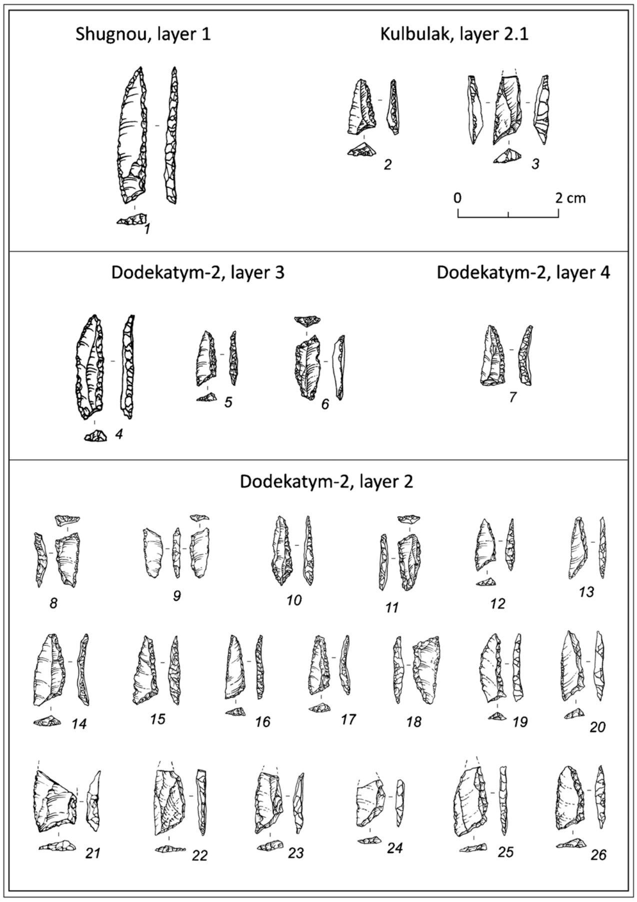

Fig. 3 Scalene triangles from Kulbulakian assemblages

et al. 2011). New data was obtained from the layer 2 of Dodekatym-2: the animal bone sample—19,148 ± 99 (UGAMS-23050, 23,231–22,898 cal. years BP at 68.2%).

The major trend seen in the industries of layers 4–2 is a gradual transition from the use of carinated cores to prismatic ones for the production of strait bladelets. In addition, the proportion of geometric and non-geometric microliths in the tool kit increased. Beginning with layer 4, scalene triangles became the most numerous tool type in the assemblage of Dodekatym-2 (Figs. 3, *4–26*, and 4).

Assemblages from layers 4–2 at Dodekatym-2 contain considerable proportions of geometric and non-geometric microliths: from 38.6% in stratum 4 to 60.3% in stratum 2. These proportions are significantly higher than those established from the earlier Kulbulakian collections (Table 2).

Scalene triangles in all Kulbulakian industries are characterized by a high degree of standardization in the morphology and metric features (Figs. 5 and 6). The triangles were mostly made of distal parts of bladelets with straight profiles. The majority of scalene triangles have a backed right elongated side. The angle between the backed edges varies from 92° to 135°; the maximum of the custom angle in the interval from 115 to 126°.

Results

Scalene triangle production

An attempt to reconstruct the production of scalene triangles has been carried out by analyzing of the collection from Dodekatym-2 layer 2, which contains the greatest amount of scalene triangles and backed bladelets (Table 2) in Central Asia. A direct correlation in tool kits between scalene triangles and backed bladelets is seen (Fig. 7). The metric traits of scalene triangles and bladelets with one backed edge are practically identical (Fig. 8). Scalene triangles and backed bladelets were fashioned out of straight and curved bladelets. The scalene triangles were mostly produced from blanks with a straight profile (Fig. 9). The same proportions of lateral profiles have been noted in the production of non-retouched bladelets ($n = 186$) within the Dodekatym-2 stratum 2. The majority of scalene triangles and backed bladelets shows retouching over the right long side (Fig. 10).

A scar pattern analysis has shown three trends in the production of scalene triangles (Fig. 11). In trend 1, scalene triangles were manufactured in two steps: firstly, the right long bladelet edge was backed; after which, backing was executed on the transverse edge. An obtuse angle was formed at the contact area (Fig. 11, *1*). In trend 2, scalene triangles were manufactured in two steps. First, the right long bladelet edge was backed, and then, the transverse edge was retouched. Retouching scars from the transverse edge overlap the retouching facets on the long edge. The tip of the obtuse angle between the retouched edges (Fig. 10, *2*) was additionally treated using the same technology. In trend 3, the scalene triangles were manufactured in a single retouching step (Fig. 11, *3*). This technology was applied mostly to the geometric microliths with the thinnest cross sections. Thin bladelets and their fragments served as blanks.

The technological analysis of scalene triangles has shown that neither the classic microburin technique (Henry 1974; Byrd 1994) nor the Krukowski microburin technique (Vardi and Gilead 2009) were used. Thin bladelets that served as blanks for the scalene triangles were produced by simple breakage. A similar technique was noted in the Levant Epipaleolithic techno-complexes (Henry 1989). Scalene triangles might have been made on distal bladelet fragments that were broken in the course of primary reduction.

Our thesis of the three fashioning trends is supported by the fact that the lithic collection under discussion did not contain any truncated bladelets. All of the artifacts showing steep truncation retouching on the transverse side represent the basal fragments of scalene triangles (Fig. 3, *21–24*).

Given the similar metric parameters of the backed bladelets and geometric microliths (Fig. 8), similar retouching patterns (Fig. 10), and the operational chains established for microliths 1 and 2 (Fig. 11, *1* and *2*), the part of the backed bladelets from

Table 1 Composition of the Middle and Late Kulbulakian lithic industries

Primary reduction category	Kulbulak, layer 2.1		Shugnou, layer 1		Dodekatym-2, layer 5		Dodekatym-2, layer 4		Dodekatym-2, layer 3		Dodekatym-2, layer 2	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
Cores[a]	336	5.5%	69	4.5%	13	7.2%	19	4.1%	1	0.6%	24	3.1%
Flake cores[a]	*64*	*1.0%*	*7*	*0.5%*			*1*	*0.2%*			*5*	*0.6%*
Blade cores[a]	*71*	*1.2%*	*9*	*0.6%*	*3*	*1.7%*	*5*	*1.1%*	*1*	*0.6%*	*5*	*0.6%*
Bladelet cores[a]	*201*	*3.3%*	*53*	*3.4%*	*10*	*5.6%*	*13*	*2.8%*			*14*	*1.8%*
Core preparation spalls[a]	290	4.8%	72	4.7%	11	6.1%	50	10.7%	2	1.2%	56	7.2%
Points[a]	13	0.2%	21	1.4%	1	0.6%	0	0.0%	0	0.0%	8	1.0%
Flakes[a]	2,550	41.8%	599	38.9%	81	45.0%	320	68.4%	123	75.0%	526	67.9%
Blades[a]	870	14.3%	391	25.4%	7	3.9%	31	6.6%	9	5.5%	43	5.5%
Bladelets[a]	1,907	31.3%	379	24.6%	60	33.3%	39	8.3%	27	16.5%	111	14.3%
Total without waste[b]	*6,102*	*13.9%*	*1,540*	*58.7%*	*180*	*50.4%*	*468*	*17.4%*	*164*	*21.4%*	*775*	*26.4%*
Waste (shatter, scales)	37,751	86.1%	1,082	41.3%	177	49.6%	2,229	82.6%	601	78.6%	2,161	73.6%
Total	*43,853*	*100.0%*	*2,622*	*100.0%*	*357*	*100.0%*	*2,697*	*100.0%*	*765*	*100.0%*	*2,936*	*100.0%*

Italic numbers mean the values in sub-category inside the "Cores" category

[a] Percent of total number of artifacts in the layer (waste disregarded)

[b] Percent of total number of artifacts in the layer

Table 2 Typology of tools from the Middle and Late Kulbulakian complexes

Tool type	Kulbulak, layer 2.1		Shugnou, layer 1		Dodekatym-2, layer 5		Dodekatym-2, layer 4		Dodekatym-2, layer 3		Dodekatym-2, layer 2	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
Scalene triangles	1	0.3	1	2.1	0	0.0	1	1.1	3	8.3	30	24.8
Backed bladelets	5	1.3	2	4.2	3	17.6	6	6.8	2	5.6	28	23.1
Arzheneh points	3	0.8	4	8.3	0	0.0	2	2.3	0	0.0	7	5.8
Retouched bladelets	22	5.8	7	14.6	1	5.9	25	28.4	7	19.4	8	6.6
Dufur bladelets	4	1.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Trihedral microlith	0	0.0	0	0.0	0	0.0	0	0.0	1	2.8	0	0.0
End-scrapers	90	23.6	17	35.4	2	11.8	14	15.9	3	8.3	9	7.4
Thumbnail end-scrapers	6	1.6	2	4.2	0	0.0	1	1.1	0	0.0	1	0.8
Splintered pieces	56	14.7	1	2.1	0	0.0	7	8.0	4	11.1	4	3.3
Microsplintered pieces	19	5.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.8
Burins	12	3.1	0	0.0	0	0.0	1	1.1	0	0.0	2	1.7
Retouched blades	37	9.7	6	12.5	5	29.4	8	9.1	5	13.9	11	9.1
Backed blades	1	0.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Perforators	18	4.7	0	0.0	2	11.8	14	15.9	4	11.1	14	11.6
Retouched points	8	2.1	0	0.0	0	0.0	0	0.0	0	0.0	1	0.8
Unifascial tool	1	0.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Side-scrapers	20	5.2	1	2.1	2	11.8	1	1.1	0	0.0	0	0.0
Notched tools	10	2.6	0	0.0		0.0		0.0		0.0		0.0
Denticulated tools	9	2.4	1	2.1	0	0.0	1	1.1	0	0.0	0	0.0
Chopper	1	0.3	0	0.0	0	0.0	0	0.0	1	2.8	0	0.0
Retouched flakes	59	15.4	6	12.5	2	11.8	7	8.0	6	16.7	5	4.1
Total	382	100.0	48	100.0	17	100.0	88	100.0	36	100.0	121	100.0

Fig. 4 Scalene triangles from Dodekatym-2, Late Kulbulakian

the Kulbulakian industries can be defined as blanks for scalene triangles. Thus, the production of backed bladelets was the first stage of scalene triangles fashioning: straight backed bladelets has been used as scalene triangle blanks. Considering the presence in the assemblage the big number of backed bladelets with a curved profile, it could be assumed that they have been separate tool type (Fig. 9).

Scalene triangles in the near and Middle East Epipaleolithic context

The Middle and Late Kulbulakian Upper Paleolithic complexes share many similarities with the Upper Paleolithic and early Epipaleolithic complexes from Zagros and Levant. In Zagros, there are found mostly in Rostamian, Baradostian (also called Zagros Aurignacian), and Zarzian complexes, while in Levant in Levantine Aurignacian and Masraqan (Late Ahmarian) complexes (Olszewski 2012; Belfer-Cohen and Gorring-Morris 2014; Kolobova 2014; Ghasidian et al. 2017). The main trends seen in the development of the lithic industries in these regions are the microlitization and development of the backing technique, which indicate the development of hafting techniques and composite tools (Yaroshevich et al. 2010, 2013; Olszewski 2012; Belfer-Cohen and Gorring-Morris 2014).

Few backed bladelets have been reported from various Baradostian Upper Paleolithic sites in Zagros (Hole and Flannery 1967; Olszewski 2012). Scalene triangles in Zagros Epipaleolithic emerged as the earliest type of geometric microlith (Fig. 12, *1–10*) (Smith 1986; Wahida 1999; Olszewski 1993a, 2012).

Based on the Warwasi stratigraphic sequence, D. Olszewski identified four chronological periods in the development of the Zarzian techno-complex. The early Zarzian is dominated by non-geometric microliths (Dufour bladelets); the tool kits also include a few thumbnail scrapers and scalene triangles. The middle Zarzian shows the dominance of geometric microliths and scalene triangles, including elongated scalene triangles. The tool kits also include non-geometric microliths, such as Arzheneh points and Dufour bladelets. An increase in the proportion of the arched backed bladelets is observed (Olszewski 2012). The Zarzian lithic collections indicate the replacement of the typically Upper Paleolithic carinated technology by other types of reduction technologies (Olszewski 2007). Formerly, due to the unavailability of absolute dates, the age of the early Zarzian lithic industries was estimated at about 22 kyr BP (Hole and Flannery 1967; Wahida 1999; Olszewski 2012). Recently, the Zarzian techno-complex from Haji Bahrami cave (TB 75) has been dated to 18,000–17,500 cal. years BP (Tsuneki 2013). The middle Zarzian period has been established in the range of 14,350 to 10,590 years BP (un-calibrated) on the basis of the dates that were generated for Palegawra and Shanidar B2 (Olszewski 1993b; Wahida 1999). A new series of dates in the range of 12,500 to 10,200 years BP has been generated for Palegawra (uncalibrated; Olszewski 2012).

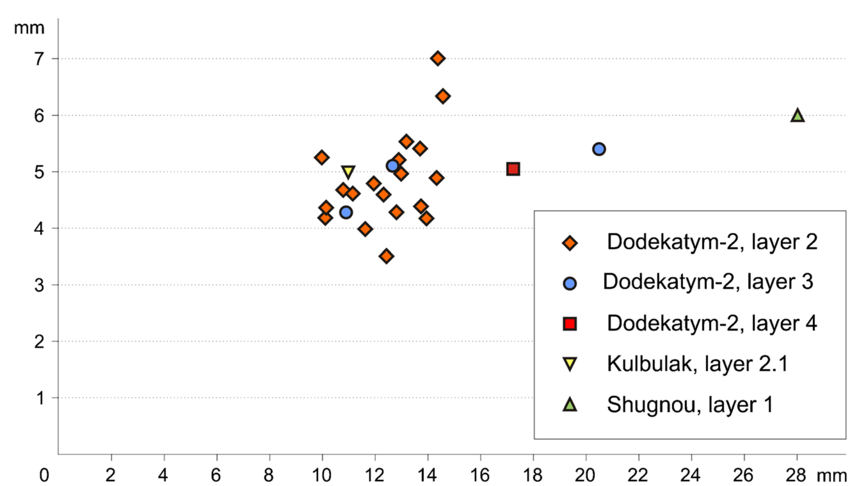

Fig. 5 Comparison of the dimensions (length and width) of the complete Kulbulakian scalene triangles

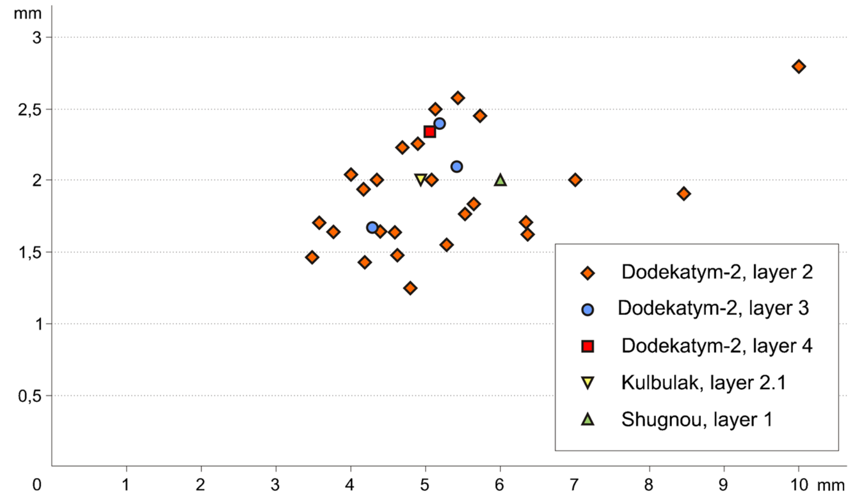

Fig. 6 Comparison of the dimensions (width and thickness) of the Kulbulakian scalene triangles

D. Olshewski analyzed scalene triangles from units 1–4 at Warwasi (Fig. 12, *3–5*). The average length of the scalene triangles is 14.8 mm, the average width 4.7 mm, and the average thickness is 1.7 mm. Respectively, the measurements of the elongated scalene triangles are 21.7, 5.4, and 1.9 mm. The researcher inferred that both regular and elongated

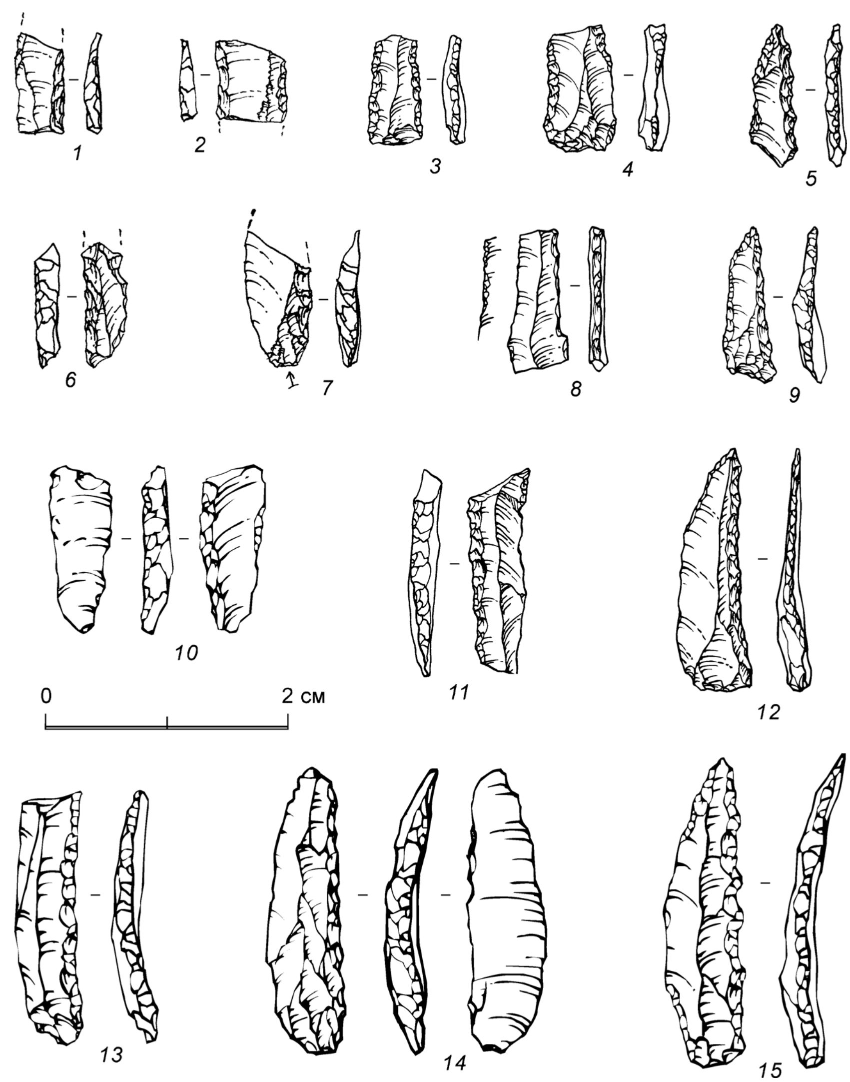

Fig. 7 Backed bladelets and Arzheneh points from Dodekatym-2, Late Kulbulakian

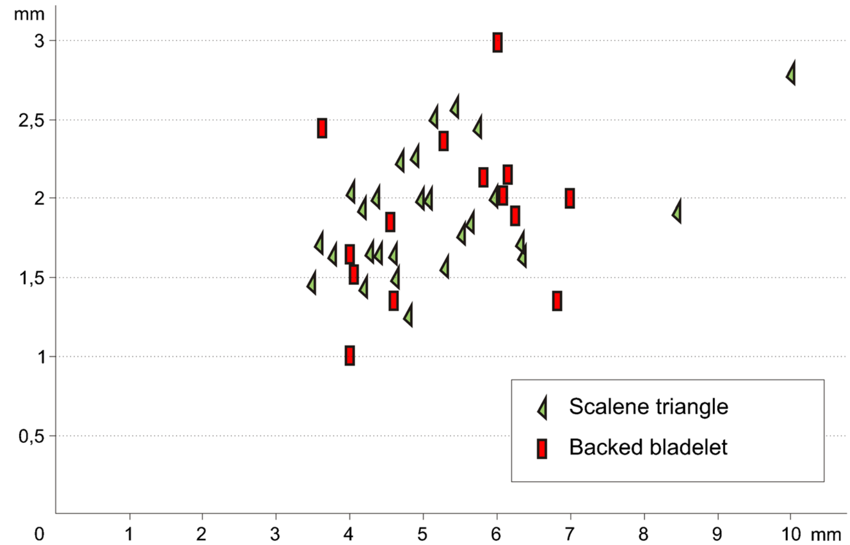

Fig. 8 Comparison of the dimensions (width and thickness) of the Late Kulbulakian scalene triangles and backed bladelets

scalene triangles were produced by the modification of truncated bladelets. The microburin technique was not used in manufacturing of scalene triangles, though this technique was noted in the Zarzian lithic industries. The long edge of the triangle was often formed by fine retouching (Olszewski 1993a). Available sketches of scalene triangles show that the right long edge was the most often retouched (Smith 1986; Wahida 1999; Olszewski 1993a, b, 2012).

Comparisons between the Early Zarzian techno-complexes with scalene triangles and the Late Kulbulakian evidenced the following traits: both industries are well rooted in the preceding local techno-complexes based on the well-developed carinated reduction. Gradually, the carinated pieces were replaced by the prismatic bladelet cores. The earliest occurrence of the backing technique has been noted in the Upper Paleolithic context, with the earliest type of geometric microliths being scalene triangles. Even accounting for questionable issues regarding methods of excavation (by conventional horizontal spits; Tsanova 2013), developmental interpretation of Warwasi cultural sequence looks logical especially in a context of Kulbulakian. General tendencies in cultural development in Kulbulakian are echoed in Warwasi complexes.

Comparative analysis of the Late Kulbulakian and Zarzian triangles has shown considerable similarities in both metric and morphological parameters. Scalene triangles were fashioned from bladelets with backing along the transverse edge and one of the long edges. Backing was mostly noted along the right side of the blank. Scalene triangles were produced without the microburin technique. The average length of the complete Kulbulakian scalene triangles is 13.5 mm, the average width is 5.2 mm, and the average thickness is 1.9 mm. These measurements are basically the same at those of the Zarzian geometric microliths. However, certain distinct features have also been noted: (1) scalene triangles were fashioned through different techniques. The Zarzian scalene triangles were made out of truncated bladelets, whereas the Kulbulakian triangles were made out of backed bladelets. Morphologically, the same scalene triangles are the result of

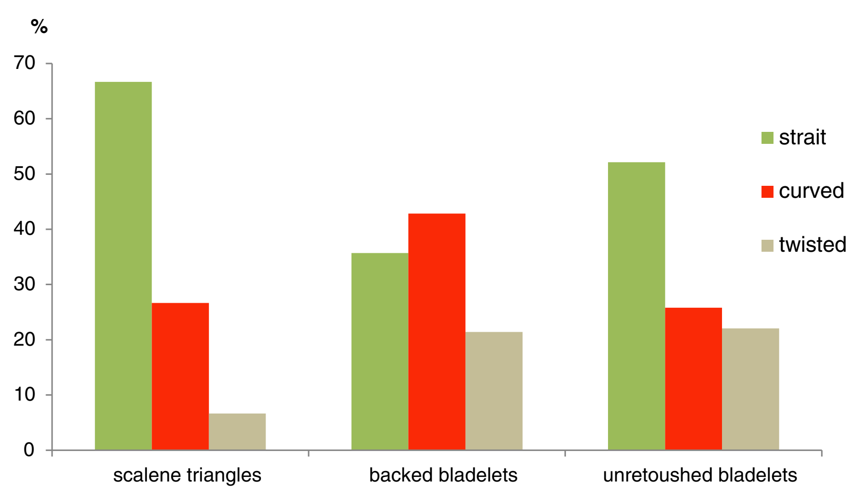

Fig. 9 Frequencies of scalene triangles, backed bladelets, and unretouched bladelets from Dodekatym-2, layer 2 with different profiles

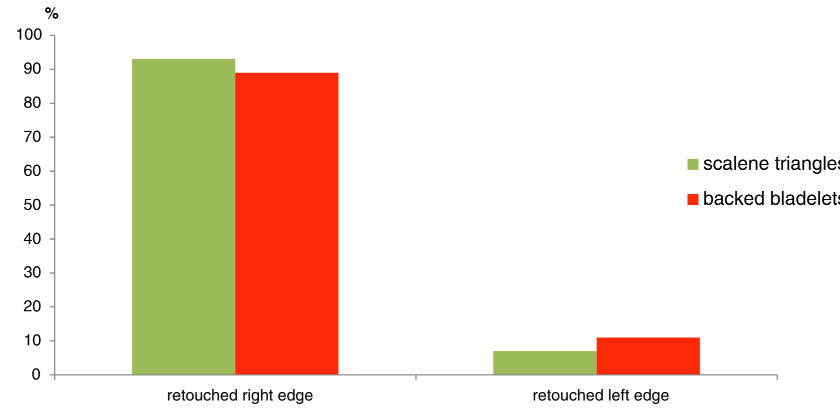

Fig. 10 Frequencies of scalene triangles and backed bladelets with retouched right or left edges

the different technique applications (Figs. 3 and 12). Hence, the first stage of scalene triangles fashioning from Kulbulakian and Zarzian techno-complexes is fundamentally different. (2) The non-backed long edge in the Zarzian scalene triangles often shows traces of retouching, whereas the Kulbulakian triangles bear utilization retouch facets along the non-backed edge. The possible reason for such secondary treatment of Zarzian scalene triangles (longer life history?) is unclear. Thus, the early geometric microliths from western Central Asia and Middle East show considerable morphometric similarities albeit through different techniques.

The Zagros Epipaleolithic demonstrates both common (Bar-Yosef 1998; Hole 1997) and distinct (Olszewski 2012) features with the Epipaleolithic techno-complexes of the Levant. However, certain researchers have highlighted the common trends in the development of the Upper Paleolithic and Epipaleolithic assemblages of these regions (Belfer-Cohen and Gorring-Morris 2014).

Abundant data on the Levant Epipaleolithic demonstrate considerable variability of the relevant lithic industries (Bar-Yosef 1970; Gorring-Morris 1987; Henry 1989; Byrd 1994). The few earliest backed bladelets have been recorded in the Upper Paleolithic techno-complexes (Bar-Yosef 1970; Gisis, Gilead 1977; Belfer-Cohen and Gorring-Morris 2002). Ohalo-II (Yaroshevich et al. 2013) yielded the earliest scalene triangles among other geometric microliths in the Levant. The Ohalo-II was associated with the Masraqan (Late Ahmarian) culture that is transitional from the Upper Paleolithic to the Epipaleolithic. The Masraqan techno-complexes show many traits characteristic of both the Upper Paleolithic and Epipaleolithic (Gorring-Morris 1995; Nadel 2003; Yaroshevich et al. 2013; Richter et al. 2011). The site has been dated to the chronological range of 22.5 to 23.5 cal. kyr BP (Nadel 2003; Nadel et al. 2006). The Ohalo-II techno-complex includes retouched pointed bladelets, backed points with straight or curved lateral edges, and scalene triangles (Yaroshevich et al. 2013). The specific feature of this complex is the combination of the Ouchtata retouch and backed bladelets (Nadel 2003). The definition "Ouchtata retouch" has been used by Nadel after Tixier (1963). The Ohalo-II scalene triangles were fashioned out of diagonally backed bladelets with signs of oblique truncation (Fig. 12, *11–20*). There are artifacts in which retouch facets cover the long edge intermittently. It is likely that D. Nadel designated geometric microliths as proto-triangles in his earliest publications (Nadel 2003; Nadel and Sorel 2005), while in his later articles, they are referred to as scalene triangles only (Yaroshevich et al. 2013).

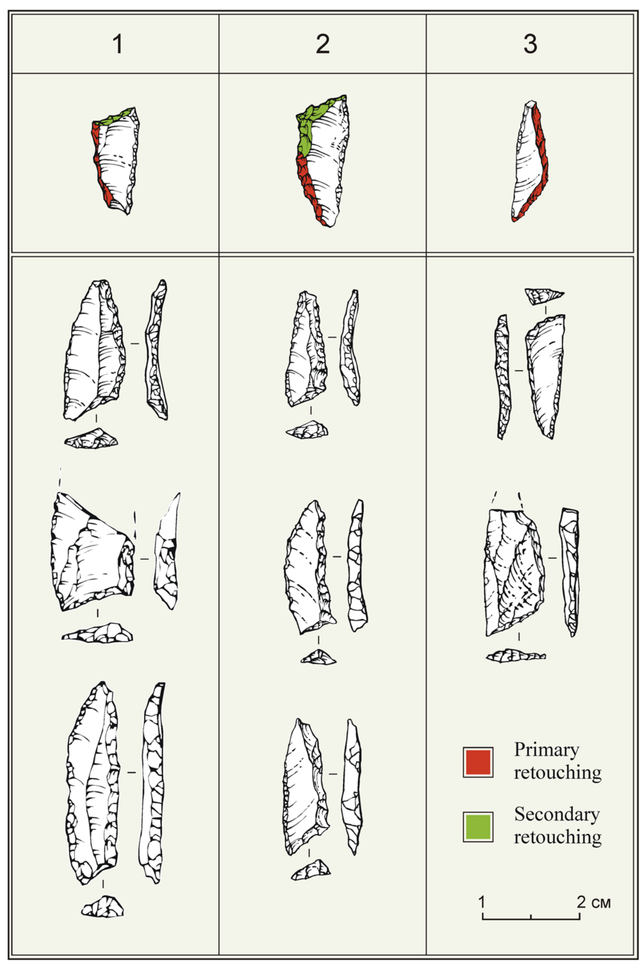

Fig. 11 Three trends in the production of scalene triangles

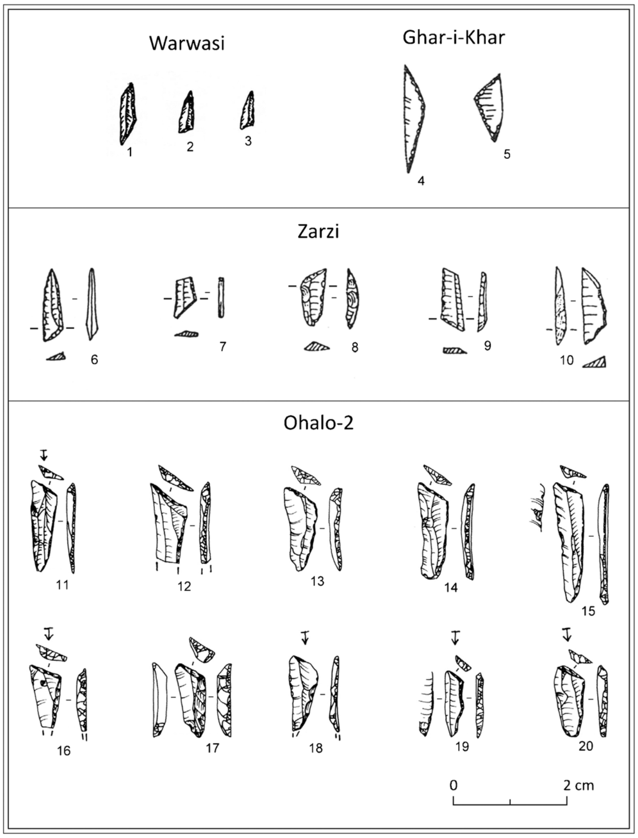

Fig. 12 Scalene triangles from Zarzian and Masraqan assemblages

The metric features of Ohalo-II scalene triangles are as follows: the maximum length is 20.6 mm, the maximum width is 6.4 mm, and the maximum thickness is 2.3 mm. Most commonly, the right long edge is backed. This feature is typical of non-geometric microliths in this industry that were primarily fashioned out of blades with a straight lateral profile. Truncated bladelets are the artifact type closest to scalene triangles. Their metric features as well as their profile shape are the same. The authors have not provided a description of the technology of scalene triangle production. The recent analytical data suggest that the Ohalo-II scalene triangles were the side elements of composite projectiles. In the assemblage from Ohalo-II, microburin technique was not used in microlith production (Yaroshevich et al. 2013; Nadel 2003).

Other Levantine Epipaleolithic cultures also show the predominance of the scalene triangles in the tool kit, but in the Nizzanan and Qalkhan, geometric microliths were produced using the microburin technique in contrast to Ohalo-II (Gorring-Morris 1995; Belfer-Cohen and Gorring-Morris 2014).

Bearing in mind the great distance between western Central Asia and the Near East, the practically synchronous appearance of geometric microliths of the same type in both areas is noteworthy. The comparison of Late Kulbulakian and Levantine triangles has revealed similar morphometric characteristics. The maximum length of Late Kulbulakian scalene triangles (Dodekatym-2, layers 4–2) is up to 20 mm with a length for most triangles between 10 and 17 mm, the maximum width is 10 mm with a width for most triangles between 4 and 7 mm, and the maximum thickness is 2.7 mm with a width for most triangles between 1.5 and 2.5 mm. Thus, metrical characteristics of Late Kulbulakian geometric microliths and Ohalo-II scalene triangles are relatively similar to each other. Scalene triangles were made from bladelets with backing on transverse edge and one of the long edges of the blank. The right long edge of the blank was backed in the majority of the specimens. Blanks with a straight lateral profile were predominantly used in both assemblages. The microburin technique has not been known in Ohalo-II and Kulbulakian. However, Ohalo-II scalene triangles might have been produced using a technology other than that used in the Late Kulbulakian techno-complexes. This assumption is supported by the presence of truncated bladelets with metric features similar to the scalene triangles in the Ohalo-II tool kit (Yaroshevich et al. 2013).

Discussion

In western Central Asia, the earliest geometric microliths and backed bladelets have been seen within the Upper Paleolithic context that are not earlier than 32 cal. kyr BP, namely, in the Middle Kulbulakian complexes together with a noticeable amount of carinated pieces. Initially, quite a few backed pieces and scalene triangles appeared in techno-complexes from layer 2.1 at Kulbulak site (one scalene triangle and five backed bladelets) and layer 1 at Shugnou site (one scalene triangle and two backed bladelets). Both backed bladelets and scalene triangles appeared in techno-complexes simultaneously.

The Kulbulakian assemblages demonstrate a shift in the predominance of non-geometric microliths (mostly retouched bladelets, Arzheneh points, and Dufour bladelets) to geometric microliths (scalene triangles) in the same way as it has been noted in the Levantine and Zagrosian Epipaleolithic collections (Bar-Yosef 1970; Olszewski 2012; Belfer-Cohen and Gorring-Morris 2014). This shift has been noted in the Middle and Late Kulbulakian lithic industries. The prominent increase of amount of geometric microliths in the tool kits containing also non-geometric microliths was fixed at 23–22 cal. kyr BP in the lithic collections from Dodekatym-2 layer 2 (Late Kulbulakian). The process of the carinated cores replacement by single platform prismatic bladelet cores (Kolobova et al. 2011) led to the emergence of scalene triangles that were predominantly manufactured out of bladelets with a straight profile. This trend indicates the transitional status of the Late Kulbulakian industries when Upper

Paleolithic approaches in primary reduction were still in use (Belfer-Cohen and Gorring-Morris 2002), implying that the final tool shape was mostly formed in the course of core utilization. The produced blanks (bladelets) were treated with secondary working techniques typical of the Epipaleolithic industries, namely, long-edge backing and truncation. Now, the Middle-Late Kulbulakian can be defined as the transition from Upper Paleolithic to Epipaleolithic.

The available absolute dates of the Dodecatym-2 site (28–23 kyr) are older than presently known ones for the early Epipaleolithic Levantine (22.5–23.5 kyr) and Zagros (~22 kyr) industries with geometric microliths, thus making it possible to conclude that Central Asia was at least one of the microlitization origin centers.

The distant locations of the lithic industries under discussion do not represent a unique feature in Paleolithic studies. Usually, the emergence of Paleolithic tool markers in geographically distant complexes is explained in terms of direct migrations, where direct contact led to the sharing of technologies (Krivoshapkin 2012; Rybin 2014). A similar case has been noted in the Near and Middle East and western Central Asian Paleolithic. "Direct contact" interpretation primarily concerns the dispersion of the transitional blade-based technologies, carinated technologies, and certain types of Aurignacian tools (Dufour bladelets, carinated end-scrapers, El-Wad points) within the transitional and Upper Paleolithic industries (Krivoshapkin 2012; Kolobova 2014). Archeological evidence from these areas suggests episodes of recurrent human interactions that took place as early as the Middle to Upper Paleolithic transition period.

The authors define the Kulbulakian case as one of the replications of the final shape of an innovative tool (scalene triangle) using different technologies, which varied across the regions. It means that this case cannot be explained either by means of direct migration or by group interaction networks, but represents the sharing of technologies. The dispersal of the idea of scalene triangles took place primarily through the replication of the shape and size of the tool with the purpose of producing artifacts with particular functional features: side elements of composite projectiles. The replication of these tools was necessitated by the borrowing of new hunting methods. Innovation tool manufacturing was executed using the technology practiced by the borrowing population. Thus, the adaptation of a beneficial innovation to the local conditions resulted in the uniformity of the tool kits of the Epipaleolithic industries in the Near and Middle East and western Central Asia.

On the other hand, the application of the ideas borrowed to the existing local technological traditions explains various dissimilarities between the lithic industries of various regions. The available data does not suggest the formation of a common interregional culture. It does, however, make it possible to infer the formation of a stable trend towards the borrowing of subsistence strategies.

Conclusions

The occurrence of backed artifacts and geometric microliths within the Kulbulakian techno-complexes provide grounds for the preliminary inference that the local Upper Paleolithic industries could have been the basis for the development of Epipaleolithic in western Central Asia. The Late Kulbulakian artifact collections indicate certain processes that are similar to the Upper Paleolithic–Upper Paleolithic to Epipaleolithic transition in Levant and Zagros (the general trend towards microtool production). At the current state of our investigation, Middle-Upper Kulbulakian could be attributed to the Upper Paleolithic to Epipaleolithic transition in western Central Asia.

Comparative analyses of the scalene triangles from western Central Asia with those from Zagros and Levant have led to the inference that fairly similar morphometric features were obtained through different technologies. The Late Kulbulakian scalene triangles were made out of backed bladelets, while the Zarzian (and possibly the Masraqan) scalene triangles were produced from truncated bladelets. It means that while the final morphology and possible function of those geometric microliths were very similar, the technology of their blank production was different, possibly implying different cultural background.

The older dates for geometric microliths in Kulbulakian in a comparison with known age estimates for the same implements in the early Epipaleolithic Levantine and Zagros industries can possibly nominate Central Asia for one of the centers of lithic microlithization and chalk out the vector of microlith's technology spread in Eurasia.

The significant morphometric similarities between the Kulbulakian scalene triangles and the relevant Zarzian and Masraqan artifacts but different blank-producing technology can be explained, from our point of view, in terms of "sharing ideas" hypothesis rather than direct cultural transfers (viz. population migrations). Almost synchronous appearance of one geometric microlith type in several neighboring regions makes it possible also to exclude the possibility of convergent development in different region.

The dispersal of the idea of scalene triangles occurs primarily through replication of the shape and size of the tool with the purpose of producing artifacts with specific functional features, namely, the side elements of composite projectiles. There can be several reasons for the replication of these tools including the borrowing of composite tool idea, reproduction of the hafting method, or the spreading of new hunting methods.

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