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Towards understanding the influence of Neolithisation for communities using the Zvejnieki cemetery, Latvia: A technological and functional analysis of the osseous artefacts discovered in the Late Mesolithic burial no 57 and Neolithic burial no 164

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Abstract: The results of traceological (technological and use-wear) studies of osseous artefacts discovered in the Mesolithic burial no 57 and Neolithic burial no 164 from the cemetery in Zvejnieki, Latvia are discussed. This research identified significant differentiation in the techniques used to make animal tooth pendants deposited in the Mesolithic grave and, by contrast, identified relative uniformity in the methods used to make those from the Neolithic grave. In addition, use-wear traces were observed on many of the Mesolithic pendants and were absent from almost all Neolithic ones, indicating the Neolithic examples were probably made for funerary purposes. This research also identified that the bone points from both graves were made in a similar manner and had been used. The technological and functional similarities and differences between the artefacts from the Mesolithic and Neolithic burials are discussed in the context of their probable origin and on observations made on other collections of similar chronology in the region.

Keywords

Zvejnieki (Latvia); Burials; Mesolithic; Neolithic; Bone artefacts; Traceology

1. Introduction

The small size and considerable mobility of the hunter-gatherer communities of the Early and Middle Holocene Europe are probably the main reasons why cemeteries from this period are sparse. In central Europe, they are usually small, containing [at most 1-5] graves, such as, for example, Janisławice (Chmielewska, 1954; Cyrek, 1978) and Mszano (Marciniak, 2001) in Poland, and Bad Dürrenberg, Groß Fredenwalde and Liepe in Germany (Gramsch, 2010, 39). The situation is different in northeastern Europe, where small cemeteries, such as Spiginas and Donkalnis in north-western Lithuania (Butrimas, 2012), are found next to large cemeteries which have clearly been used over long time periods (cf. Grünberg, 2016), such as

Oleniy Ostrov in north-western Russia (Gurina, 1956), Zvejnieki in Latvia (Zagorskis, 1987; 2004; Zagorska, 1992) and Dudka and Szczepanki in northeastern Poland (Gumiński and Bugajska, 2016). Settlement sites are equally crucial for the study of the prehistoric hunter-gatherer communities of the region. Thanks to favourable environmental conditions like those in the cemeteries, they also exhibit well-preserved and rarely available organic archaeological material, mainly bone. Examples of these sites are Šventoji in Lithuania (Rimantienė, 2005) or Pulli and Kunda-Lammasmägi in Estonia (Indreko, 1948; Jaanits and Jaanits, 1975).

Osseous raw materials have undoubtedly played a key role in the life of hunter-gatherer communities of the Early and Middle Holocene. The products made from them were used in all aspects of the lives of these human groups. Not only were they one of the basic materials for making tools and hunting weapons (David, 2005a), but they also served an essential function in social and spiritual life. They became a means for expressing symbolic ideas through realistic figurative art (Płonka, 2003; Mantere and Kashina, 2020) and highly decorative ornaments on artefacts from that period (Płonka, 2003). Bones and items made of bone were used for communicating the social role and position of individuals (Larsson, 2009) and belongingness to a local group (David, 2006). They were an essential element of rituals (e.g. Osipowicz et al., 2020a, b; Eliott et al., 2018; Gummesson et al., 2018) and a permanent constituent of burial gifts where their observed technological and formal diversity suggest sensitive indicators of many regional cultural traditions (David, 2007). Lastly, products made of osseous raw materials appear to have been important items of exchange within the inter-social relations of that period (Manninen et al., 2021), sometimes across large areas (cf. Osipowicz et al., 2017), involving not only the artefacts themselves but also the ideas related to them, of technology (David, 2005a, 2007; David and Kjällquist 2018), style and form (Manninen et al., 2021) and ornament (e.g. Płonka, 2003).

The region of northeastern Europe is an area with some of the best conditions for the preservation of organic material from the Early and Middle Holocene, and its potential for the study of osseous collections from these periods is exceptionally valuable. However, most research on bone material has focused on typology and zooarchaeology, and targeted research on their technological and functional aspects is the subject of few published articles.

Osseous materials from Estonia, from the sites Pulli (David, 2005b), Saaremaa (Luik et al., 2011), and single finds from the Pärnu river (Luik and Haak, 2017) have mainly been studied with a focus on artefacts and their technology. To date, no osseous materials from Estonia have been subjected to functional analyses. In Latvia, osseous artefacts from the Zvejnieki cemetery have been the subject of research on their technology (David and Zagorska, 2004; David, 2006; Larsson, 2006), and there is one generalised functional study on the animal teeth pendants (Larsson, 2006, 2009). From Lithuania, most osseous materials traceologically studied have come from the complex of sites in Šventoji (Luik and Piličiauskienė, 2016; Gaižauskas, 2017; Iršenas et al., 2018; Osipowicz et al., 2019a, b, 2020a, b, d, e; Osipowicz, 2020) and Kaltanėnai site (Piličiauskas et al., 2020). Additionally, single papers presenting the results of the analyses, including preliminary technological studies, on selected stray finds from Lithuania, have been published (Ivanovaitė et al., 2018; Rimkus et al., 2019). In Russia, the research has mainly focused on the osseous materials from Zamostje (e.g. David, 1996; Lozovska, 1997; Gyria et al., 2013; Maigrot et al., 2013; Treuillot, 2013) and the sites located

within the Upper Volga region (e.g. Zhilin, 1998, 2015, 2020). Also, materials, mainly pedants, from the burial site at Yuzhniy Oleniy Ostrov have been analysed traceologically (Rainio et al., 2021; Mannermaa et al., 2021, 2022).

There is a real need for more research in this area.

1.1. East Baltic Plain – an outline of inter-cultural transformations and impact in the Early and Middle Holocene (with particular emphasis on the area of today's Latvia)

The East Baltic Plain area is extremely interesting regarding cultural changes that took place there in the Early and Middle Holocene. Throughout this period, it was, as one might put it, 'on the borderlines between two worlds', accumulating ideas from vast areas; yet, the communities living here continued the foragers' way of life till the end of the Stone Age.

The oldest known traces of humans in the territory of Latvia belongs to reindeer hunters, which arrived at the very end of the Late Palaeolithic (10500-9000 cal BC). They are associated with the Swiderian tradition, expanding from its core area covering the region from Ukraine to Poland and Lithuania (Kozlowski, 1989).

For most of the Mesolithic, the East Baltic Plain was inhabited by people assigned to the Kunda culture (9000-6500 cal BC). The genesis of this unit is still in question (Ostrauskas 2006); however, it is assumed that it came into existence after the convergence of a wave of migration from north-eastern Europe and the inheritance of Swiderian culture. Some researchers also consider the influence of Madlenian and later the Maglemose traditions (Jaanits 1990, Zagorska 1993, Rimantienė 1984). Recently, eastward affiliation has been suggested (Sorensen et al., 2013). The osseous inventory of Kunda culture is characterised by Kunda-type fish spears, harpoons, bone points of a triangular cross-section, Shigir points, and single specimens with one or two slots (Kozłowski 1971, 1989, Zagorska et al., 1993).

As a result of the technological studies of collections of implements made of osseous raw materials originating from selected Early Mesolithic sites in Europe conducted recently, three technocomplexes have been distinguished on our continent (cf. David 2005a, 2007). Due to the presence of the so-called Z-method (named after site Zamostje, Russia - David 2007) in the applied methods for manufacturing semi-products for osseous points, the Kunda culture was qualified as the easternmost group of the Northeastern technocomplex (David 2007; David and Zagorska 2004). Likewise, in this regard, it is situated on the borderline between different cultural systems.

Significant transformations in Latvian Stone Age occurred during the Late Mesolithic (6000-5400 cal BC) and Early Neolithic (5400-4100 cal BC). This period was divided by the appearance of so-called Narva ceramics, bearing the influence of more southern territories (Piezonka, 2015). Still, the subsistence economy did not change – it was a time of optimal climatic conditions, an increase in food resources and population increase and a flourishing hunter-fisher-gatherer way of life (Loze, 1993).

At approximately 4100-4000 cal BC from north-eastern Europe, the Pit-Comb Ware culture appears, starkly differing from previously observed traditions. This phenomenon is characterised by new types of pottery (with pit and comb ornament), the emergence of an extensive amber exchange network, the shift in lithic technology and distinctive burial practices, such as collective burials, different grave goods and others (Berg-Hansen et al 2019; Zagorska, 2016).

At the same time, old, local burial traditions continued to be practised (single inhumations, tooth-pendant dominance, bone and antler grave goods). Both graves from the

Zvejnieki burial ground analysed in this article (graves 57 and 164) belong to this local Mesolithic-Neolithic burial tradition.

In light of the presented data, it seems reasonable to hypothesise that the intercultural influences connected to the Neolithisation of the discussed region that were noticed in the case of pottery and stone artefacts may also be visible in production methods and use of the osseous products.

1.2. Objectives

This article aims to present the results of traceological studies on the collections of bone artefacts from two burials at the site in Zvejnieki, Mesolithic grave no 57 and the Neolithic grave no 164. The microscopic analysis of these artefacts was undertaken primarily to characterise the manner of their production and to interpret their probable function. The data obtained was used to identify and interpret the origins of possible technological and functional differences between the Mesolithic and Neolithic artefacts and also to seek to identify behaviour related to their funerary purpose. Some of the analysed objects, mainly the pendants from grave 57, had previously been subjected to similar analyses using a small magnification of ×10 (Larsson, 2006, 256). In the case of such artefacts, the main objective of this research was to supplement, if possible, the existing findings using higher magnification and an optical microscope for technological analyses, higher magnification to enable the analysis of polish, and a metallographic microscope for the study of function.

1.3.-Zvejnieki

The Zvejnieki Stone Age complex in northern Latvia includes one of the most significant hunter-fisher-gatherer cemeteries in northern Europe in terms of both the exceptional number of individuals buried there and the long period of use. It is located on a gravel ridge of glacial origin, which was formerly an island close to the shore of the palaeolake Burtnieks in northern Latvia (Fig. 1).

In the 1960s, Francis Zagorskis directed a large-scale excavation at Zvejnieki in response to the accidental discovery of ochre-stained human bones during gravel extraction at the site. The burial ground was excavated from 1964 to 1971, with minor interruptions. The Neolithic settlement, Zvejnieki I, was excavated from 1964 to 1966, and in the 1970s, excavations were undertaken in the Mesolithic settlement, Zvejnieki II (Fig. 1C; Zagorskis, 1987, 2004; Zagorska, 1992, 2006b).

The favourable preservation conditions for skeletal remains, implements made of osseous materials, and the arrangement of the cemetery helped form the basis of a preliminary chronological outline and archaeological interpretation (Zagorskis, 1987). The Zvejnieki archaeological complex consists of a burial ground used over a period of five millennia (approximately 7500–2600 cal BC) and two settlement sites partly contemporaneous with it.

The excavation at Zvejnieki revealed one of the largest Stone Age burial concentrations in northern Europe. Still, the exact number of individuals buried at the site is not known. A total of 308 burials were recorded in the 1960s and 1970s, including some collective burials of up to six individuals. Recent excavations, ending in 2009, added 27 other individuals to the total number discovered, and many burials may still remain beneath the unexcavated ruins of a

farmhouse at the site. Additionally, a number of graves were destroyed in the western part of the cemetery during the gravel extraction that prompted the research in the 1960s (Zagorska, 2006b).

The extraordinarily rich material from the site has been investigated by a wide range of specialists from Latvia and other countries (e.g., Zagorska and Zagorskis, 1989; Zagorska and Lõugas, 2000; Larsson, 2006, 2010; Lõugas, 2006; Mannermaa, 2006; Zariņa, 2006; Nilsson Stutz et al., 2013; Larsson et al., 2017; Henderson et al., 2022; Macāne, 2022), and radiocarbon dating has established the chronology of the site (Larsson and Zagorska, 2006; Mannermaa et al., 2007; Meadows et al., 2018).

2. Materials and methods

2.1. Materials

The osseous artefacts subjected to the traceological analysis conducted for the studies described in this article are stored at the Museum Storage Facility in Riga. The burials included were chosen for analysis because of the high amount of osseous artefacts in the grave goods and the presence of the radiocarbon datings, establishing their precise chronology.

Grave no 57 (Fig. 2)

The grave contained the burial of an adult female in an extended supine position with the head to the northwest (cf. Zagorskis, 1987, 27; Zagorska et al., 2018). An intensive ochre layer surrounded the skeleton and the sides of the pit. The grave inventory was rich and included a bone point, a flat stone axe, flint artefacts, as well as 49 pendants made from the teeth of elk (*Alces alces;* 24), red deer (*Cervus elaphus;* 22) and aurochs (*Bos primigenius;* 3) (Macāne, 2022, table 1, 426). They were found on and beside the skeleton and as decoration on other grave goods. Some of the tooth pendants had been placed in groups at some distance from the skeleton, in an intense patch of ochre. The most striking find in this grave was a bone dagger with an elk head representation forming the handle (cf. Zagorska et al., 2018; hereinafter referred to as an elk-like shaft to avoid functionally profiled terms before the final confirmation of the function of such artefacts). This elk sculpture was found at the knees of the interred woman, across the left leg, with the handle pointing downwards. Grave no 57 was the richest female burial in the cemetery (Zagorska, 2016). It was dated to the Late Mesolithic (6825±60 BP, Ua-3636; 5838-5624 cal BC; Zagorska, 2006a; Zagorska et al., 2018).

Grave 164 (Fig. 3)

Human remains in burial 164 belong to an adult male. The grave depth was about 40 cm and was filled with black soil. A small amount of powdered ochre was powdered at the back of the skull and at the right elbow of the deceased. The upper part of the left arm of the skeleton was destroyed (Zagorskis, 2004, 30). The grave goods comprised nine pendants made of animal teeth:- aurochs (*Bos primigenius*; 1), dog (*Canis familiaris*, 1), otter (*Lutra lutra*; 4), red deer (*Cervus elaphus*; 1), wild boar (*Sus scrofa*; 1), and elk (*Alces alces*; 1), 16 bone points deposited between the legs of the skeleton and a fragmentary bone spearhead placed over the left side of the chest (Macāne, 2022, table 1, 428). A complete set of one otter's upper and lower canines

were identified in the grave, suggesting an intentional choice of teeth coming from the same animal (Macane, 2022, 138). The act of placing bone points between the legs of the deceased in grave 164 is unique at Zvejnieki. The burial also contained 42 wing bones (carpometacarpi and carpal phalanges) of jay (*Garrulus glandarius*) found on the right arm, on the trunk, at the right knee, and at the feet (Mannermaa, 2006). It is possible that the wings decorated the funerary garment, thereby playing a symbolic role (Zvelebil, 2003; Mannermaa, 2006: 296; Mannermaa, 2008a, 216–217). The burial is dated to the Middle Neolithic (5230±95 BP, Ua-15544; 4326-3801 cal BC; Zagorska, 2006a).

2.2. Methods

The traceological analyses were performed using two microscopes. Studies on the technological traces and, in the case of tools, the general characteristics of the working edges were undertaken using a Nikon SMZ-745T microscope (magnification up to ×65) fitted with a Delta Pix Invenio 6EIII camera. The latter was used to take the photomicrographs presented in Fig. 4C-G; 5; 6; 7; 8; 9; 10A-G, I, J; 11A, D-H. Observations on the polish were performed using a Motic AE2000MET microscope with up to ×50 magnitude (magnification up to ×500) fitted with Moticam 5+ camera. The photomicrographs presented in Fig. 4A, B; 10K; 11B, C, I, J were also taken with this equipment.

The terminology applied in this research was based on the system adopted in the literature (e.g. Korobkova, 1999; Newcomer, 1974; Legrand, 2007; Buc, 2011; Orłowska, 2016; Osipowicz et al., 2020b), adjusted to the needs and requirements of each specific artefact.

The preservation of the artefacts from both included burials is similar, indicating that the decomposing process was alike in both cases and did not significantly influence the analysis results. The traceological studies were hampered by the damages and surface erosion of some artefacts, as well as the presence of ochre and other contaminants covering them. The biggest obstacle, however, was the substance used to preserve the specimens (with similar optical features to a kind of lacquer), which in many cases, made it completely impossible to observe and analyse the polish. Some of the artefacts also wear traces of modern exfoliation of the surface.

Calibration of ^{14}C datings presented in this article was performed against IntCal20 (Reimer et al., 2020) with OxCal ver. 4.4 (Bronk Ramsey, 2020).

3. Results

A summary of the key data obtained in the course of the traceological studies is shown in Table 1.

3.1. Technological analysis

3.1.1. Grave 57

The surface of the osseous point discovered in the burial was formed at the final stage by scraping, probably with the use of the natural, that is not retouched, edge of a blade or flake (Fig. 4E, G). This technique was supplemented by whittling, which resulted in the traces being particularly visible at the base (tang) of the point. Here can be observed chatter-marks (Fig. 4D)

and incisions (Fig. 4C), typical for this technique. The presence of chatter marks indicates that the processed raw material was not softened or was softened poorly.

The preservation of the elk-like shaft is very poor. The only technological traces visible on its surface are poorly readable remains of whittling (linear bands with incisions – Fig. 5A), chatter marks – Fig. 5B), and scraping (Fig. 5C).

As a result of these traceological analyses, it was found that the collection of pendants from grave no 57 comprises: 17 unperforated pendants but with other traces of processing (Fig. 2: 4-20), 12 perforated pendants (Fig. 2: 21-32) and 20 animal teeth with no traces of processing (Fig. 2: 33-52).

The technological traces observed on the unperforated pendants in most cases (15 specimens), are limited to the grinding of the teeth's roots and crowns from one face or two opposite faces (Fig. 2: 4-18; Fig. 6). In the remaining two cases (Figs. 2: 19, 20), parallel scraping traces were observed on the teeth's roots.

The examination of the perforated pendants disclosed one artefact with a bifacial drilled perforation (Fig. 7: 1) but damaged to such a degree that further interpretation was impossible, and 11 pendants with perforations made by carving techniques which could be deconstructed. There is a visible differentiation in methods and tools used in this process; in some cases, each side of the same perforation was created differently (cf. Larson 2006, 255).

Generally, it is possible to distinguish three variants of the perforation method:
(1) grinding or whittling of the tooth's surface and then scraping and whittling the hole (Fig.7: 2, 3). In this case, scraping was probably conducted using a dull claw-like tool (possibly a kind of morphological perforator?) with a wide and rounded working edge. Whittling was mainly used to widen the hole. This method was observed most frequently (11 cases; considering each side of the perforation as a separate case);
(2) grinding or whittling the surface of the root to flatten it and then cutting or grooving the hole (3 cases – Fig.7: 4). Cutting or grooving was performed with the sharp, thin, un-retouched working edge of a stone tool, as in the case of some types of morphological burins or with edges created as the result of breaking the flake (cf. Osipowicz, 2019). The perforations were later widened usually by whittling;
(3) scraping, whittling or grooving, without "flattening" grinding (7 cases – Fig. 7: 5).
In the case of one of the pendants, it was not possible to determine the method of forming the perforation on one of the faces due to the extensive damage to the surface.

On some pendants, other less standard technological traces were also observed. In the case of two artefacts (Fig. 2: 21, 27), the sides of the perforations bear interesting pairs of V-shaped cuts. They have the opposite location, which means that if the incision created on the upper face of the pendant was made from the left side, then the one created on the opposite face is located on the right side (Fig. 8). Two pendants with perforations bear technological traces also on the crowns. In one case, scraping and in the second circumferential grinding of the entire crown were employed.

3.1.2. Grave 164

All bone points that were deposited in this burial were made in a very similar way. Two main techniques were used to form their final shape: whittling (Fig. 9A, B – yellow arrows marks incisions) and scraping, which was usually secondary to whittling and conducted with the use

of the natural edge of a blade or sometimes, seemingly, a claw-like tool (Fig. 9C, D). No technological traces are preserved on the artefacts, which would allow the identification of the techniques used in the earlier stages of their production.

Four of the points are ornamented. The ornaments are usually constructed from single cuts (Fig. 9I, F) with U-shaped cross-sections (Fig. 9J, G), which is not typical of the use of flint tools (Olsen, 1988; Greenfield, 1999, 2006). Multiple cuts are sporadic (Fig. 9H).

Perforations are visible at six of the nine animal teeth found in the grave. In most cases, they were created by whittling (method 1 above) to flatten the surface and then scraping to create the hole (9 cases – Fig. 10A-D, G). In three cases, an additional cutting/grooving was also performed (method 1/2 – Fig. 10E, F). No other traces of processing were observed on these artefacts.

3.2. Use-wear

3.2.1. Grave 57

The point found in this burial displayed no typical impact traces but had been used, as indicated by the presence of the linear polish with flat topography and smooth texture preserved (thanks to the absence of the preservation detergent) on the point's tip (Fig. 4A, B). The polish follows the artefact's axis and is connected with the short, similarly oriented scratches (filled-in and black striations).

No use-wear traces are visible on the elk-like shaft, possibly due to the high post-depositional destruction of its surface. In the case of the unperforated pendants, traces of usage were not observed.

In the group of perforated pendants, more visible use-wear traces were observed on three specimens. On seven artefacts, it was not possible to determine the presence of use-wear inside the perforations due to the damage and covering of a preservative. In the case of only one pendant can we convincingly argue that it had not been used.

The remaining two artefacts could each have been used for a short period of time, as indicated by the differently visible technological traces on various parts of their perforations. In some areas of their circumferences, these had been more or less obliterated (cf. Osipowicz et al., 2020b). No cracks or small waste fragments of bones, such as typically seen on new pendants, were observed (cf. the results of the studies on the artefacts from grave no 164). However, due to the damage, the presence of contaminations on their surface and, above all, the thick layer of preservative covering the artefacts, the possibility that they had been utilised for short periods cannot be verified by observing the distribution of the polish.

3.2.2. Grave 164

Among the 17 osseous points that have been found in burial no 164, five specimens bear probable impact traces, such as micro-burin spalls, pecking and other (rounding of the tip, linear polish and striations), indicating they were used as projectile points (Fig. 11C-E). Two other points, also probably used as projectiles, displayed rounding of the tip and linear polish without impact traces (Fig. 11A, B). The remaining ten artefacts were probably not used, or the use-

wear traces are no longer visible on their surfaces due to post-depositional damage or preservatives.

Some of the used points also showed other, less typical use-wear traces. Three artefacts bear interesting retouching and pecking on both side edges in their widest area where the tip part transitions into the base, or tang (Fig. 11F-H). The probable origin of these marks will be discussed later. In the case of two points, the use polish was observed only on the upper part of the artefacts, while their bases are completely without it (Fig. 11I, J). The broken tip of one point was repaired by secondary scraping.

Only one of the pendants discovered in this burial was used. It bears use-wear traces, that is, linear polish and rounding of the perforation edge, only on one side (Fig. 10I, K), while on the opposite side, where technological traces are still evident, use-wear traces are absent (Fig. 10J). The suggested way the adornment was mounted on clothes is shown in Fig. 10H. The remaining pendants found in the burial were not used, indicating they were made just before deposition. This is corroborated by the presence of-small, sharp fragments of bones occurring during the perforating of the pedants, still visible inside the perforations (Fig. 10B, D, G - marked with yellow arrows). These would have been rubbed away the first time the string was threaded into the holes.

4. Discussion

This research analyses only osseous artefacts from two of the over 324 burials from Zvejnieki. However, it allows for several technological and functional observations, the verification of which, through microscopic examination of the materials deposited in other burials from the site, may lead to a significant expansion of knowledge about the life and funeral practices of hunter-gatherer communities using those cemeteries.

4.1. Pendants

The results of the traceological analysis of the animal tooth pendants from the Mesolithic grave no 57 differ to some extent from the earlier findings of Larsson (2006), who states that the vast majority of these artefacts do not show signs of processing, that seven teeth have no perforation but exhibit grinding on one face of the root, and 11 pendants have perforations, of which ten were carved, and one was drilled (Larsson, 2006, 259).

In the course of our analysis, it was possible to identify the other ten pendants, without perforation but with other traces of processing, among the animal teeth in the collection, an almost 2.5-fold increase on those identified by Larsson's research. The discrepancy may be due to the fact that Larsson only occasionally analysed tooth crowns (Larsson, 2006, 255), and it is on them that the vast majority of the newly observed technological traces are located.

The results of the microscopic examinations of the perforated pendants essentially confirm the findings of Larsson (cf. Larsson, 2006, 255). Additionally, this research has been able to distinguish three perforation methods in the group of pendants with carved holes.

Significantly, it seems that the main methods applied to produce the pendants from burial no 57 are somehow related to the type of raw material used and their intended purpose, meaning that their clusters within the grave contain technologically uniform artefacts (cf. Fig.

2: 1a, 1b). All the deer teeth discovered in the grave are processed unperforated pendants and were deposited in two clusters, one next to the left shoulder and the other next to the left thigh. The perforated pendants were made exclusively from elk teeth except for one aurochs' tooth. The cluster of this type of pendant, five specimens, were laid over the left arm. Elk's teeth from this grave are also largely unprocessed specimens; in 4 cases, they were transformed into unperforated pendants.

There are some discrepancies between the results of this research and the results of Larsson's (2006, 259) in that this research suggests that there were probably more pendants with traces of usage from the Mesolithic grave no 57. This difference, however, is small and does not affect the overall picture, namely that most teeth and pendants show no signs of wear.

While discussing our results, reference should also be made to the origin of the newly identified atypical technological traces discovered on some of the artefacts. These include V-shaped cuts observed on the sides of the perforations of two pendants from burial no 57 (Fig. 2: 21, 27). If, as it seems, their creation was intentional, their purpose could have been to give the pendants a slightly different orientation inside the composite ornament than can be observed in the case of "typical" pendants (as shown in the sketch in Fig. 8: 2). Both pendants were found side by side, in independent concentration, on the right side of the deceased's pelvis (Fig. 2: 1b). It may confirm that they originally formed one ornament. The third pendant found in this place (Fig. 2:19) has a damaged root, so it cannot be stated whether the same technological process was used in that case.

As mentioned above, traceological studies of Early and Middle Holocene osseous artefacts from the region of North-Eastern Europe, especially from the southeastern coast of the Baltic Sea, are relatively rare. Detailed microscopic studies aimed at interpreting the method of production and use have only been conducted on animal tooth pendants from the sites in Šventoji (Osipowicz et al., 2020b) and the Yuzhniy Oleniy Ostrov cemetery (Mannerma et al., 2021; Rainio et al., 2021).

The vast majority of pendants made from elk teeth in the cemetery at Yuzhniy Oleniy Ostrov were made using a different technology than those from the graves in Zvejnieki. At Yuzhniy Oleniy Ostrov, the area to attach the string was created by carving one or several grooves around the root tip (cf. Mannerma et al., 2021). Unique to one burial (no 127), two pendants were drilled through, with additional grinding on the root. There were also 22 unperforated pendants but with traces of grinding on the roots. Similar to burial no 57 in Zvejnieki, grave no 127 from Yuzhniy Oleniy Ostrov is dated to the Late Mesolithic. There is no radiocarbon dating made for this feature. However, it is suggested that the cemetery at Yuzhniy Oleniy Ostrov was used in 6300-6050 cal BC (Schulting et al., 2022). Therefore, both features could be discussed as analogies for each other. The current knowledge about the funerary traditions of the hunter-gatherer communities in the discussed area, their mobility, and intergroup relations is, however, too limited to draw any further conclusions in this regard. Increasingly, however, the academic discussion focuses on the flow of ideas and artefacts between the areas of northwest Russia, including the arctic zones and the southeastern coast of the Baltic Sea (Osipowicz et al., 2017). Recently, thanks to the developments in isotope research, attention has also been paid to the possibility of people moving long distances in the region (Piličiauskas et al., 2022). Authors of this study, by comparing $^{87}Sr/^{86}Sr$ human intra-tooth variation with the local baselines, identified 11 non-local individuals in Mesolithic and Subneolithic Lithuania. Six of the 11 non-

locals had higher $^{87}Sr/^{86}Sr$ ratios, indicating that they might have come from southern Finland and/or Karelia (so, a distance of even several hundred kilometres). On the other hand, two individuals from the Donkalnis cemetery (Mesolithic and Subneolithic) probably come from the Lithuanian coast of the Baltic sea to the inland area, indicating mobility up to 85 km.

All pendants from the sites in Šventoji (dated to 3200-2500 cal BC) have perforations, of which almost 80% were drilled, and only about 20% were scraped (cf. Osipowicz et al., 2020b). No grinding traces were observed on any of them. However, more than 50% had the drilled surface prepared by scraping. Thus, the techniques of perforating the pendants from Šventoji differ significantly from those observed in the graves from Zvejnieki analysed here.

4.2. Points

According to the results of studies conducted by David (2006) on Early and Middle Mesolithic materials from Zvejnieki, this site belongs to the Northeastern technocomplex, illustrating the so-called Z-method used to split the raw material during the bone processing (David, 2006). It was not possible to identify this technique during the traceological analyses of points from graves 57 and 164, probably due to the retreatment of their surface in the later stages of the operational chain of their production.

For the same reasons as in the case of pendants, it is difficult to find the analogies for the technological and functional features of the discussed artefacts. There is, however, a fragment of an arrowhead from Šventoji (site 23), which comes with a form similar to the artefacts analysed, that has been subjected of traceological studies. As a result, traces of scraping made to finish the surface were observed on it, with characteristics analogous to those visible on the Latvian points (Osipowicz et al., 2020b, 159). However, scraping is one of the basic techniques used to form the surface of the osseous products, so in this case, no further conclusions can be drawn.

The atypical retouch and pecking marks observed on the edges of three points from burial 164 (Fig. 11F-H) could have been created in two ways:

1. Intentionally, by their users, to fit the arrowheads to the arrow shafts in the area where the cord was bound;
2. Unintentionally, as a result of the friction of the cord against the point mounted in the arrow shaft. It is suggested that this last interpretation is more plausible.

Our observations in this regard should be integrated into the context of the osseous points from other burials. However, even taken on their own, these traces should be considered significant, probably allowing the calculation of the width of the arrow/spear shafts used. The traces observed on the points discovered in grave 164 can also be helpful in the reconstruction of their hafting length. The absence of use-wear polish on the basal end of one of the specimens probably reflects the depth of the arrow/spear shaft (Fig. 11I, J).

Importantly, our analyses for the first time confirmed the use of the points laid in the graves in Zvejnieki as the projectiles and also their subsequent repair.

4.3. Elk-head shaft

Elk-head shafts occur widely in the northern parts of Eastern Europe, and the elk silhouette is depicted on rocks around Lake Onega and in other areas (Mantere and Kashina, 2020). Elk sculptures dominate Stone Age art in Lithuania (Rimantiene, 1996). Elk-like stylisations made in antlers occur in the Boreal sites of Poland and Germany (Kabaciński et al., 2011). Unfortunately, except for the research of Iršėnas et al. (2018) on the artefacts from Šventoji, other artefacts with elk depictions have not yet been subjected to any detailed traceological analysis, and Iršėnas et al.'s research did not allow for conclusions on their function and detailed technology. Similarly, this research will not add much to the debate because the analysed elk-like shaft from Zvejnieki bears only poorly visible and simple technological traces.

4.4. "Neolithic patterns" - are they legible in the analysed materials?

One of the aims of the reported studies was to gather new data for discussion on the issue of whether neolithisation influenced enough the members of the community using the cemetery in Zvejnieki to reflect on the way they made and used osseous items. In the light of the results of this research, the following can be stated:

1. Drawing an analogy with the interpreted use of very similar implements, both the Mesolithic and the Neolithic points analysed in this research are used hunting weapons, and not just grave goods.

2. The pendants from the Mesolithic burial illustrate several methods in shaping and making the perforations. Conversely, the Neolithic burial studied shows a certain standardisation in this respect. Moreover, none of the Neolithic pendants was ground before making the perforation, which was the most frequent technique in the case of Mesolithic burial.

3. The pendants from the Mesolithic burial seem to be also varied from the functional perspective, even if it cannot be unequivocally confirmed by the attributes of the polish. Most of the better-preserved artefacts, suitable for use-wear analysis, seem to have been used for various lengths of time, and only one is probably completely new. This might suggest that they were intended and used as adornments on clothing, and damaged pendants were replaced with new ones over time. Other options are that either (1) used pendants or pendants previously made and stored for some time were added to the grave at the time of burial-(cf. Larsson, 2006, 281) or (2) the pendants were used a short time for ritual purposes before being placed in the grave. This last option has been suggested for the artefacts from the site Yuzhniy Oleniy Ostrov (Rainio et al., 2021). Whatever the correct option, it is clear that these pendants were used before deposition. In the Neolithic grave, the pendants, with one exception, were made for funerary purposes. This confirms the suggestion made with respect to the wider assemblage of artefacts from Zvejnieki by David (2003, 2006).

The typical profile of most of the pendants from both burials analysed in this research matches the results of David's research, which found significant differences between artefacts of this type from settlement contexts and grave finds. In the light of this study, perforated pendants seem to be typically found in funeral contexts, as is the grinding technique used to flatten the root extremity before making the perforation, a technique not recorded on the domestic material (David, 2006).

It is not possible to state at this stage whether the observed differences between the two assemblages are specifically the result of the neolithisation or whether they resulted from coincidence, cultural behaviour, individual preferences of the people buried in the graves, their social position, gender or other factors. This question can only be answered by more studies on artefacts from other burials in Zvejnieki and other sites in the region, which will allow for statistical analysis. Larsson's studies on pendants from the cemetery in Zvejnieki provided promising conclusions in this regard (2006, 274), and their supplementation with new data from in-depth traceological studies, contextual multi-aspect analyses of other types of osseous and stone artefacts from the site, and further comparative studies of grave and settlement materials will be of crucial importance for the successful research in this area.

At the moment, it can only be stated that the influence of neolithisation is not visible in the results of the conducted microscopic studies on these artefacts that were most likely related to obtaining food, which was one of the basic attributes differentiating the typical economy of hunter-gatherer and Neolithic communities. Well-developed use-wear traces observed on the osseous points from the Mesolithic and Neolithic burials indicate very clearly that in both periods, hunting played an essential role in the life of the communities using the cemetery in Zvejnieki.

Conclusions

The cemetery in Zvejnieki is one of Europe's most important prehistoric sites. The multi-faceted and interdisciplinary study of the archaeological sources from here will continue for a long time and will probably provide a vast amount of invaluable information about the Early- and Middle-Holocene communities from Northeast Europe. The osseous material examined here represents a very small part of the cemetery's artefact assemblage. However, the results of their microscopic examination have allowed some interesting observations which will feed into the results of the microscopic examinations of future research, will allow a statistically based verification and lead to a better understanding of the culture and traditions of the communities in prehistoric Zvejnieki. For this to be possible, however, it is necessary to carry out further traceological studies on the collections of osseous artefacts from both the cemetery and the accompanying settlements. These should be integrated as much as possible with other studies, including, in particular, modern palaeobiological research, but also essential for traceological studies, interdisciplinary analyses of residues preserved on the bone and stone objects in graves. The artefacts from Zvejnieki present an enormous interpretive potential, and that targeted research of the type discussed here should be considered one of the primary research objectives in the near future.

Author contributions

Grzegorz Osipowicz: Conceptualisation, Methodology, Data curation, Validation, Investigation, Writing - Original Draft, Visualization, Supervision, Project administration, Funding acquisition. **Justyna Orłowska:** Data curation, Visualization **Ilga Zagorska:** Resources, Visualization

Data availability

Datasets related to this article are available from the corresponding author upon reasonable request.

Declaration of competing interest

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

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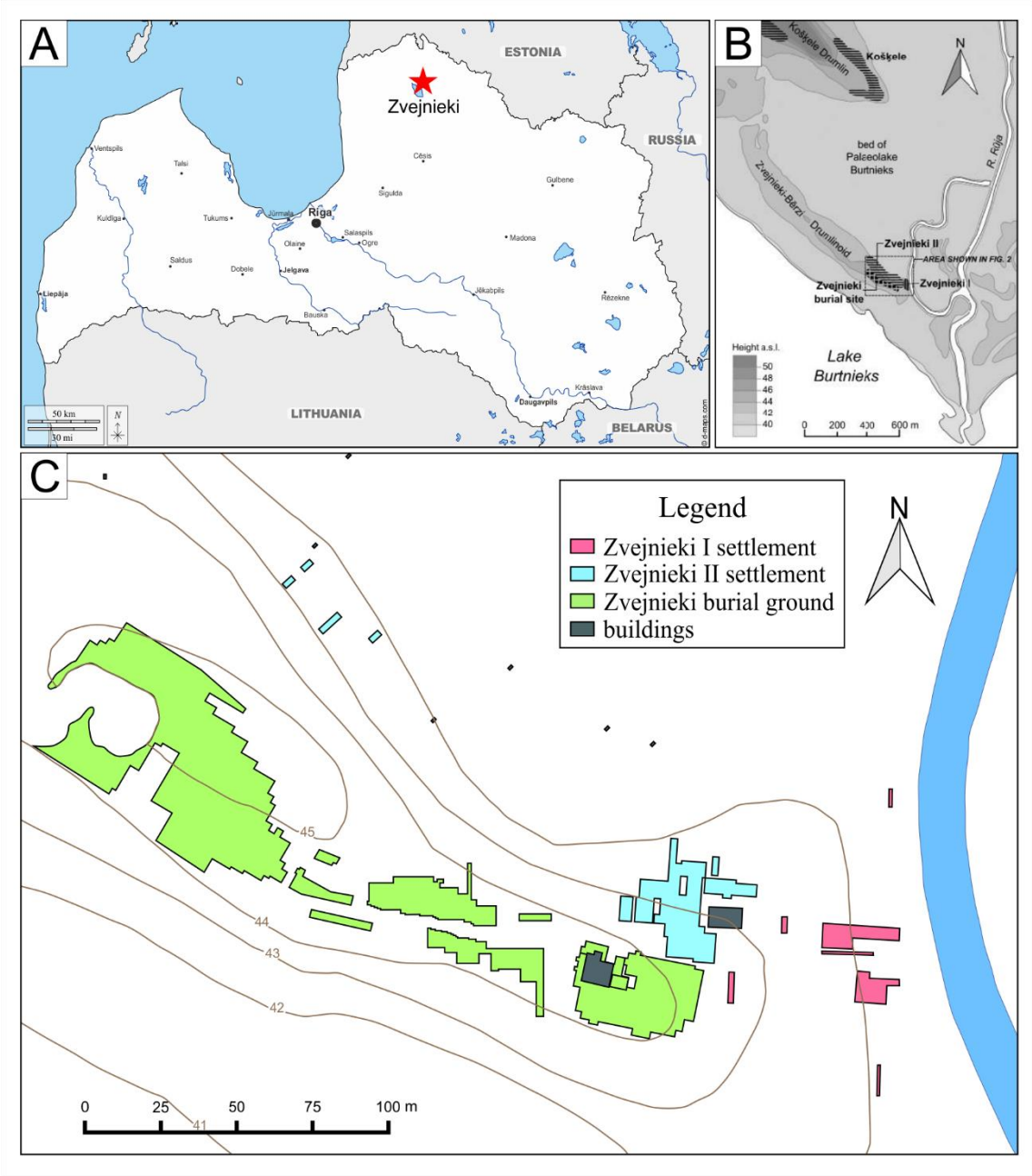

863

864 Fig. 1. Location of the site Zvejnieki: A - Latvia with the location of site Zvejnieki. B -
865 Location plan showing the Zvejnieki archaeological complex and the Košķele sites in relation
866 to the palaeolake Burtnieks. Drawing after Larsson et al.2017, Fig. 2, 58). C – Plan of the
867 Zvejnieki archaeological complex. Redrawn after Larsson et al. 2017, Fig. 3, 59.

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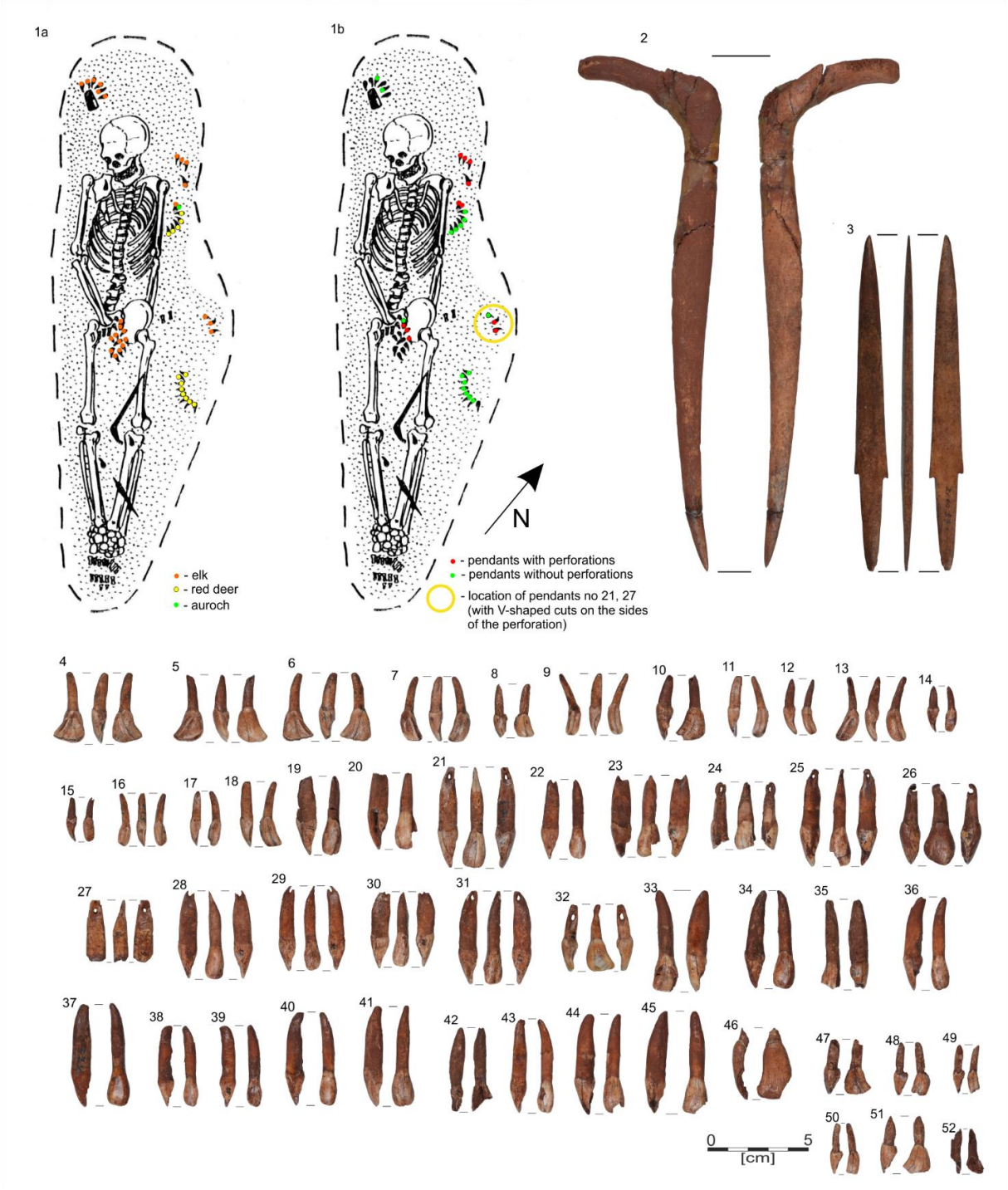
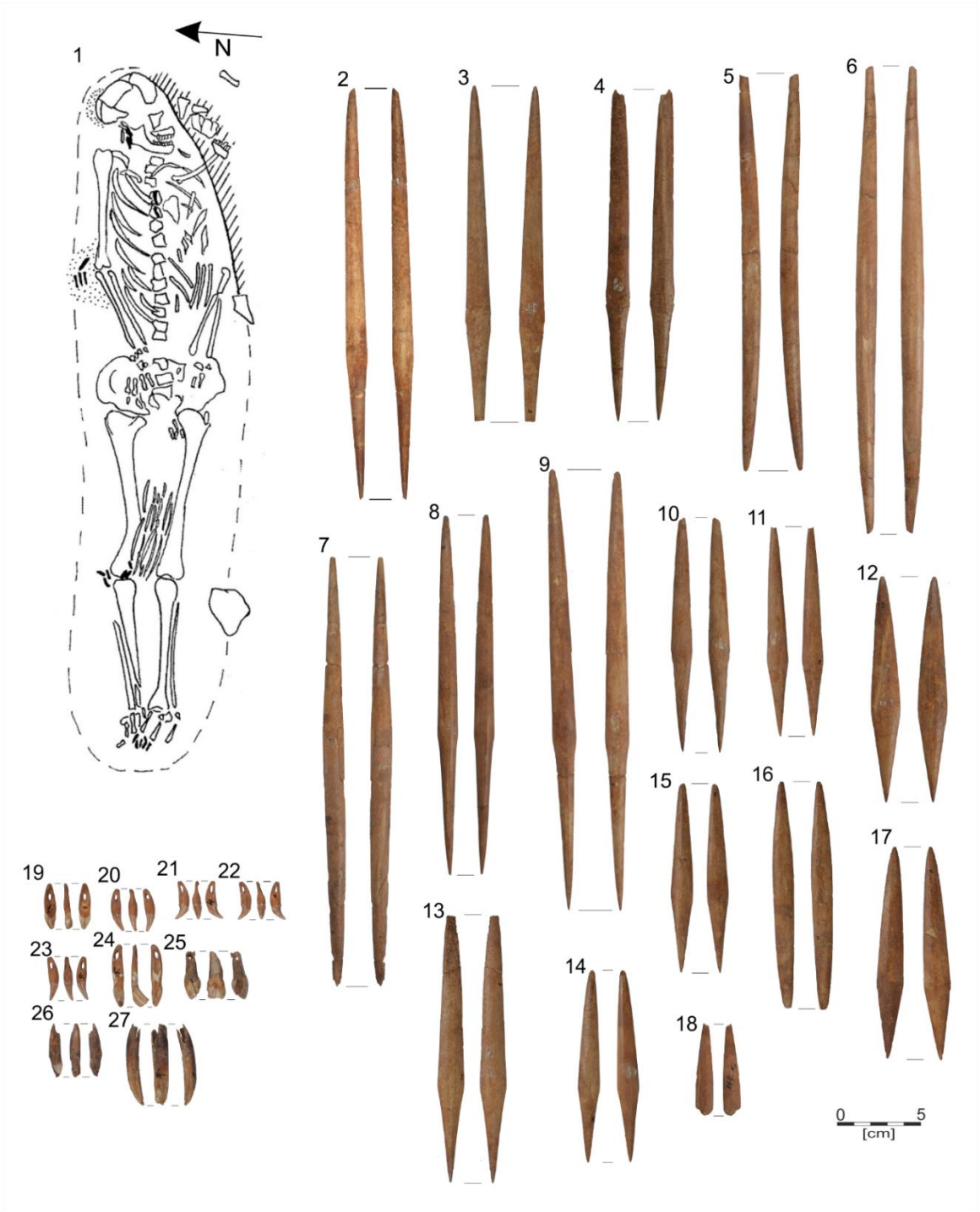


869

870 Fig. 2 Zvejnieki, grave no 57: Plan of the burial with marked the distribution of pendants
871 according to species (1a) and technological types (1b). 2-52 – osseous artefacts from the
872 grave: 2 – elk-like shaft; 3 – point; 4-52 – pendants (Fig. 2.1a and 2.1b after Larson 2006 with
873 authors changes).



874

875 Fig. 3. Zvejnieki, grave no 164: Plan of the burial (1) and discovered osseous artefacts (2-27):
876 2-18 – points; 19-27 – pendants. Fig. 1 after ????????.

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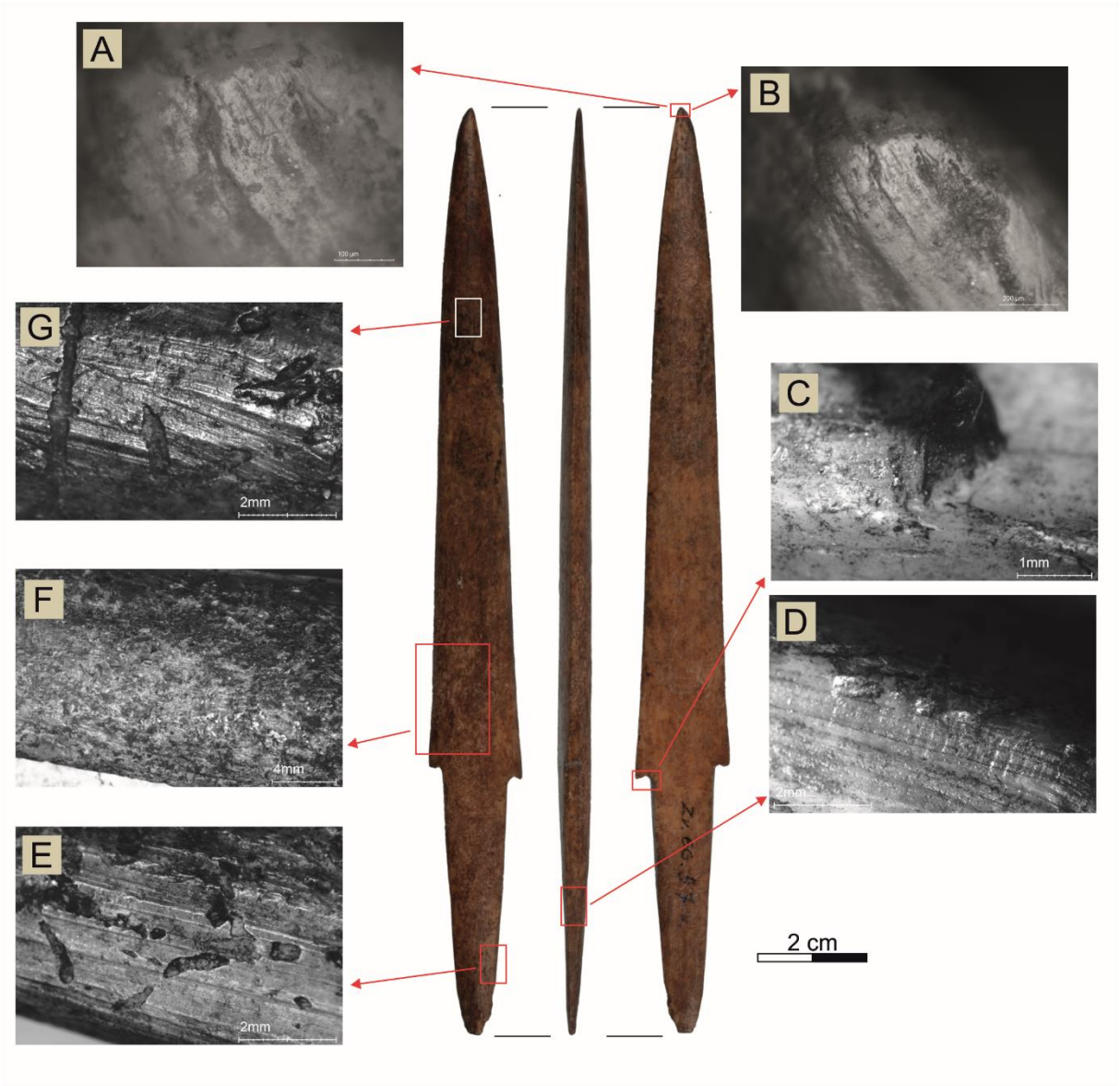

878

879 Fig. 4. Zvejnieki, grave no 57. Bone point from a grave and examples of the use-wear (A, B)
880 and technological (C-G) traces discovered on its surface

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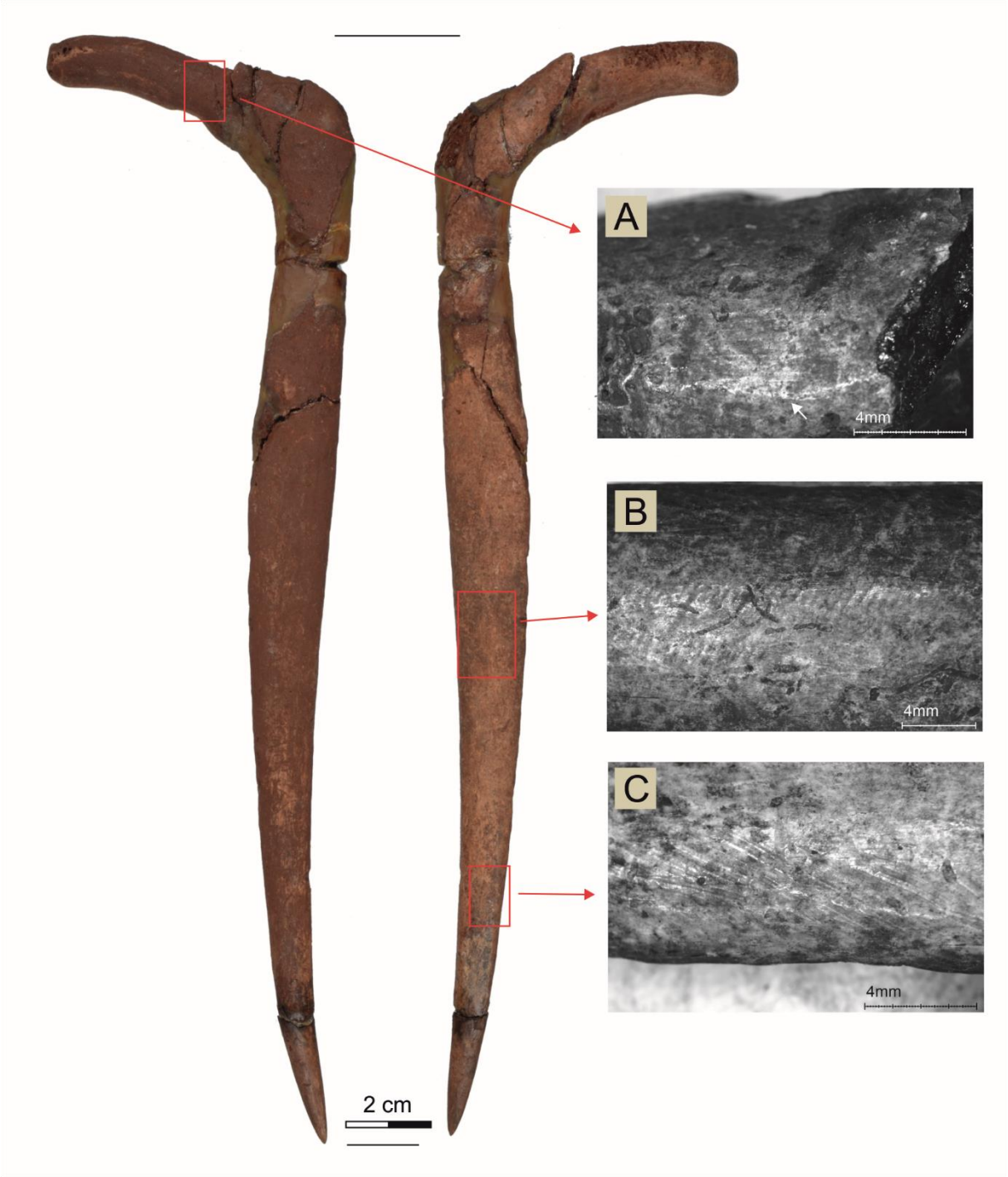

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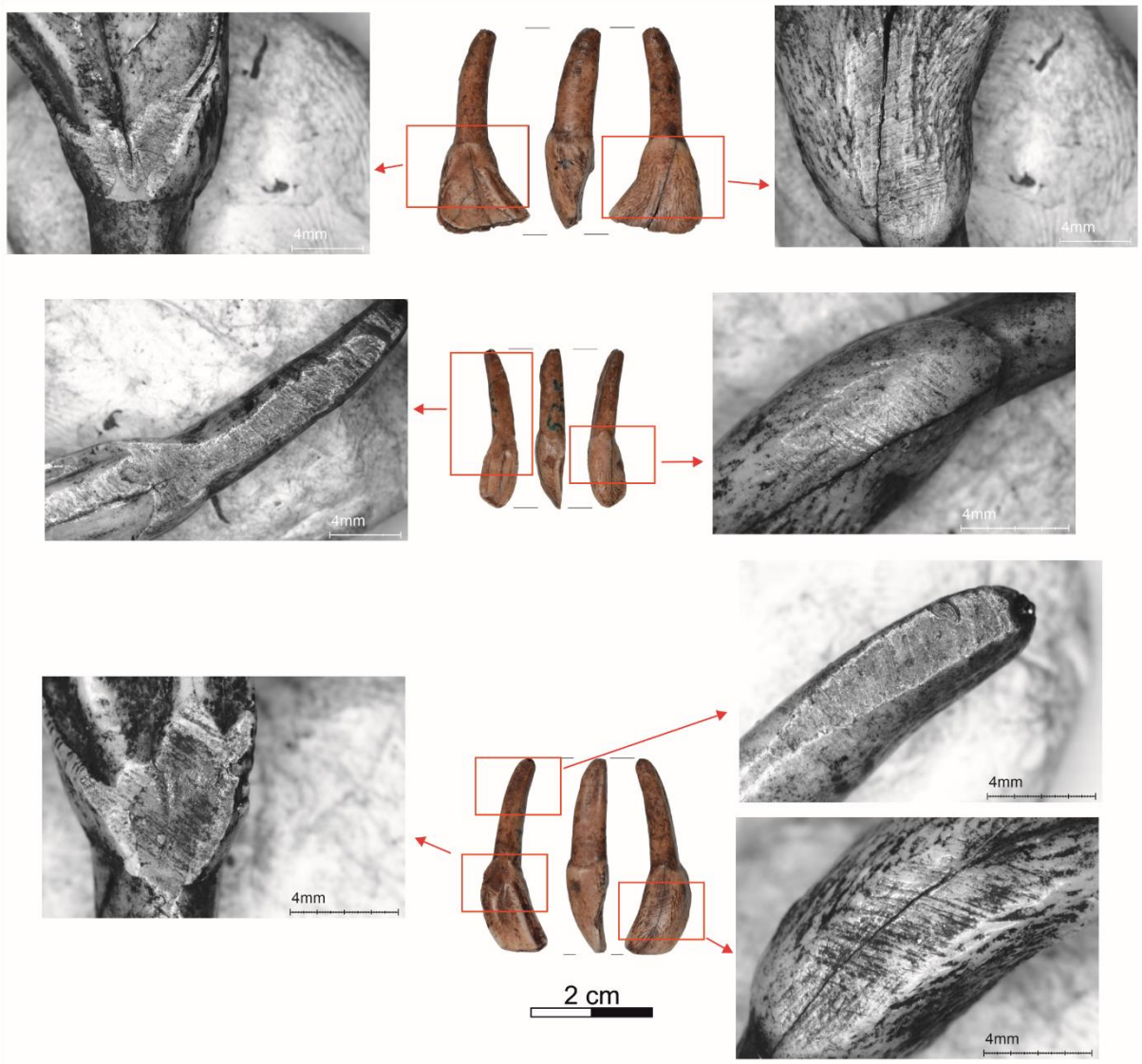
883

884 Fig. 5. Zvejnieki, grave no 57. Elk-like shaft from a grave and examples of the technological
885 traces discovered on its surface



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888 Fig. 6. Zvejnieki, grave no 57. Pendants without perforations and examples of the
889 technological traces discovered on their surface.

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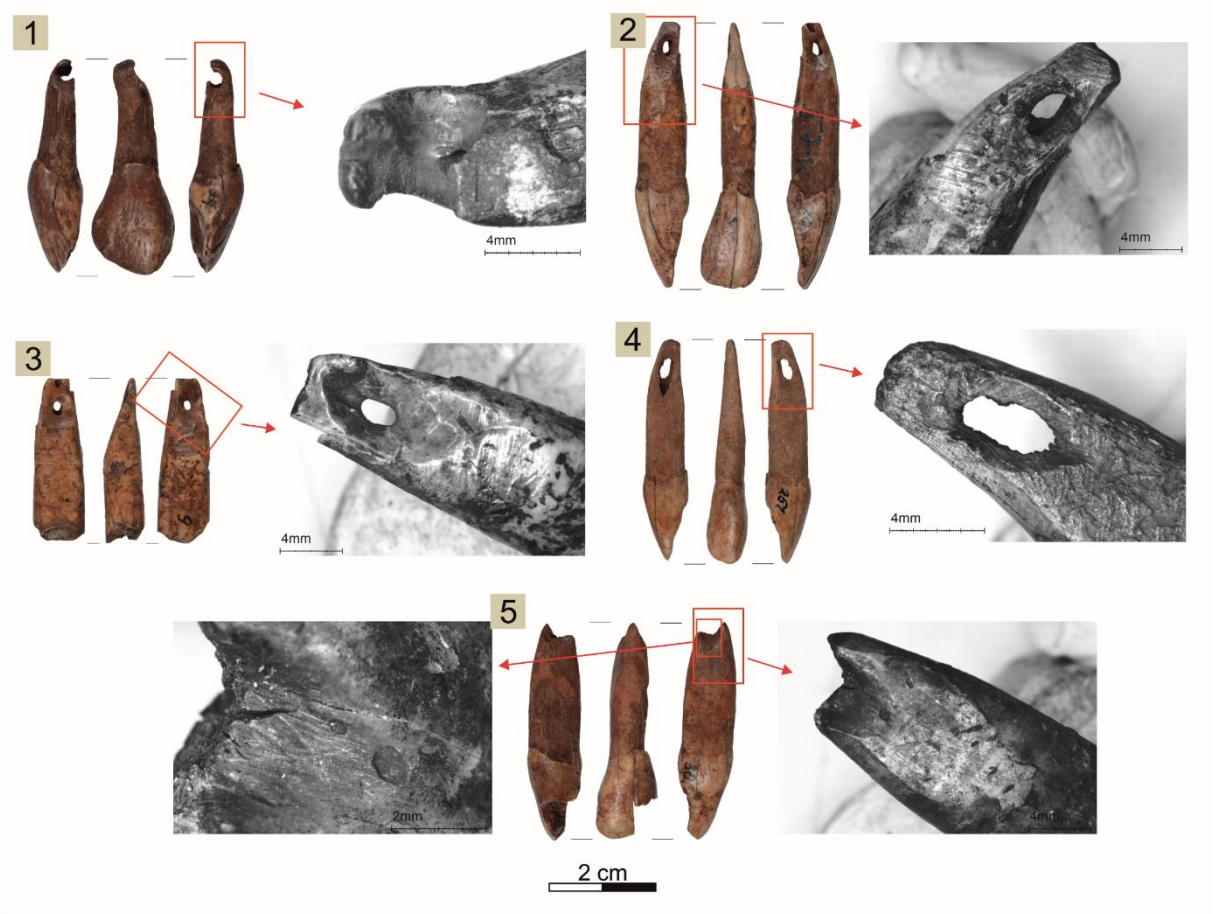

Fig. 7. Zvejnieki, grave no 57. Pendants with perforations and examples of the technological traces discovered on their surface.

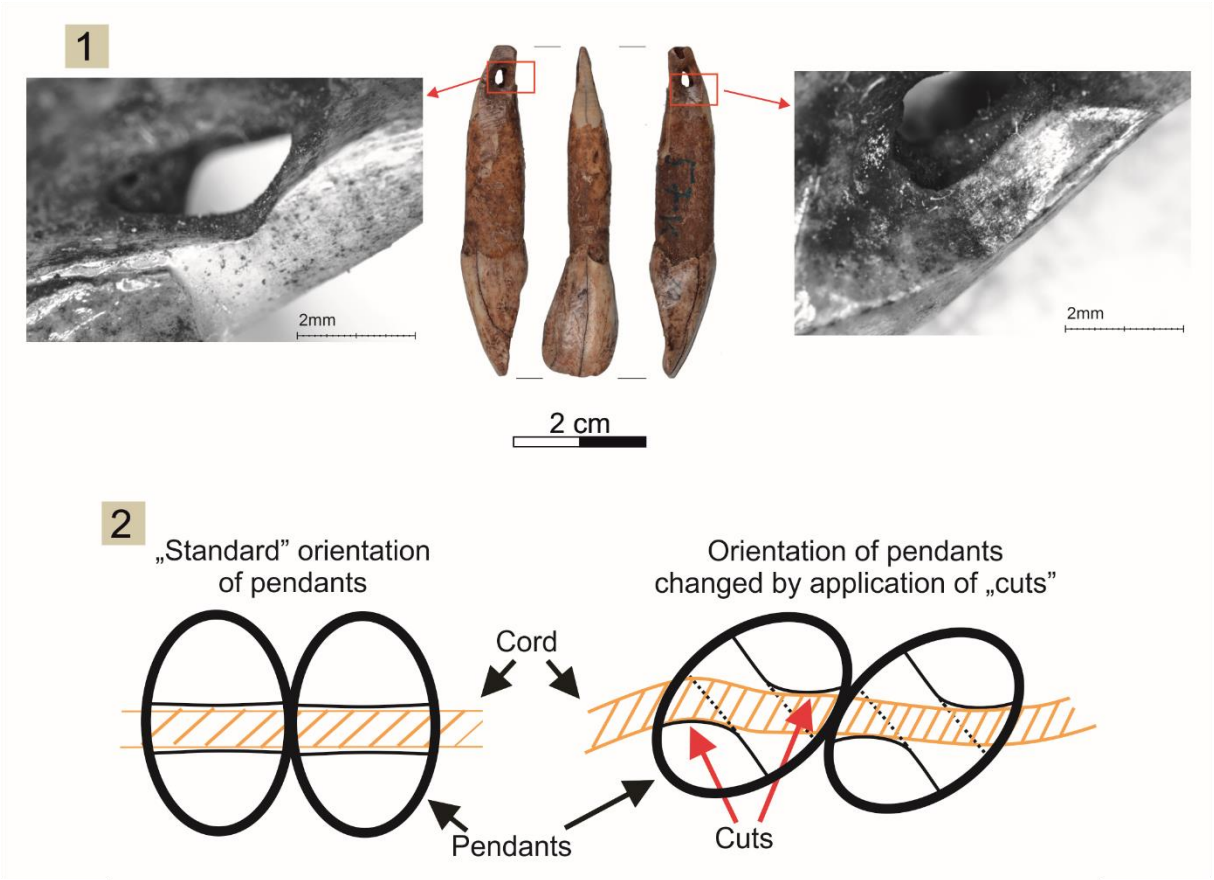

Fig. 8. Zvejnieki, grave no 57. An example of atypical traces observed on pendants with perforations (1) and scheme showing the possible orientation of artefacts prepared this way on clothes.

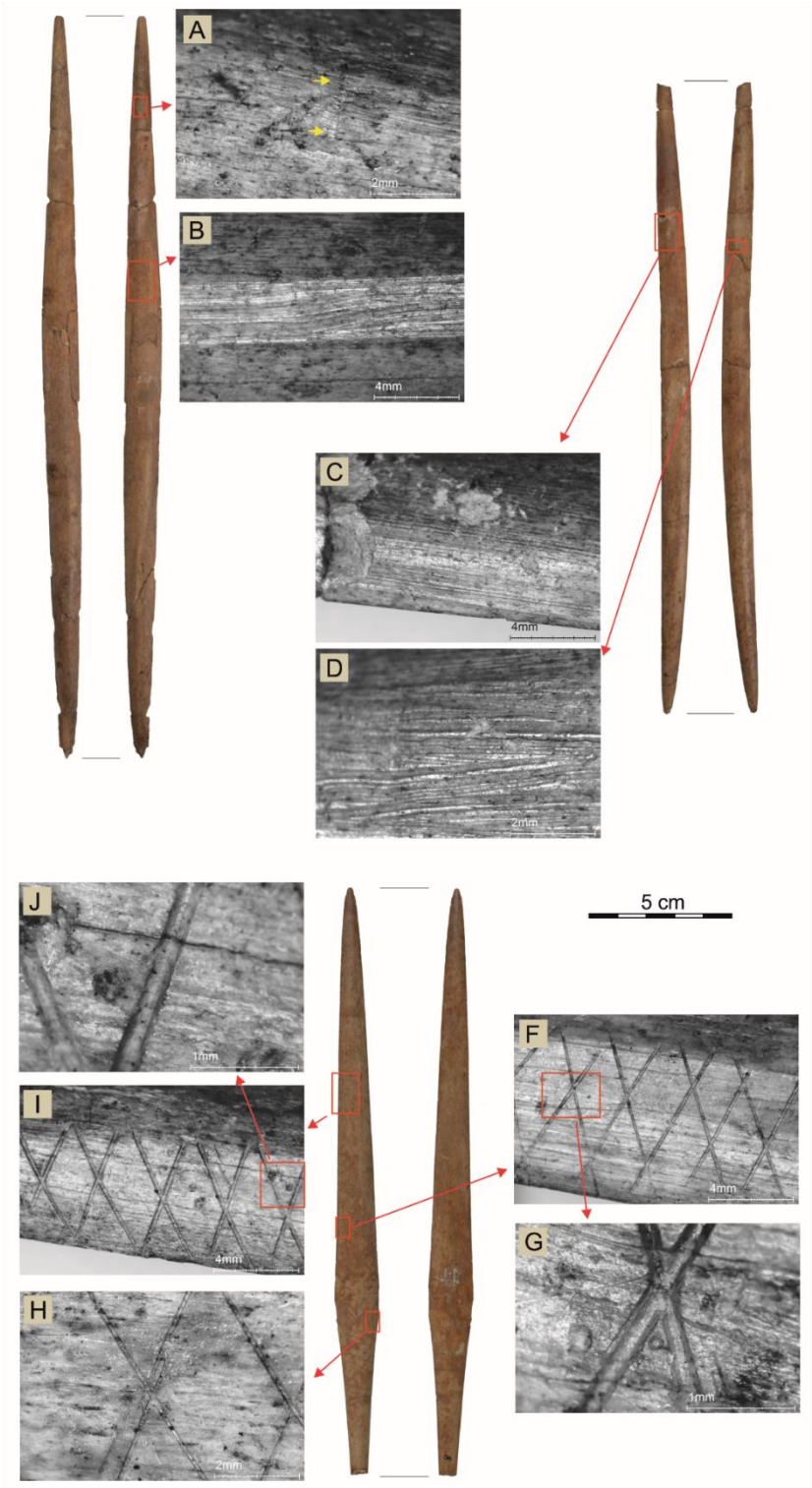

Fig. 9. Zvejnieki, grave no 164. Points from the grave and examples of technological traces (A-D) and ornamentation details observed on their surfaces

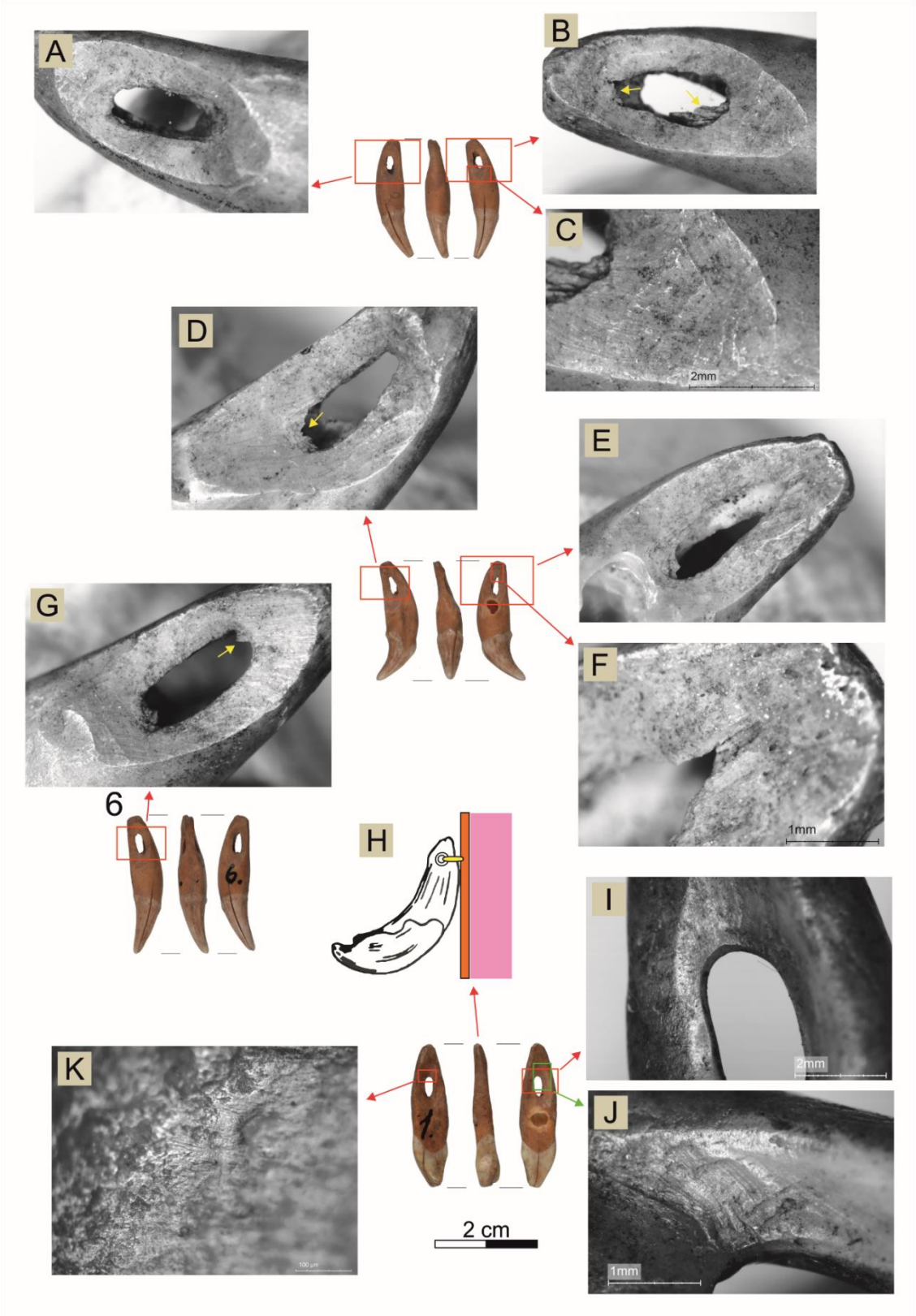

Fig. 10

Fig. 10. Zvejnieki, grave no 164, pendants. The examples of the technological (A-G, J) and use-wear (I, K) traces discovered on their surface. H – scheme presenting the way the only used pendants was probably mounted to the clothes.

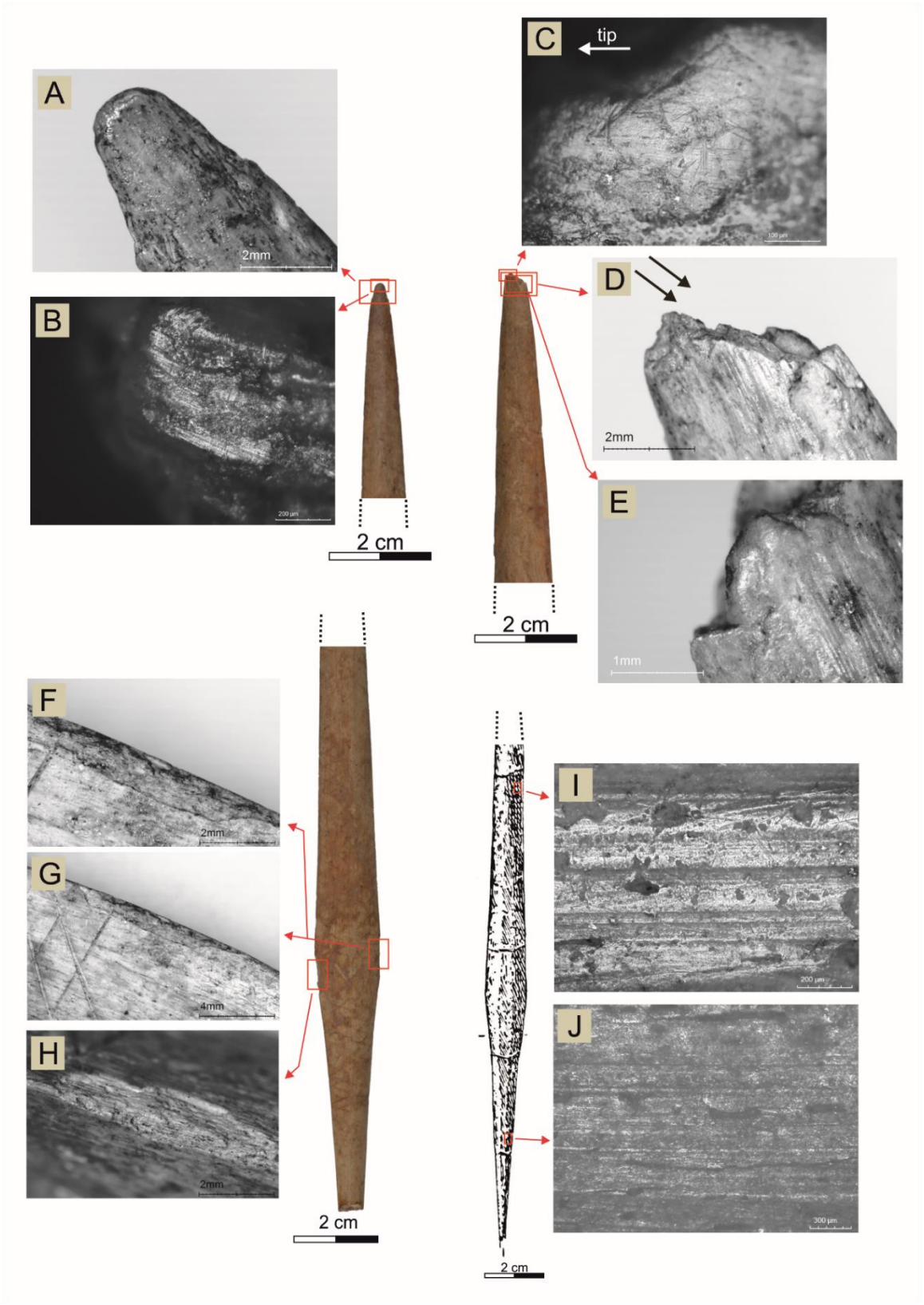

Fig. 11. Zvejnieki, grave no 164. The example of use-wear traces observed on points.

914 Table 1. Characteristic of the osseous artefacts from burials 57, 164 in Zvejnieki, studied traceologicaly.

915

Grave no.	Type of artefact	Specimen inv. number	Preservation	Technological traces*	Use-wear traces	Figure
164	Point	VI 93:228 (15)	Good	Whittling, scraping	Impact traces? on the tip; retouching of side edges in their widest area; usage polish on the upper part of the point	Fig. 3:2
		VI 93:221 (8)	Good	Whittling; Ornament: cutting	Rounding on the tip of the point, polish, striations; retouching of side edges in their widest area	Fig. 3:3
		VI 93:214 (1)	Good	Whittling, scraping Ornament: cutting	Not readable; retouching of side edges in their widest area	Fig. 3:4
		VI 93:217 (4)	Good	Whittling, scraping	Not readable	Fig. 3:5
		VI 93:218 (5)	Slightly exfoliated	Whittling, scraping	Not readable	Fig. 3:6
		VI:219 (6)	Slightly exfoliated	Whittling, scraping	Not readable	Fig. 3:7
		VI: 93: 220 (7)	Good	Whittling, scraping	Not readable	Fig. 3:8
		VI: 93: 222 (9)	Good	Whittling, scraping; Ornament: cutting	Possible impact traces and usage polish	Fig. 3:9
		VI: 93: 226 (13)	Good; erosion on the tang	Whittling, scraping	Impact traces, rounding on the tip, polish	Fig. 3:10
		VI: 93: 225 (12)	Slightly eroded on the tang	Whittling, scraping	Not readable	Fig. 3:11
		VI: 93: 223 (10)	Good	Whittling, scraping	Not readable	Fig. 3:12
		VI: 93: 215 (2)	Good, partly eroded	Whittling, scraping; Ornament: cutting	Not readable	Fig. 3:13
		VI: 93: 229 (16)	Good	Scraping	Impact traces on the tip	Fig. 3:14
		VI: 93: 227 (14)	Good	Whittling, scraping; repaired	Not readable	Fig. 3:15
		VI: 93: 224 (11)	Good	Whittling, scraping	Not readable	Fig. 3:16
		VI: 93: 216 (3)	Good	Whittling, scraping	Not readable	Fig. 3:17
		VI: 93: 230	Good	Weakly readable	Not readable	Fig. 3:18
	Pendant	VI 93:231/1	Good	Perforation: the method 1, the method 1/2	Used rounding in the perforation	Fig. 3:19
		VI 93:231/2	Good, broken root	Not readable	Not readable	Fig. 3:26
		VI 93:231/?	Good	Perforation: method 1, method 1	New, not used	Fig. 3:20
		VI 93:231/4	Very good	Perforation: method 1,	New, not used	Fig. 3:21

				method 1		
		VI 93:231/5	Good	Perforation: method 1, method 1/I2	Probably used/not used	Fig. 3:24
		VI 93:231/6	Very good	Perforation: method 1, method 1	New, not used	Fig. 3:23
		VI 93:231/?	Very good	Perforation: method 1, method 1/2	New, not used	Fig. 3:22
		VI 93:231/8	Bad	Not readable	Not readable	Fig. 3:25
		VI 93:231/9	Bad	Not readable	Not readable	Fig. 3:27
57	Point	VI 93: 65	Good, surface eroded in spots	Surface: scraping, whittling	Linear polish and striations on the tip of the point	Fig. 2:3
	Elk-head shaft	VI 93: 71	Very bad, broken in a few places, covered with ocher and detergent	Surface: whittling, scraping	Not readable	Fig. 2:2
	Pendant	VI:93: 64/27	Good	Not readable	Not readable	Fig. 2:33
		VI:93: 64/31	Bad	Not readable	Not readable	Fig. 2:34
		VI:93: 64/24	Bad, exfoliation on the root, broken crown	Not readable	Not readable	Fig. 2:35
		VI:93: 64/25	Good	Not readable	Not readable	Fig. 2:36
		VI:93: 64/39	Good	Not readable	Not readable	Fig. 2:37
		VI:93: 64/33	Bad	Not readable	Not readable	Fig. 2:38
		VI:93: 64/28	Slightly exfoliated surface	Not readable	Not readable	Fig. 2:39
		VI:93: 64/32	Slightly exfoliated surface	Not readable	Not readable	Fig. 2:40
		VI:93: 64/37	Good	Not readable	Not readable	Fig. 2:41
		VI:93: 64/41	Bad	Not readable	Not readable	Fig. 2:42
		VI:93: 64/40?	Slightly exfoliated root	Not readable	Not readable	Fig. 2:43
		VI:93: 64/26	Good	Not readable	Not readable	Fig. 2:44
		VI:93: 64/49?	Good	Not readable	Not readable	Fig. 2:45
		VI:93: 64/10	Bad, surface exfoliated	Perforation: method 1, V-shaped cuts on the sides of the perforation method 1?	Not readable	Fig. 2:21
		VI:93: 64/21	Bad, surface exfoliated; perforation partly broken	Perforation: method 3, method 3	Not readable	Fig. 2:22
		VI:93: 64/30	Bad, surface exfoliated; perforation partly broken	Perforation: method 1, ?	Not readable	Fig. 2:23
		VI:93: 64/18	Bad, surface exfoliated	Perforation: method 2, method 1?	Not readable	Fig. 2:24
		VI:93: 64/35	Slightly exfoliated; perforation party broken	Perforation: method 2, method 3	Used, rounding in the perforation	Fig. 2:25

		VI:93: 64/34	Bad, surface exfoliated	Perforation: drilling	Used, rounding in the perforation	Fig. 2:26
		VI:93: 64/9	Good, broken	Perforation: method 1, method 1; V-shaped cuts on the sides of the perforation	Probably used, rounding in the perforation	Fig. 2:27
		VI:93: 64/22	Good, perforation party broken	Perforation: method 1, method 3	Not readable	Fig. 2:29
		VI:93: 64/20	Good, perforation party broken	Perforation: method 1, method 1	Not readable	Fig. 2:28
		VI:93: 64/11	Bad, surface exfoliated	Scraping?	Not readable	Fig. 2:19
		VI:93: 64/19	Bad, surface exfoliated, perforation party broken	Perforation: method 2, method 3	Not readable	Fig. 2:30
		VI:93: 64/36	Good, broken	Scraping	Not readable	Fig. 2:25
		VI:93: 64/23	Bad, surface exfoliated	Perforation: method 1, method 1	Probably used	Fig. 2:31
		VI:93: 64/48?	Fragment	Not readable	Not readable	Fig. 2:46
		VI:93: 64/5	Good	Crown and root: grinding	Not readable	Fig. 2:4
		VI:93: 64/13	Exfoliation on the root	Crown and root: grinding	Not readable	Fig. 2:5
		VI:93: 64/4	Good	Crown: grinding	Not readable	Fig. 2:6
		VI:93: 64/3	Good	Crown and root: grinding	Not readable	Fig. 2:7
		VI:93: 64/43	Exfoliation on the root	Root: grinding	Not readable	Fig. 2:8
		VI:93: 64/6	Good	Crown and root: grinding	Not readable	Fig. 2:9
		VI:93: 64/29	Good	Perforation: method 3, method 3	Not readable	Fig. 2:32
		VI:93: 64/44	Bad	Not readable	Not readable	Fig. 2:47
		VI:93: 64/16	Exfoliation on the root	Crown and root: grinding	Not readable	Fig. 2:10
		VI:93: 64/46	Bad	Not readable	Not readable	Fig. 2:48
		VI:93: 64/2	Good	Crown and root: grinding	Not readable	Fig. 2:11
		VI:93: 64/15	Good	Crown and root: grinding	Not readable	Fig. 2:12
		VI:93: 64/42	Bad	Not readable	Not readable	Fig. 2:49
		VI:93: 64/47	Bad	Not readable	Not readable	Fig. 2:50
		VI:93: 64/45	Bad	Grinding?	Not readable	Fig. 2:51
		VI:93: 64/14	Good	Grinding, scraping	Not readable	Fig. 2:13
		VI:93: 64/38	Bad	Not readable	Not readable	Fig. 2:52
		VI:93: 64/17	Good, exfoliation	Crown and root: grinding	Not readable	Fig. 2:14
		VI:93: 64/12	Good	Crown and root: grinding	Not readable	Fig. 2:15
		VI:93: 64/8	Good	Crown and root: grinding	Not readable	Fig. 2:16
		VI:93: 64/1	Good	Crown and root: grinding	Not readable	Fig. 2:17

		VI:93: 64/7	Good	Crown and root: grinding	Not readable	Fig. 2:18

916 * Perforation methods in the pendants according to classification developed in the text.

917