

Experimentally obtained examples of projectile damage: cases of similar fracture types on microlithic tips and side elements

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Introduction

Archery experiments with stone-tipped weapons have been applied as a methodological approach in the investigation of prehistoric flint points since the late 1970s (Hayden 1979). The first experimentally based studies described diagnostic impact fractures (DIF) and confirmed the function of Upper Paleolithic and Mesolithic points of various types as tips of projectile weapons (Barton, Bergman 1982; Bergman, Newcomer 1983; Fischer et al. 1984; Moss, Newcomer 1982; Odell, Cowan 1986). Subsequent experiments involved point types characteristic of earlier periods and extended the range of research objectives including such issues as invention of projectile weapons and human evolution (Lombard 2005; 2007; 2008; 2011; Lombard, Pargeter 2008; Lombard, Philipson 2010; Lombard et al. 2004; Villa, Lenoir 2006; Villa, Soriano 2010; Villa et al. 2009a; Villa et al. 2009b; Shea 1988; 1989a; 1989b; 1991; 1993; 2003; 2006; Sisk, Shea 2009; Sisk, Shea 2011).

The use of microlithic tools as elements of projectile weapons is known from a number of intact archaeological finds from Upper Paleolithic and Mesolithic contexts in Europe and Asia, Ancient Egypt, as well as from ethnographic evidence. These examples show a variety of designs with microliths of variable morphology fitted as tips of the weapons as well as their side elements. These archaeological and ethnographic examples have provided a basis for designs of experimental projectiles in studies aimed at investigating prehistoric microlithic assemblages in terms of weapon technology. Such studies have shown a link between microlith morphology and mode of hafting in particular sites (Caspar, De Bie 1996; Crombé et al. 2001). Moreover, investigation of assemblages representing succeeding cultures and periods showed that the change through time in microlith morphology and the technology of their production was connected to changes in the design of projectile weapons (Nuzhni 1989; 1990; 1992; 1993; 1999; 2008; Yaroshevich 2010; Yaroshevich et al. 2010; 2011; in press). In particular, in the Levant the shift from trapeze/rectangles (backed and truncated blade-lets) to lunate shaped microliths characterizing the Geometric Kebaran–Natufian transition was associated with the change from projectiles fitted with lateral elements to the proliferation of tips, including transverse points. These changes toward simpler and more easily

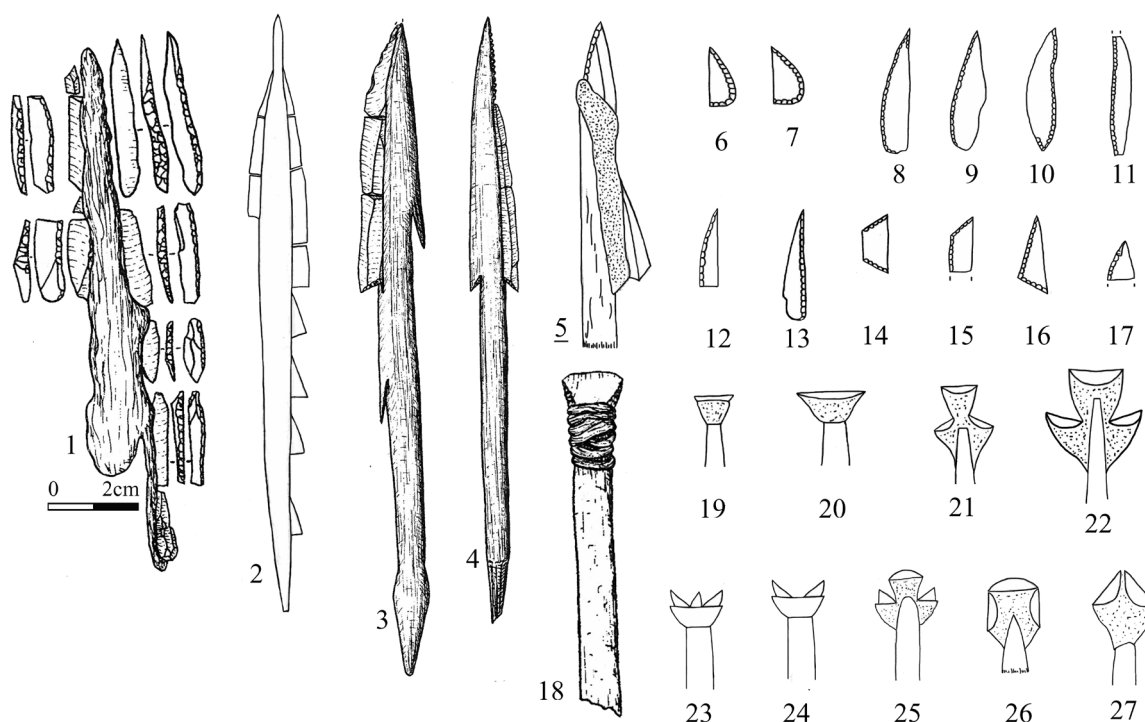


Fig. 1. Archaeological and ethnographic projectiles fitted with microliths and schematic representation of microliths found embedded or among human and animal bones. 1: projectile with lateral blades from Talitsky, Russia; 2: self pointed projectile with lateral blades and barbs from Tlokoowo, Poland; 3: self pointed projectile with lateral blades from Nizhnee Veretje, Russia; 4: self pointed projectile with lateral blades from Oleni Ostrov, Russia; 5: arrow with pointed tip and barb from Løshult, Sweden; 6, 7: Jebel Sahaba, Sudan; 8-11: site E71K12; 12-14: Vasilievsky, Ukraine; 15-16: Voloshskij 1 grave, Ukraine; 17: Voloshskij 3 grave; 18: transversal arrowhead fitted with trapeze from Petersfen, Germany; 19-26: arrowheads from Ancient Egyptian sources; 27: arrow with double oblique point of San Bushmen

Обр. 1. Археологически и етнографски метателни оръжия със съставни микролити и схематично представяне на микролити намерени забити или в близост до човешки и животински кости. Разновидности на метателни оръжия: 1 – с латерални (странично закрепени) пластини от Talitsky, Russia; 2 – със заострен ствол и латерални пластини и зъбци от Tlokoowo, Poland; 3 – със заострен ствол и латерални пластини от Nizhnee Veretje, Russia; 4 – със заострен ствол част и латерални пластини от Oleni Ostrov, Russia; 5 – стрела с кремъчен връх и латерални зъбци от from Løshult, Sweden; 6, 7 – Jebel Sahaba, Sudan; 8-11: site E71K12; 12-14: Vasilievsky, Ukraine; 15-16: Voloshskij 1, гроб, Ukraine; 17 – Voloshskij 3 гроб, Ukraine; 18 – трансверсална стрела с трапец във върховата част от Petersfen, Germany; 19-26 – стрели по древноегипетски източници; 27 – стрела с 2 косо прикрепени елементи от San Bushmen

prepared and maintained designs were connected with economic changes in the region during the Final Pleistocene, namely intensified exploitation of animal resources, increased use in plant-based food and the subsequent emergence of agriculture (Yaroshevich 2010; Yaroshevich et al. 2010).

In this paper I shall focus attention on the fact that microlithic tips and side elements of projectiles can acquire similar kinds of diagnostic impact fractures. The examples pre-

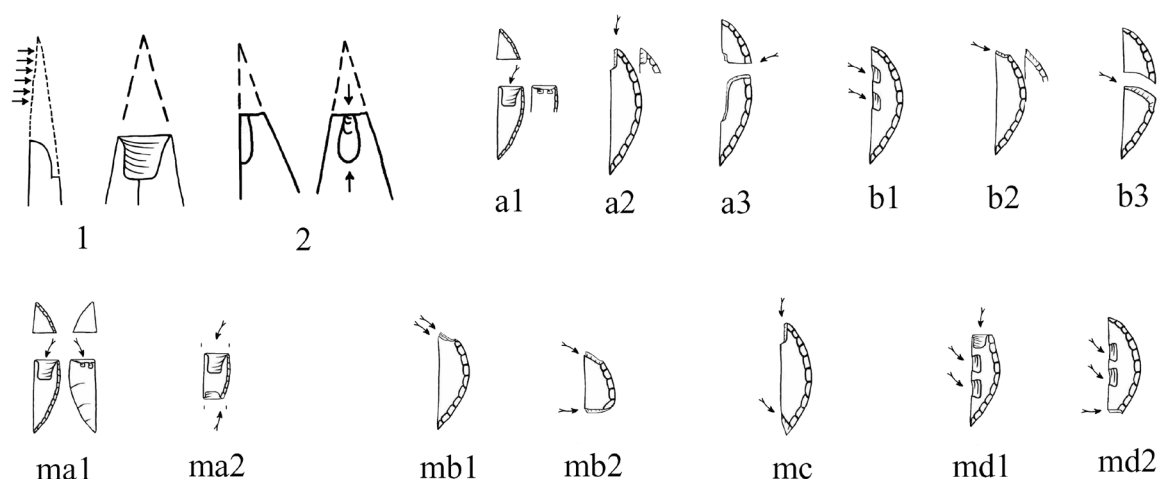


Fig. 2. Types of diagnostic impact fractures: 1: step terminating bending fractures; 2: spin-off fracture (after Fischer et al., 1984); a1, a2, a3: single parallel fractures; b1, b2, b3: single oblique/perpendicular fractures; ma1, ma2: multiple parallel fractures; mb1, mb2: multiple oblique/perpendicular fractures; mc: parallel and oblique/perpendicular fractures on opposite ends; md1: fracture along sharp edge and parallel fracture; md2: fracture along sharp edge and oblique/perpendicular fracture (after Yaroshevich et al., 2010)

Обр. 2. Типове диагностични пречупвания: 1 – извито стъпаловидно; 2 – инцидентно (според Fischer et al., 1984); a1, a2, a3 – обикновени успоредни; ; b1, b2, b3 – обикновени коси/перпендикулярни; ma1, ma2 – множествени успоредни; mb1, mb2 – множествени коси/перпендикулярни; mc – успоредно и косо/перпендикулярно на противоположните краища; md1 – негативи на острия ръб и успоредно пречупване; md2 – негативи на острия ръб и косо/перпендикулярно успоредно пречупване (според Yaroshevich et al., 2010)

sented here were observed on experimental replicas of microliths characteristic of different Epipalaeolithic cultures in the Levant (Yaroshevich 2010; Yaroshevich et al. 2010). I believe this contribution has a significant methodological value for studies aimed at interpreting variability of microlithic tools in terms of projectile weapon design and technology. Before proceeding to the experimental examples, a brief survey is presented of projectile designs with microliths hafted as tips and as side elements based on archaeological findings and ethnographic record.

Designs of microlithic projectiles as shown by archaeological finds and ethnographic examples

Lateral elements: projectile weapons with microlithic lateral elements appear during the Upper Paleolithic and continue through the Mesolithic and Neolithic in Europe as well as in Eastern Asia (e.g. Clark 1936; 1969; Kozłowsky, Kozłowskaja 2001; Lozovskaja 2001; Petillon et al. 2011 and references therein; Pitulko 1997; Serikov 2001). The examples of microlith types fitted as lateral elements include the microgravette point and backed fragments from the Upper Paleolithic site of Talitsky, Ural Mountains, Russia (Gvosdover 1952) (fig. 1.1); triangles and partially retouched bladelets exhibited by the projectile from the Early Mesolithic site near Tłokowo village, Poland (Sulgostowska 1993) (fig. 1.2); trun-

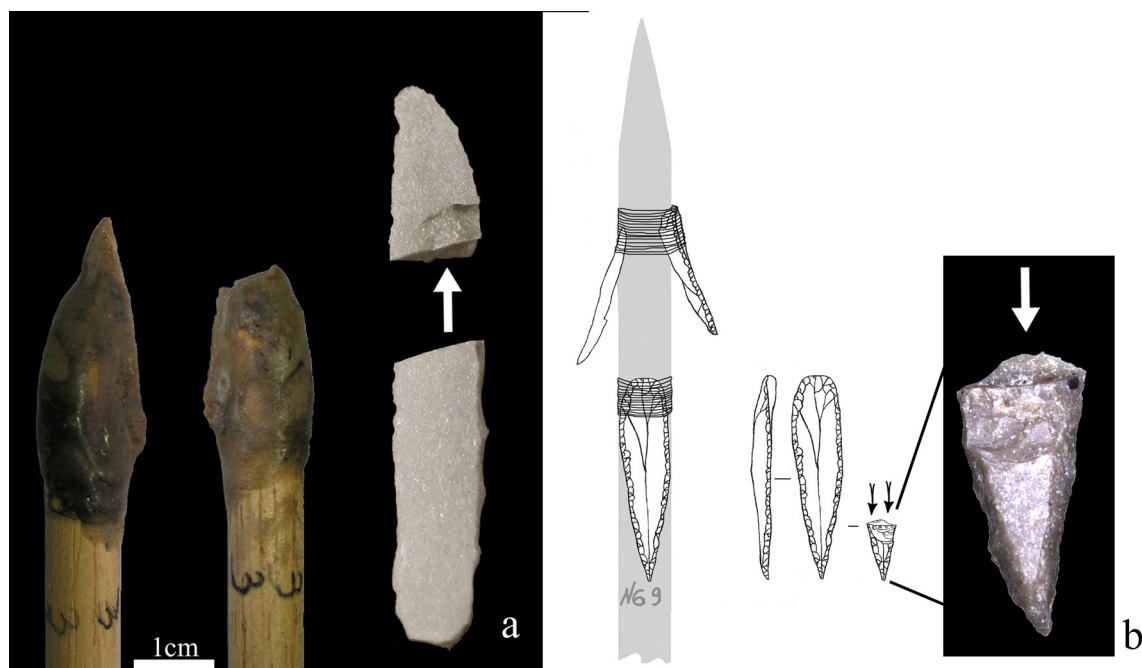


Fig. 3. Examples of similar fractures on microlithic tips and side elements of experimental arrows (after Yaroshevich et al., 2010). Type a1 on pointed tip and on twisted barb

Обр. 3. Примери за сходни/идентични пречупвания на микролити закрепени като връхчета и/или странични елементи на експериментални метателни оръжия (стрели). Тип a1 върху (кремъчен) връх и върху извити латерални (странично закрепени) зъбци

cated bladelets as shown by examples from the Mesolithic sites of Nyzhnee Veretje I (Osibkina 1983) (fig. 1.3) and Oleny Ostrov (Gurina 1989) (fig. 1.4).

Pointed tips: the Boreal layer of the Løshult peat bog, Sweden (Malmer 1969) provided a 88cm long fragment of a wooden arrow with a triangle fitted as a pointed tip and a bladelet with straight retouched edge fitted as a barb (fig. 1.5).

Findings of microliths embedded in animal or human bones also can be interpreted as pointed tips. Examples include backed segments and trapeze-like points from the Final Pleistocene site of Gebel Sahaba in Sudan (Wendorf 1968) (fig. 1.6, 1.7); pointed backed and arch-backed bladelets from the kill/butchery site of E71K12, Upper Egypt, dated to ca. 19ka BP (Wendorf et al. 1997) (fig. 1.8-1.11); a point with a curved retouched edge found embedded in a cervical vertebra of a skeleton from the Voloshskij grave (Telegin, 1982, fig. 1.12-1.14); backed and truncated bladelets, points with curved back and a point with the tip made through microburin technique from the Final Pleistocene graves of Vasilievskoe 1 and 3, Ukraine (Stoljar 1959; Telegin 1982) (fig. 1.15-1.17).

Transverse tips: recent studies indicate a very ancient age of transverse arrowheads as this kind of weapon was identified, based on DIF and residue analyses, from 64 ka old segments and backed pieces from Sibudu Cave, South Africa (Lombard 2011; Lombard, Phillipson 2010).

In the Levant this design was identified for lunates - the type fossil of the Late Pleistocene Natufian culture, based on the analysis of macro- and micro- DIF (Yaroshevich 2010; Yaroshevich et al. 2010; 2011; in press). Transverse hafting was also one of the two alternative suggestions based on the character of the injury caused by a lunate with bifacial (Helwan) retouch embedded in the vertebra of a male skeleton from the Natufian layer of

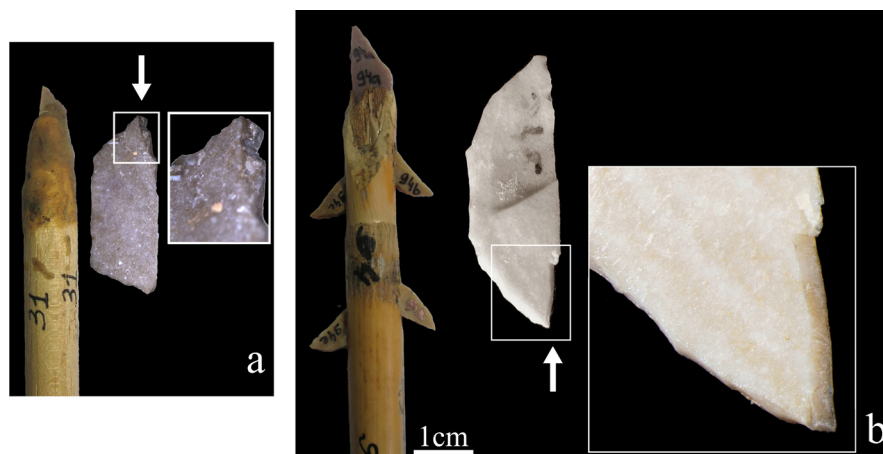


Fig. 4. Examples of similar fractures on microlithic tips and side elements of experimental arrows (after Yaroshevich et al., 2010). Type a2 on pointed tip and on oblique barb

Обр. 4. Примери за сходни/идентични пречупвания на микролити закрепени като връхчета и/или странични елементи на експериментални метателни оръжия (стрели).
Тип a2 върху връх и върху извити къси зъбци

Kebara Cave (Bocquentin, Bar-Yosef 2004).

Intact finds of transverse arrowheads are known from Mesolithic and Neolithic sites in Europe and from Ancient Egyptian sources. Transverse arrowheads from the European record were fitted with wide symmetrical trapezes attached to the shaft through binding, either sinew or fibre (Clark 1936, 1969; Madsen 1868; Paulsen 1990; Pfeifer 1920; Troels-Smith 1960, 1961) (fig. 1.18). Ancient Egyptian examples occur in a variety of designs. Four main groups were defined based on the length of the transversely fitted microlith and the presence or absence of barbs (Clark et al. 1974) (fig. 1.19-1.22). A separate type consists of transverse arrowheads fitted with snapped unretouched inserts (Clark et al. 1974). An arrowhead comprising a transversely hafted microlith together with two laterally hafted microliths producing a rectangle-like arrowhead (fig. 1. 26) was described by Vignard (1935). In all the cases the microliths were attached with the aid of adhesive material.

Composite tips: Tips composed of two or several microliths are known from the ethnographic accounts of Bushmen hunters (Clark 1977; Goodwin 1945) (fig. 1. 27) and Ancient Egyptian arrow types (Vignard 1935) (fig. 1.23, 1.24). These are composed mostly of lunate-like microliths.

Methodological background

Following archery experiments a variety of fractures resulting from projectile impacts were described based on the morphology of fracture initiation and termination as seen in profile (Hayden 1979). Subsequent experiments delineated two types of fractures as diagnostic of projectile impact (Fischer et al. 1984). The first type, the step terminating bending fracture, has a smooth initiation which lacks a negative of bulb of percussion (bending initiation), continues parallel to the point's surface and terminates abruptly in a right angle break (fig. 2.1). The smooth initiation indicates forces distributed over a large area as opposed to forces applied at a particular point when cone initiating fracture occurs. The second type of DIF is spin-off fracture, a secondary cone initiating fracture which originates

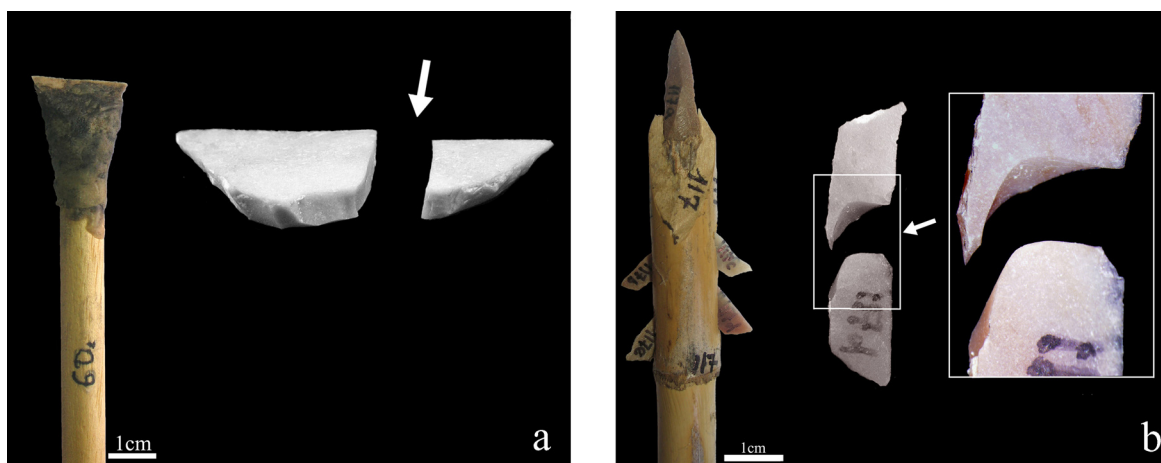


Fig. 5. Examples of similar fractures on microlithic tips and side elements of experimental arrows (after Yaroshevich et al., 2010). Type b3 on transverse tip and on oblique barb

Обр. 5. Примери за сходни/идентични пречупвания на микролити закрепени като върхчета и/или странични елементи на експериментални метателни оръжия (стрели).
Тип b3 върху трансверсален връх и върху извити кòси зъбци

on the surface of a bending fracture (fig. 2.2). Spin-off fractures occur when already broken pieces of the flint projectile element are pressed together as a result of kinetic energy stored in the shaft during impact. Spin-off is considered as diagnostic of impact based on the size of the flint insert. For microlithic inserts a spin-off of 1mm length is considered as diagnostic of impact (Fischer et al. 1984). Recent experiments conducted by Pargeter (2011) showed that DIF can occur in very low frequencies (up to 3%, depending on the type of the fracture) as result of trampling. Still, macro-DIF comprise a reliable and available method to identify projectile function of stone points.

Fischer and colleagues (1984) also determined microscopic DIF. These are linear polishes and striations. The striations appear when microscopic pieces of flint, removed during impact, scratch the point's surface. The direction of micro-DIF roughly corresponds to the direction of arrow movement (Fischer et al. 1984; Crombé et al. 2001; but see Yaroshevich et al. 2010 for examples when the direction of micro-striations does not perfectly correspond to the direction of the arrow). Experiments also indicated that mode of hafting affects the frequency of DIF. Thus, frequencies of macro-DIF on projectile tips vary from 32% (Crombé et al. 2001) to 41% (Fischer et al. 1984) to about 53% for single straight points (Yaroshevich 2010; Yaroshevich et al. 2010). Microliths hafted as side elements are damaged in lower frequencies. Thus, in the experiments by Crombé and colleagues (2001) micro-DIF observed on barbs comprised about 5%; in the experiments with Epipaleolithic microliths from the Levant the frequency varied from 12.5% for lateral blades (fitted parallel to the shaft) to about 25% on average for obliquely hafted barbs (Yaroshevich 2010; Yaroshevich et al. 2010).

Archery experiments with microliths characteristic of the main Epipaleolithic cultures of the Levant fitted in a variety of modes, i.e., as tips (straight, oblique and transverse) and as side elements (lateral blades, oblique barbs and twisted barbs) allowed the development of a detailed typology of macro-DIF (fig. 2) based on fracture direction (parallel vs oblique or perpendicular to the long axis of the microlith) and location of initiation (surface, sharp edge or retouched edge of the microlith). The findings may be summarized as follows: 1) most types of single DIF (types a1, a2, a3, b1, b2, b3) can occur on differently hafted micro-

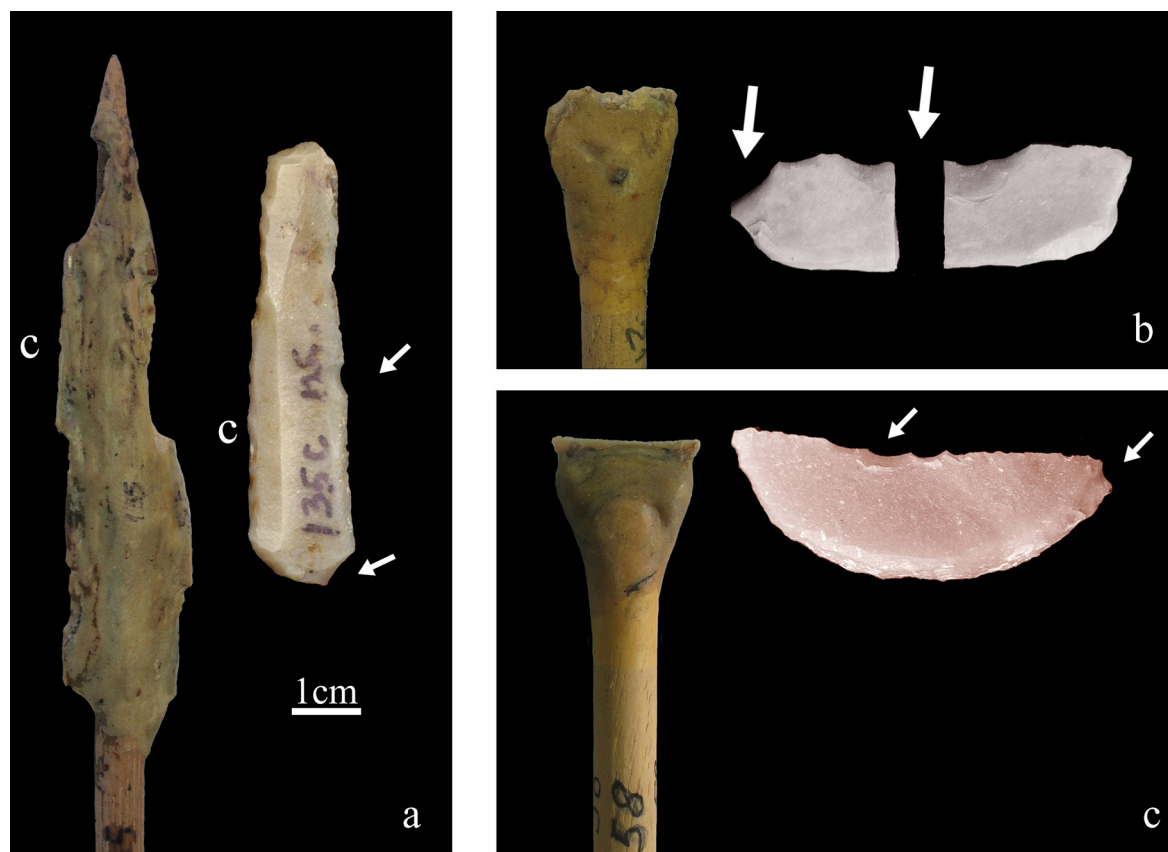


Fig. 6. Examples of similar fractures on microlithic tips and side elements of experimental arrows (after Yaroshevich et al., 2010). Type md2 on transverse tip and on lateral blade

Обр. 6. Примери за сходни/идентични пречупвания на микролити закрепени като върхчета и/или странични елементи на експериментални метателни оръжия (стрели).
Тип md2 върху трансверсален връх и латерално прикрепена пластина

liths, therefore, they cannot provide a reliable basis for reconstructing the mode of microlith hafting in an archaeological assemblage; 2) the most reliable data for reconstructing hafting modes are multiple DIF of the same type that appear either on the same end (proximal or distal) or on opposite ends (proximal and distal) of the microlith. Straight points are particularly associated with multiple parallel DIF on the same end, on dorsal and ventral surfaces (type ma1) or at opposite ends, oriented one toward the other (type ma2); transverse points are especially characterized by multiple DIF initiating on the sharp edge of the microlith either on the same end (type mb1) or on opposite ends (type mb2) and oriented in a sharp or straight angle relative to the long axis.

Examples of similar macro-DIF on experimental tips and side elements

DIF initiating on the ventral or dorsal surface (type a1, both step terminating bending and spin-off) occur most frequently on pointed tips of projectiles. In one case, however, a fracture of this type, namely spin-off, was observed on the twisted barb attached with its ventral surface to the shaft through binding and adhesive (fig. 3). The barb was fitted with a retouched bladelet with a twisted lateral profile. The location and direction of the fracture suggest the fracture occurred when the arrow was removed from the target.

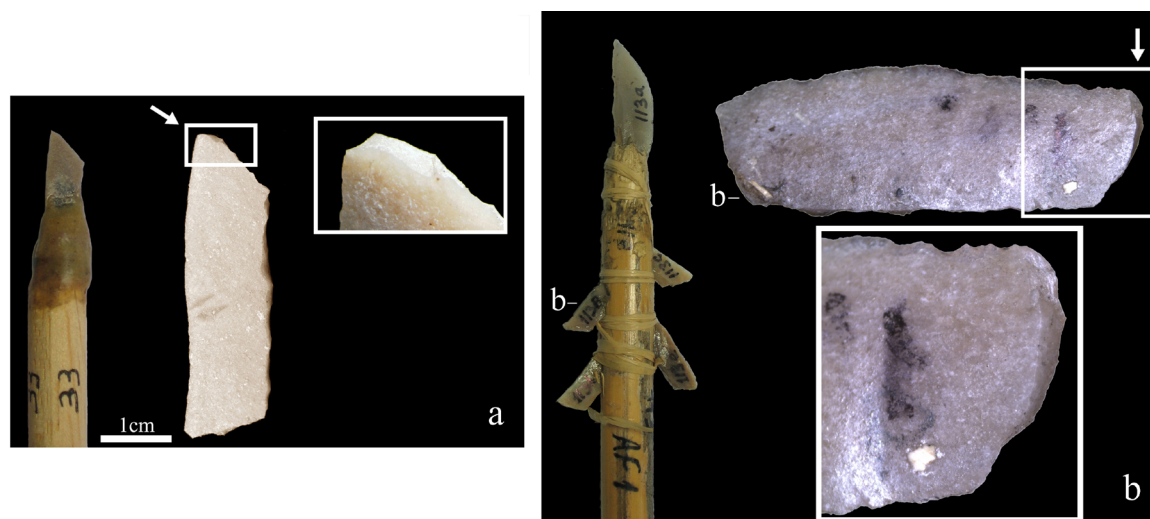


Fig. 7. Examples of similar fractures on microlithic tips and side elements of experimental arrows (after Yaroshevich et al., 2010). Type b2 on pointed tip and on oblique barb

Обр. 7. Примери за сходни/идентични пречупвания на микролити закрепени като върхчета и/или странични елементи на експериментални метателни оръжия (стрели).
Тип b2 върху връх и върху коси зъбци

DIF initiating on the retouched edge of the microlith and removing a small part of its lateral edge (type a2) also occurred mostly on the pointed tips of the arrows. However, in several cases similar fractures were observed on microliths hafted as barbs, on the end which was distant from the tip of the arrow (fig. 4). Again, the location and the direction of the fractures indicate that they occurred as a result of removing the arrow from the target.

DIF initiating on the sharp edge also occurred on tips as well as on lateral elements. Specifically, fracture of type b3 - a breakage across the microlith's body - occurred on transverse arrowheads as well as on oblique barbs (fig. 5). Fracture of type md2 - fracture along the sharp lateral edge along with other types of oblique fracture - occurred on transverse points and on lateral edges of blades (fig. 6). Fracture of type b2 - oblique fracture removing only the tip of the microlith - occurred on barbs and on one pointed tip, fitted with a trapeze/rectangle (fig. 7).

Concluding remarks

Several cases have been presented when experimental microliths hafted as tips and as side elements of projectile weapons exhibited similar types of DIF. While most of these fractures occurred during impact - some probably occurred during removal of the arrow from the target. All the cases, however, are relevant for studies aimed at reconstructing the design of microlithic projectiles. The similarity in DIF types between differently hafted microliths emphasizes the importance of a comprehensive approach: when possible, other kinds of evidence, such as adhesive remains and residue location should be considered. If such evidence is lacking - the reconstruction should be based on multiple macro-fractures, direction of micro-striations along with the frequency of DIF as well as the morphology of microliths and their size. Such comprehensive analyses will permit reliable reconstruction of projectile design and, subsequently, explana-

tion of the technological and morphological variability of microlithic tools whether regarding particular sites or whole sequences of cultures and periods.

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Експерименти с метателно оръжие (стрели): фрагментиране на кремъчните върхове и латерални елементи

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Резюме

Находките на запазени метателни оръжия, съоръжени с геометрични микролити, демонстрират широк диапазон от композиции с различно закрепване на микролитите като върхове и странични (латерални) съставни елементи. Подобни примери, обаче, са сравнително редки и реконструкцията на праисторическите метателни оръжия (стрели) обикновено се основава на анализа на диагностичните макро- и микродеформации (пречупвания), причинени от удар. Анализът на фрагментирането причинено от удар, и по-точно честотата, началото и посоката на оставените негативите, разкриват зависимост между морфологическите и технологичните характеристики на микролитите и начина им на закрепване. Провежданите експерименти по изстрелване на съставни стрели, и последващото им проучване, предоставят данни за интерпретация на микролитите в морфо-типологичното им разнообразие и в зависимост от тяхната функция като елементи от съставни оръжия. Друг съществен аспект в интерпретацията на микролитните ансамбли е проследяване на хронологическите изменения в стила на оръжията в локален и трансрегионален мащаб.

Статията представя любопитни и специфични резултати от експерименти с реконструирани в широк спектър съставни метателни оръжия (стрели). Опитите с тях показват аналогично фрагментиране на кремъчните микролити, закрепени като върхове или като странични съставни елементи. Тези резултати са много съществени за правомерната интерпретация на археологическото разнообразие от микролити. Те предоставят надеждни и добре илюстрирани реферативни данни за възможното използване на микролитите като елементи от праисторически метателни оръжия.