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COMBINING RESIDUE AND MACROSCOPIC USE-WEAR ANALYSIS OF QUARTZ OBJECTS IN KRAAKANMÄKI 3 LATE NEOLITHIC SETTLEMENT SITE, WESTERN FINLAND

Abstract

Microscopic remains of plants, hairs, blood, bone, and sinew have been detected on Stone Age implements as evidence of the ways the tools were used. Together with use-wear analysis, microresidues enable us to obtain additional information of artefact biographies. However, the preservation of residues is not a straightforward issue. Although bones, plant matter, and wood have a tendency to decompose rapidly in acidic podzol soils, the acidity favours the preservation of keratinous tissues such as hairs and feathers. Because the analysis of microresidues has not been applied on Finnish quartz artefacts, this paper presents a preliminary testing of the method in a Late Stone Age settlement site in Kraakanmäki 3, western Finland. As a result, we found microscopic remains of hairs, feathers, and plants, which enable us to speak for the careful handling of quartz and stone tools at the excavations for further analyses.

Keywords: Macroscopic use-wear, hairs, plant remains, phytoliths, feathers, Stone Age

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INTRODUCTION

The research on microscopic residues on the surfaces of ancient tools has been recognized as an important means of studying the functions of the implements (e.g., Kealhofer et al. 1999; Pearsall et al. 2004; García-Granero et al. 2015; Frahm et al. 2022). The identification of deposited microparticles such as hairs, feathers, phytoliths, pollen, sinew, and collagen fibres is based on their morphological features studied by light and scanning electron microscopes (SEM) as well as by SEM-EDS (Hayes & Rots 2019), aDNA analysis (Hardy et al. 1997; Shanks et al. 2005), analysis of lipids (Buonasera 2007; Luong et al. 2017) and proteins (Craig & Collins 2002; Heaton et al. 2009).

The most essential source critical questions rely on the preservation of organic residues and the possible contamination of artefacts with microparticles that are not related to the past use of the artefact. This is because microparticles might have been extracted from the surrounding soil (Pedergnana 2020) or accumulated during the excavation and in the laboratory environment (Frahm et al. 2022). Therefore, contamination needs to be minimised by a careful handling protocol from the field to the lab, and the microparticles should be compared with use-wear analysis (Kealhofer et al. 1999; Dietrich et al. 2019). Furthermore, the distribution of residues on artefact surfaces can give additional information of the origin of the particles (Hayes & Rots 2019; Frahm et al. 2022). A critical moment for the preservation of microparticles on stone artefacts is the handling of finds after the excavation. The recommendation not to clean objects automatically even without considering their further analysis was given already in the 1980s (Loy 1983; Lampert & Sim 1986).

Microparticles have been examined on artefacts excavated in different types of sites and environments (e.g., Cooper & Nugent 2009; Hardy & Svoboda 2009; Lombard & Wadley 2009; Robertson 2009; Juhola et al. 2019). Favourable environmental conditions for the preservation of residues can be found in contexts where organic materials tend to preserve, i.e. in Arctic areas and ice sheets (e.g., the research on Iceman Ötzi's tools by Thomas Loy [1998; see Fullagar 2004; 2009: 5–6]; Wierer et al. 2018), in arid environments, stable rock shelters and caves (Ward et al. 2006; Heydari 2007; Jones 2009) as well as in soils rich in clay particles (Loy 1983). However, microresidues have been reported to have been detected on artefacts in open-air sites in the northern boreal forest zone of Canada (Loy 1983; however, see e.g., Smith & Wilson 1992) in an environment roughly comparable to that of Finland. Moreover, mammalian hairs, bird barbules, and plant fibres were detected in soils samples excavated in a Mesolithic red ochre grave in eastern Finland (Kirkinen et al. 2022).

In Finland, the production and use of quartz artefacts has been studied mostly from the point of view of typological and technological aspects. Earlier studies have focused on tool typology and morphology (e.g., Luho 1948; 1956; Siiriäinen 1968; Matiskainen 1986), but the focus has shifted gradually toward different types of stone technology analyses and studies that touch on stone technology in some context (Rajala 1996; Tallavaara 2001; 2005; Manninen 2003; Jussila et al. 2007: 149–157; 2012: 13–17; Rankama et al. 2011; Manninen & Knutsson 2014). Some useful studies utilising the low magnification analysis method on wear marks on Finnish materials have been conducted by several researchers (Rankama 2002; Pesonen & Tallavaara 2006: 18; Tallavaara 2007: 63–89; Kankaanpää & Rankama 2011: 230–232), following the examples and results of Swedish and international scholars (Broadbent & Knutsson 1975; Broadbent 1979; Knutsson 1978; Knutsson & Linde 1990; Knutsson & Knutsson 2009). Use-wear analysis on quartz, using high-power (microscopic) methods in Finnish materials was largely pioneered by Noora Taipale (2012; 2013), who continued her work by using both low- and high-power methods along with Nordic colleagues (Knutsson et al. 2015; Taipale et al. 2019).

Both low- and high-power microscopy have been found to be useful for use-wear analysis on archaeological quartz material. The combination of both methods has gone a considerable way to approaching quartz use-wear marks, but as with most issues, the research question should determine the method (Taipale 2012: 47). The low-power method can be useful in defining whether the quartz tool was used for soft or hard material. However, reliability of macroscopic analysis depends greatly on wear preservation and angles of the use edges (Taipale et al. 2014). These categories can offer clues as to whether the tool was used on hard materials such as wood or bone, or soft materials such as animal skin or meat. The low-power method is also sufficient in defining wear marks within these two categories; however, high-power microscopy is preferred for more specific definitions of worked materials, accurate directions of use or other subtle use-wear marks (Grace 1990), as well as tool edges with obtuse angles (Knutsson 1988a; Taipale et al. 2014). The low power method is useful especially as a basis upon which further high-power methods can be applied. As quartz is still a fairly uncommon material in the general field of use-wear analysis, the experimental reference data specifically focusing on low-power imaging remains thin. For this reason, the authors feel that it is unnecessary to make assessments beyond the soft/hard qualification of these quartz artefacts, even as further assessments—based on the low-power method—may be a satisfactory approach for materials like flint or chert.

In this paper, a preliminary study on animal and plant residues on quartz artefacts and flakes is presented. The findings are compared to the morphology of the items as well as to the use-wear marks. Our aim is to widen our understanding of the use of Stone Age quartz implements and especially stress the importance of microresidue research of artefacts and flakes excavated in Fennoscandian open-air sites. We also encourage the excavation leaders to consider a careful handling and packing of stone artefacts at the field without cleaning them, which would enable further microparticle analysis.

KRAAKANMÄKI 3 SETTLEMENT SITE

The site and field work

The study material was collected in 2021 at *Kraakanmäki* 3 settlement site, which is located in the municipality of Harjavalta, Western Finland (Fig. 1). The area was first surveyed in 2013, when the current slag-spreading area was planned. At the time, two previously unknown Stone Age settle-

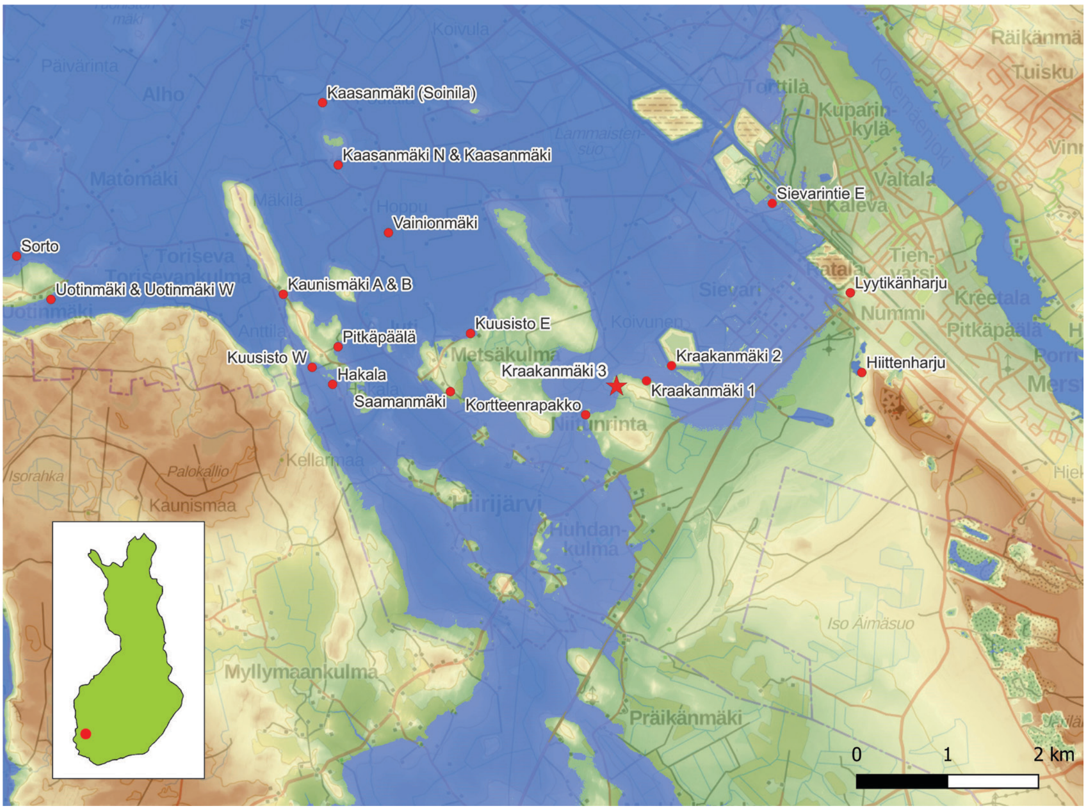

Figure 1. The locations of Kraakanmäki 3 and other known nearby Stone Age sites. The sea is visualised at 33 MASL, illustrating the sea level during the habitation of Kraakanmäki 3 site around 4000 BP. Map: National Land Survey of Finland, modified by T. Väisänen.

Figure 2. An ongoing excavation at Kraakanmäki 3 settlement site. Photo: V. Laulumaa.

ment sites were discovered on the slopes of Kraakanmäki and were named Kraakanmäki 1 and 2 (Bilund 2013). In 2014, rescue excavations were carried out at both sites before the area was released for land use. The material of the excavations was connected to the Late Neolithic Kiukainen Ware Culture and dated with radiocarbon dating to around 2900–1770 CalBC (Pesonen 2014a; 2014b).

As a new slag-spreading area was being planned along the same ancient shoreline (32.5 elevation curve) west of Kraakanmäki 1, the area was surveyed again in 2020, with the discovery of Kraakanmäki 3 and *Kortteenrapakko* settlement (Seppä 2020). In 2021, the Finnish Heritage Agency conducted a rescue excavation at the Kraakanmäki 3 site (Fig. 2). An area of 250 m2 was opened at the settlement and the excavation was carried out in successive spits of 5 cm. The layers were documented by drawing and photographing. The find locations were measured with Sokkia Set 2 total station.

Features and find material

During the excavation, it was observed that the Kraakanmäki 3 settlement site had been well preserved, as there were no indications of contamination by historic or modern land use. The only disturbances visible in the soil were the tracks of a forest machine in the western part of the excavation trench, as well as minor disturbances by roots of trees that had possibly fallen due to heavy wind.

The excavation did not reveal any structures, such as fireplaces. The observations suggest that the area has been under the influence of coastal forces. The phenomenon is explained by the fact that the settlement site has been near the beach and in a low-lying area, where the sea level fluctuations caused by the wind can be very large (Laulumaa & Seppä 2022: 14).

The research resulted in a total of 4310 finds typical of a Stone Age settlement. The finds comprise predominantly quartz flakes, burnt bone, and pottery. The pottery is mostly frag-

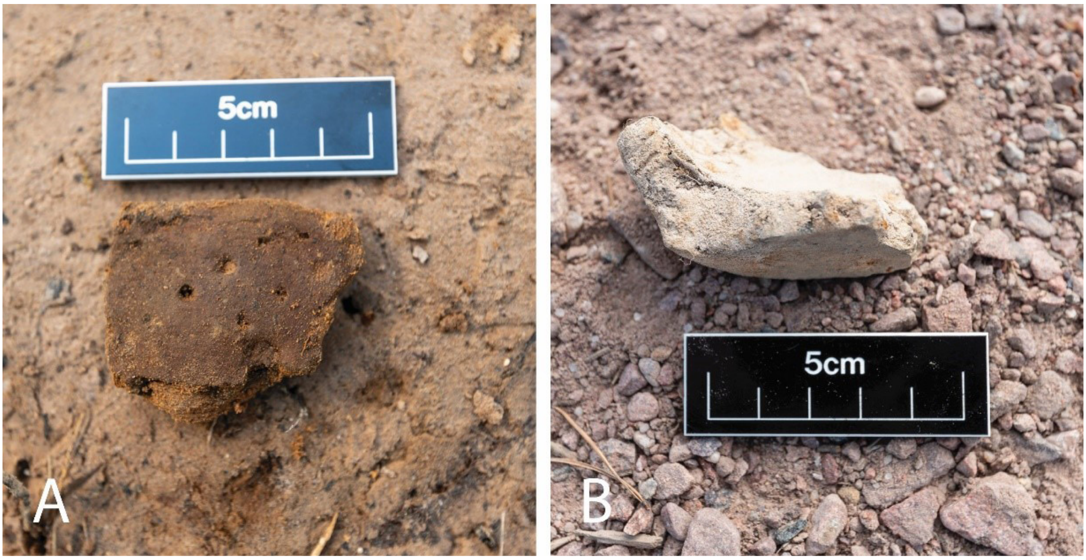

Figure 3. Kiukainen pottery from Kraakanmäki 3. A) decorated rim sherd (KM 43282:177) and B) undecorated sherd from a flat-bottomed vessel (KM 43282:395). Photos: V. Laulumaa.

ile and without decoration but based on the few decorated pieces and shape of the vessels (Fig. 3), they belong to the Late Neolithic Kiukainen Ware (2500–1800 calBC; Halinen 2015: 58).

The majority of bone fragments could not be identified within any taxon. However, 48 fragments were identified as seals (Phocidae), two more specifically to harp seal (*Phoca groenlandica*), and one fragment to Eurasian beaver (*Castor fiber*). Fish are represented by perch (*Perca fluviatilis*), pike (*Esox lucius*), common bream (*Abramis brama*), and some cyprinid (Cyprinidae) species. One unidentified bone fragment is probably from a grooved artefact (Nurminen 2022).

The lithic material consists of 2,320 pieces, 2,176 of them being quartz. Most of them were unmodified quartz flakes and fragments detached using the basic bipolar technique. Retouch was found on 136 quartz implements, 66 of them from the edges of broken tools. Different quartz tool types from the site consist of 64 scrapers or scraper fragments, six piercing or chisel tools, seven cutting tools as well as many tool fragments with too little remaining characteristics for an accurate tool-type definition. Many of the quartz implements without retouch or formal tool characteristics could also reveal use-wear, if they would have been studied with microscopy. Non-quartz lithic material consisted of 187 pieces of other stone types such as slate, schist, sandstone and porphyritic stone (Eranti 2022).

Quartz artefacts chosen for this study were collected from the site during the excavation. Implements that were tentatively recognised as tools were picked for the analysis, before they were handled or cleaned. These items were not touched with bare hands but put into zip-lock bags immediately after they were unearthed in the field.

Dating

The site is located 33 metres above sea level, suggesting the phase at the end of the Stone Age, around 4000 calBP. This is also supported by C14-dating from three pieces of burnt seal bones, which were dated to c. 4300–4000 calBP (Ua-74422, 74423, 74424; Laulumaa & Seppä 2022). See Table 1.

MATERIALS AND METHODS

In total 20 artefacts and flakes of quartz (18 pieces), quartzite (1) and porphyritic stone (1) were picked for the analyses at the excavations

Table 1. Radiocarbon dates of the Kraakanmäki 3 site. radiocarbon dates are calibrated with software program IOSACal: v0.4.0 using the IntCal20 atmospheric curve (Reimer et al. 2020).

Lab index	^{14}C age BP	Dated material	Species	calBC	%C	Collection no. (KM)
Ua-74422	3832±32	Burnt bone	Phoca groenlandica	2340–2203	68,2	43282:2639
Ua-74423	3770±32	Burnt bone	Phocidae	2278–2138	68,2	43282:2813
Ua-74424	3733±32	Burnt bone	Phocidae	2198–2043	68,2	43282:2848

(listed in Table 2). The selection criterion was that they were classified tentatively as scrapers. However, after cleaning the items, some were reclassified as retouched artefacts and flakes. As such, they cover only about 0.8% of the total number (2176 items) of quartz items detected at the excavation.

Microparticles

At the laboratory, the sand was removed from the items gently by hand with a wooden stick. As the items were still dusty and there was only a limited visibility on the surface, a stereomicroscopic examination was not made before the final cleaning of the objects. Instead, the implements were washed in a small amount of distilled water by using a soft brush. The liquid was divided into 5 ml Eppendorf tubes. The tubes were centrifuged 2500 rpm in 7 minutes, and the material just below the supernatant was pipetted on microscope slides for analysis. The slides were analysed with an Amscope 40X–1600X Advanced Professional Biological Research Kohler Compound Microscope and documented with a 10MP USB 3.0 camera. After that, the washed items were studied under Amscope SM-1TS/BS stereomicroscope with 90x zoom and a ring light for the remaining microresidues.

The hairs were identified after Tóth (2017) and Appleyard (1978) and feathers after Dove and Koch (2010), and further by comparing them to the reference collections of Fennoscandian mammals and birds. The phytoliths were analysed using standard procedures (Piperno 2006; ICPT 2019), and the morphologies were identified with the help of literature and by producing a comparative phytolith collection from modern local plants.

For evaluating the possible soil-derived contamination, three reference samples outside the settlement site and one sample from the cultural layer were analysed for microparticles.

Macroscopic use-wear analysis

The analysis applied in this study is defined as *macroscopic* or *low-power use-wear* analysis, based on the magnification of the microscope. Macroscopic use-wear analysis has been found to be an effective method for sharp-edged tools (Taipale 2012: 47). Round-edged tools in this analysis are simply classified as such, and further suggestions are made based on the residue analysis conducted. Overall features of the artefacts based on a general examination with the microscope and the naked eye were also documented. More accurate functional determinations of use-wear on quartz tools benefit from high-power microscopy (Knutsson 1988a; Sussman 1988), especially on round edged tools.

Moreover, environmental effects such as waterflow and a multitude of other types of phenomena can sometimes affect the edges of quartz tools in a way that is detrimental to use-wear analysis (Knutsson & Linde 1990). However, this natural wear should not be considered edge selective (Rankama & Kankaanpää 2011: 233). Every item in the analysis was inspected, keeping this in mind by scanning the artefacts on every edge and on every surface, to minimise environmental effects from influencing interpretations of the analysis.

All the microparticle and fibre analyses were conducted before the artefacts were again available for use-wear analysis. Before the use-wear analysis, all samples were cleaned with the standard tool-cleaning protocol used by the

Table 2. The studied artefacts with the identifications of microresidues, typo-technological tool types and use-wear marks by O. Eranti, T. Juhola and T. Kirkinen.

Catalogue nro [KM 43282:]	Hairs	Barbules	Plants	Tool type	Use-wear
548	Unidentified mammal			Platform core	no
572				Cutting implement	N/A
675				Scraper	N/A
802	Possibly red squirrel (*Sciurus vulgaris*), unidentified mammal			Cutting implement (includes edge used for scraping)	Hard use
804				Bipolar flake	N/A
941	Unidentified mammal or bird			Scraper	Slight hard use
1286	Two unidentified mammals			Scraper (retouched)	Hard use
1450	Eight hairs, possibly seals?		Plant cell structures	Scraper fragment	Slight hard use
1680				Scraper	N/A
1832		Two unidentified birds	*Elongate sinuate*	Scraper	Soft use
1881	Unidentified mammal	Unidentified bird		Cutting implement (includes edge used for scraping)	Soft use
1890				Scraper	N/A
1929				Scraper	N/A
1950	Unidentified mammal or bird			Scraper	Hard and soft use
1956				Flake fragment	N/A
2194		Waterfowl (Anseriformes), 4 unidentified birds		Scraper	Soft use
2241	Unidentified mammal			Scraper	Slight hard use
2247	Unidentified mammal		Plant cell structures	Scraper	Hard use
2258				Scraper	N/A
2335				Tool fragment	N/A

Archaeological Field Services of the Finnish Heritage Agency. This protocol includes brushing the finds with commercial toothbrushes in a bowl of warm water and drying them. After that, the samples were catalogued and stored in the collections of the Finnish Heritage Agency. This was done before the prospect of conducting the use-wear analysis by SEM (scanning electron microscope) or other HPA (high power microscopy) methods. The authors agree that this analysis would normally require HPA or SEM methods, but as the acquisition and transport of the artefacts from the collections to a laboratory with high-power microscopes could take many months to years, it was concluded that the time requirement for this operation would make timely publishing of this article too challenging. Because of this practical obstacle, a smaller low-power microscope was used, and the artefacts were analysed with the LPA (low power) method. It was concluded by the authors that, even as the LPA method is generally not preferable for this type of analysis, it at least marks a beginning.

The finds were analysed with Discovery Artisan 64 digital microscope with 600x zoom. Microscopic photos were taken and edited with Portable Capture Plus software. All artefacts were examined throughout and along all the edges with the microscope. Use-wear was identified from the microscopic view and classified into hard wear or soft wear, based on the experimental data on quartz from the main reference material of this analysis (Broadbent & Knutsson 1975; Knutsson 1988b). The classification method followed some useful Finnish macroscopic use-wear analyses by Rankama and Kankaanpää (2011) and Rankama (2002), that have been based on experimental quartz reference material (Broadbent & Knutsson 1975). The classification to hard and soft wear is based on the edge being sharper when used on a hard material and rounder when used on a softer material, when observed with the microscope.

Macroscopic use-wear analysis was conducted on the following quartz artefacts: KM 43282: 802 (unmodified flake), :1450 (scraper fragment), :1832 (scraper), :1881 (dull-edged tool/scraper), :2194 (cutting tool), :2247 (scraper), :2241 (thin-edged scraper), :1286 (scraper), :1950 (scraper), :941 (informal scraper), and :548 (platform core). The selection was based on the appearance of microresidues.

Reference samples

Three reference soil samples outside the settlement site area and one from the cultural layer in the excavation trench were studied for microparticles. The reference samples taken from the immediate vicinity of the settlement site area were taken from locations, where soil and elevation were similar to that of the settlement site area. The reference samples were taken from shovel test pits, at the same depth as the cultural layer of the excavation trench. The cultural layer sample represented a context that was darker than the surrounding area.

From each bag, a subsample of 50 g was separated. The samples were rinsed in a measuring glass by adding 50 g of distilled water several times. The water was sieved with a 0.125 mm sieve, and the accumulated material was divided in 15 ml conical centrifuge tubes. The tubes were centrifuged for 7 min at 2500 rpm by the TD4A-WS desk centrifuge. The samples were prepared for transmitted light microscope examination by pipetting the extracted material on microscope slides and by covering them with coverslips. The material was studied using Amscope 40X-1600X Advanced Professional Biological Research Kohler Compound Microscope with 100x - 400x magnification. The material was documented with Amscope 10MP USB3.0 camera. The microscopy was conducted in a microscope room. The contamination of samples by modern fibres was prevented by intensive cleaning of the surfaces and by taking control samples with a bowl filled with water.

RESULTS

Microresidues

Hairs and feathers

Mammalian guard and fine hair fragments, 16 in number, were detected on the residues of seven (possibly nine) items (KM 43282: 548, 802, 1286, 1450, 1881, 2241, 2247; possibly also :941 and :1950). The hairs were 0.14–3.2 mm in length, and as highly degraded, most of

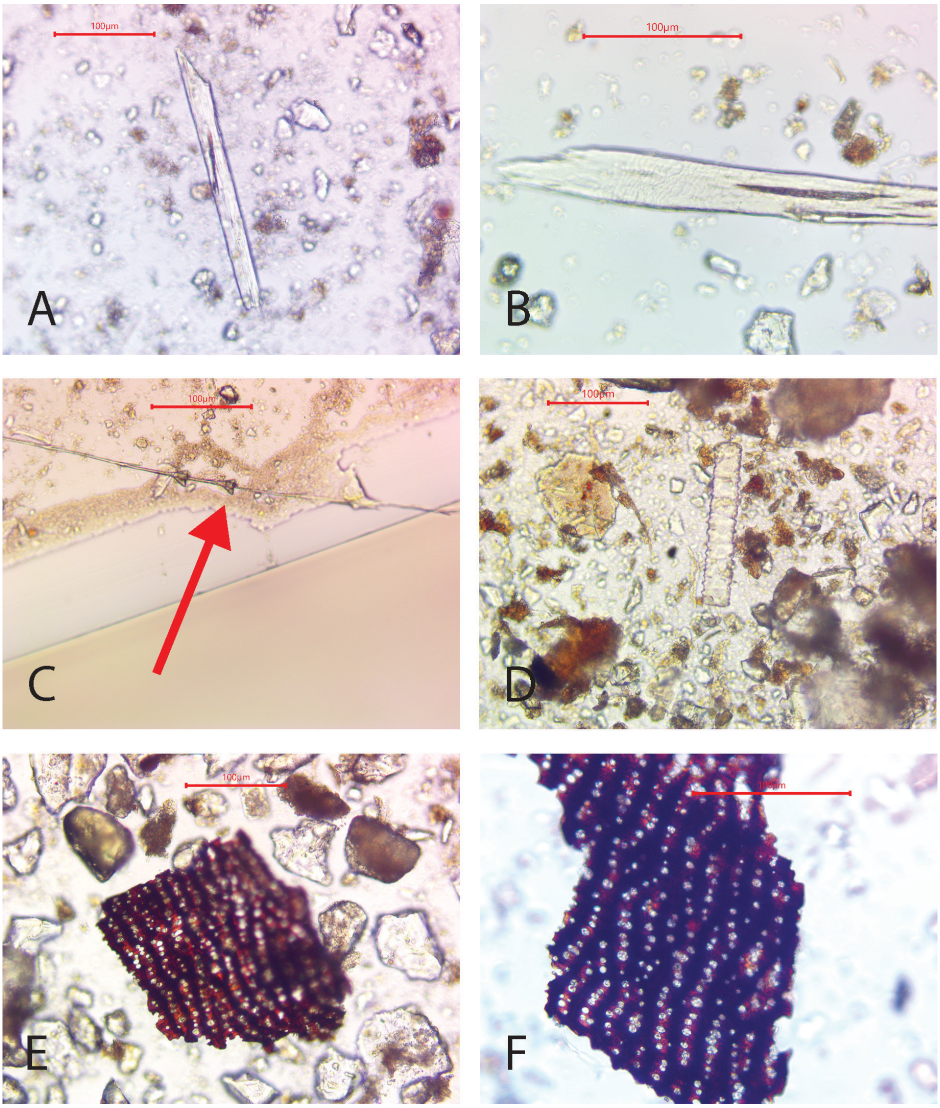

Figure 4. A) Possible seal hair with a diagonal cut (KM 43282:1450); B) unidentified mammal hair (:1286); C) waterfowl barbule (:1842); D) elongate sinuate phytolith (:1832); E) plant cell structure (:1450), a probable cut mark on top; F) plant cell structure (:2247). Photos: T. Kirkinen.

them were impossible to identify. Thus far, one possible red squirrel (*Sciurus vulgaris*) hair was detected on the residues of a bipolar flake (:802), and the fragments detected in contact of a scraper (:1450) originated probably from a seal. Most interestingly, the fragments showed diagonal cut-marks (Figs. 4A, 5A). The cut-marks are comparable with the ones that archaeologist Johanna Seppä produced in her experimental scraping of a cervid skin with a quartz tool (Fig. 5B). For the identifications, see Appendix 1. See also Kirkinen 2022.

In total, eight bird-down fragments, barbules, were detected on the residues of three quartz items, i.e., a bipolar flake (:1832, two barbules), a dull edged tool/scraper (:1881, one barbule) and a cutting tool (:2194, five barbules). The barbules were 0.51–0.74 mm in length. Only

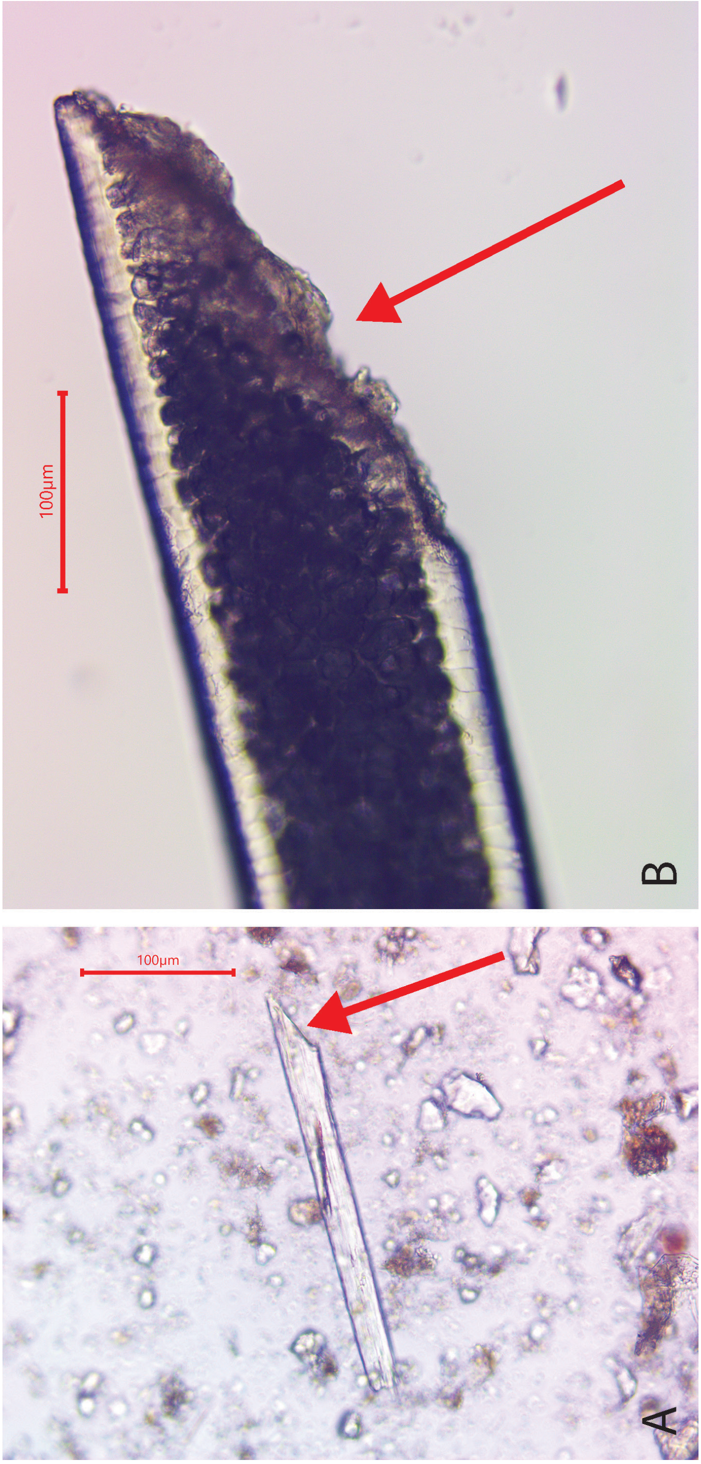

Figure 5. A) diagonal cut mark in a hair B) detected on the surface of a scraper fragment (KM 43282:1450) B) produced by experimental scraping of skin with a quartz scraper by archaeologist Johanna Seppä. Photos: T. Kirkinen.

one barbule was identified as a waterfowl (Anseriformes) by its triangular-shaped nodes and prongs at the distal end (Fig. 4C).

Phytoliths

The phytoliths recovered from the quartz tools were common species, such as the Elongate sinuate, indicating leaf epidermis, and identified from the residues of a quartz flake (:1832). This type of phytolith is present in several plant families, for instance Poaceae, Cyperaceae, Pinaceae, or Polypodiopsida.

On a quartz flake (:2247) and a quartz scraper (:1450), there was a thick crust of plant residue, consisting of microscopic pieces of plant cell structures, that had accumulated onto these stone tools. There was a probable cut mark on a cell structure on the latter tool (:1450) (Figs 4D-F).

Use-wear analysis

The use-edges were identified and classified based on different fracture types or rounded, dulled, and smoothed edge surfaces. Some tools showed very little macroscopically visible use-wear, others were considerably worn. Use-wear was found on all artefacts, except one platform core :548 made of porphyritic stone. Tools that did not show evidence of residues were excluded from the use-wear analysis. In the following, the items studied microscopically for use-wear evidence are divided into tools used on a hard or a soft material.

Tools used on a hard material

In the macroscopic use-wear analysis, six items in total were classified as having marks of hard material processing. Sharp-edged tool :802 (Appendix 2 Fig. 1) has step terminations on one side of the edge, and smaller hinge terminations on the other side (App. 2 Figs. A and B), suggesting use against a hard material. Scraper :2247 (App. 2 Fig. 2) has most likely been of limited use on a hard/medium material (App. 2 Fig. C). Scraper fragment :1450 has a small use edge remaining. Only slight wear is visible with the low-power microscope. Most likely it has been used on a hard material, based on small step fractures on the edge. Not enough marks were visible to determine the possible soft material wear. Scraper :2241 was used slightly against some hard material (App. 2 Figs. 3 and D), as was double-edged scraper :941 that also included some plausible soft wear that could not be confirmed at used magnifications (App. 2 Figs. 4 and E). Scraper :1286 includes a retouched edge that has been used against some hard material, resulting in small step and hinge scars along the use edge (App. 2 Figs. 5 and F).

Tools used on a soft material

Based on our analysis, four items were classified as having marks of soft material processing. On the scraper :1832 (App. 2 Figs. 6 and G), the edge is noticeably duller and feels smooth when handled. The edge is also round with no sharp protruding points. This item was most likely used extensively against soft material like animal skin. On the dull-edged tool :1881 (App. 2 Figs. 7 and H), the edge is robust, smooth on the surfaces and rounded. It has most likely been used against at least soft material, for example scraped or cut soft material like animal skin or meat. Also, it might have been used to work against hard material in its previous use-phase. Also, the dull-edged tool :2194 has a rounded and clearly dulled use edge. Most likely it has been used against soft material like animal skin. Scraper :1950 includes both slight hard use-wear and a clearly visible rounded and smoothed edge from soft use (App. 2 Figs. 8 and I).

Reference samples

Neither hairs nor bird feather fragments were found in soil samples. However, it is quite probable that hairs do exist in the settlement site layers but as they can be assumed to have been spread unevenly in different activity areas, it cannot be excluded that single hairs and barbules have been attached to the artefacts from the surrounding soils. A preliminary phytolith analysis was conducted from one of the reference samples and from one sample from the settlement-site area, and the results indicate open canopy with cold climate grasses (Juhola 2022).

DISCUSSION

The research of microparticles on the surfaces of quartz artefacts and flakes appeared to be successful; on 11 items out of 20 there were remains of organic materials such as hairs, barbules, phytoliths, and fragments of plant tissue. The items on which the organic remains were detected were mostly scrapers or cutting and scraping tools.

The strongest evidence of plant processing was discovered in the surface samples of a quartz flake (:2247) and a quartz scraper (:1450). The thick crust of plant matter and a probable cut mark on a cell structure suggest that plants were cut and scraped with these tools. Based on the use-wear analysis, small step and hinge fractures of the use edges in :2247 and :1450 indicate that the processing of plant matter was most likely done against a hard surface like wood. These wear marks also suggest that the tool edges were not heavily used.

It is worth noting that some quartz items may have been used in a multitude ways, and macroscopic use-wear analysis shows only a few of these. Some older use-wear marks can be obstructed by or completely removed by further use, remodification or retouch. Some plausible indicators of use against soft material were also detected from the use edge of scraper fragment :1450. Interestingly, eight possible hairs of seals with clear cut-marks were detected on this tool. However, SEM-imaging is required to confirm this hypothesis.

Wear marks on scraper :1832 include rounding and dulling of the use edge, resulting in a smooth and shiny finish of the edge. This supports the hypothesis that the tool was used on soft material like meat or skin. This is in line with the bird-feather barbules found on the item. Moreover, its smooth and thoroughly rounded edge would probably require a considerable amount of use to form. In addition, the wear marks on the dull-edged tool (:1881) show evidence of use on soft materials, which is in line with the animal hair and barbule detected on the artefact. Accordingly, the dull-edged tool :2194 also has a rounded and clearly smooth use-edge, which speaks for its use against soft materials. On this item, five barbules were found, including one waterfowl (Anseriformes) barbule.

The possible seal hair identified on the scraper fragment :1450 is in line with the seal bones identified at the settlement site osteological taxa, indicating that the seals were prepared and consumed at the site. Instead, bird-down fragments are interesting as their bones were not detected at the site and they are also generally quite rare in the osteological material of the sites (see Mannermaa 2008: 74). The barbules might be an evidence of the preparation of bird carcasses or skinning them to be used as a raw material for pouches, bags, and garments (e.g., Itkonen 1948: 299; Hatt & Taylor 1969).

The question of possible contamination was controlled by the careful handling of finds in the field as well as in the laboratory. In addition, the study of reference samples taken outside and inside the settlement site supports the hypothesis that at least most of the residues were remnants of actual past artefact use. Accordingly, it is possible that the quartz flake (:1832) had been used for cutting leaves, but it is also possible that there is contamination from the soil, because many elongate phytolith types were frequently present in a preliminary analysis of soil samples on the site (Juhola 2022). Although no hairs or bird-feather fragments were found in the reference sample taken inside the settlement site, it can be assumed that hairs and barbules have spread unevenly in different activity areas and that single hairs and barbules might have been attached to the artefacts from the surrounding soils, too. Especially the unidentified mammal hair on the surface sample of a platform core :548 with no use-wear marks can be interpreted as a contamination.

The interpretation of residues as functional remnants of past artefact use or as sediment-derived remnants would have been supported by an in-situ analysis of the items before washing them. In the in-situ analysis, the residues that are not clearly attached to the artefact can be verified to derive from the surrounding cultural layer in which all kinds of microremains of past activities might have been preserved (see e.g., Cnuts et al. 2022 and references therein). Therefore, we stress the importance of the in-situ analysis of residues prior to extraction in the future studies. However, our results are valuable both for understanding past human activities and for developing methods that meet the particular challenges posed by podzol soil sites.

CONCLUSIONS

The results of our combined microresidue and use-wear analysis provided evidence that microscopic organic materials can also be found on the surfaces of quartz items in Finnish podzol soil open-air settlement sites. The findings included animal hairs, bird-feather fragments, phytoliths, and plant tissues. Although only some plant remains were documented in this study, this experiment demonstrates the potential for analysis of plant remains on tool surfaces. Finnish archaeology can greatly benefit from the new data this kind of analysis may provide on prehistoric plant gathering and processing, plant foods and medicine.

The keratinous fibres detected on the items gave us detailed information on the use of quartz artefacts. Especially the number of bird barbules indicated the importance of birds as game animals, information of which was not present in the bone material. Also, the cut-marks in plant remains and possible seal hairs gave us minute evidence of skin and plant processing. Moreover, data from the use-wear analysis showed a clear difference of tools used either on hard or soft material. Most probably, this is in line with the different ways that plant- and animal-originated materials were prepared.

Finally, our research showed the importance of combined microresidue and use-wear analysis to gain new information on the preparation and use of plant and animal resources. The next step would be to select items for high magnification optical microscopy analyses to receive more detailed information of the distribution of microresidues. In the future, this kind of research requires careful handling of finds already in the field, i.e., avoiding any touching of finds by hands that might cause contamination. Additionally, the current protocol of cleaning the finds with a toothbrush should be reconsidered. This is because brushing removes residues and destroys valuable evidence. One possible solution is to archive a selection of uncleaned finds for further research.

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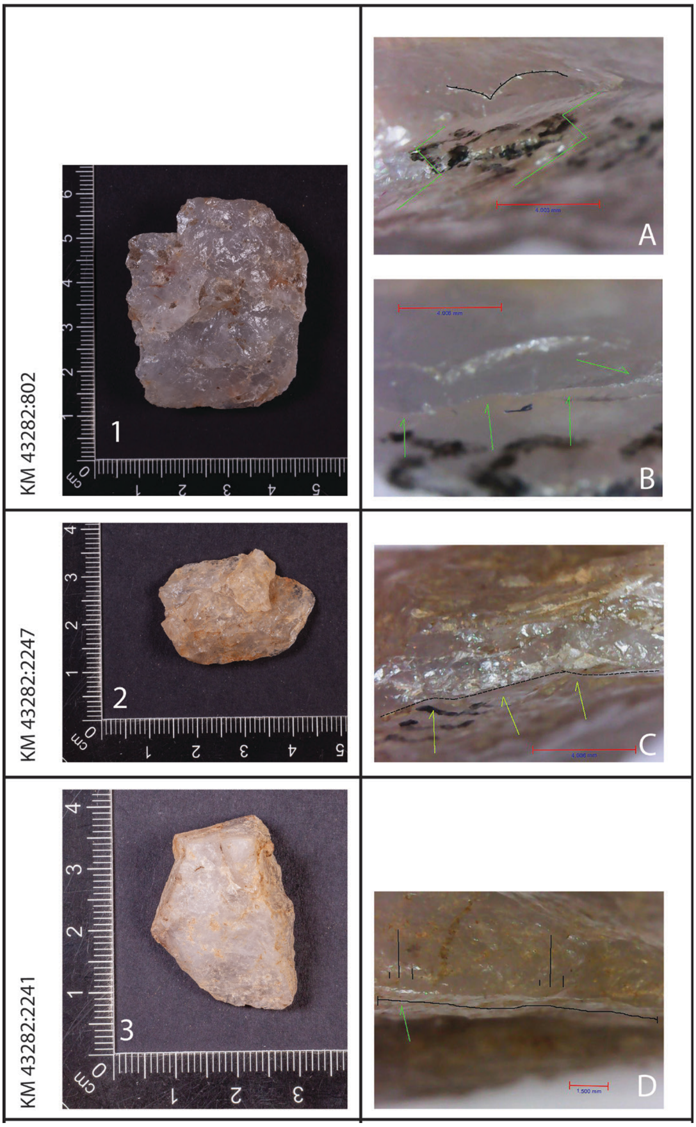
Appendix 1. Animal hair and feather identifications by T. Kirkinen.

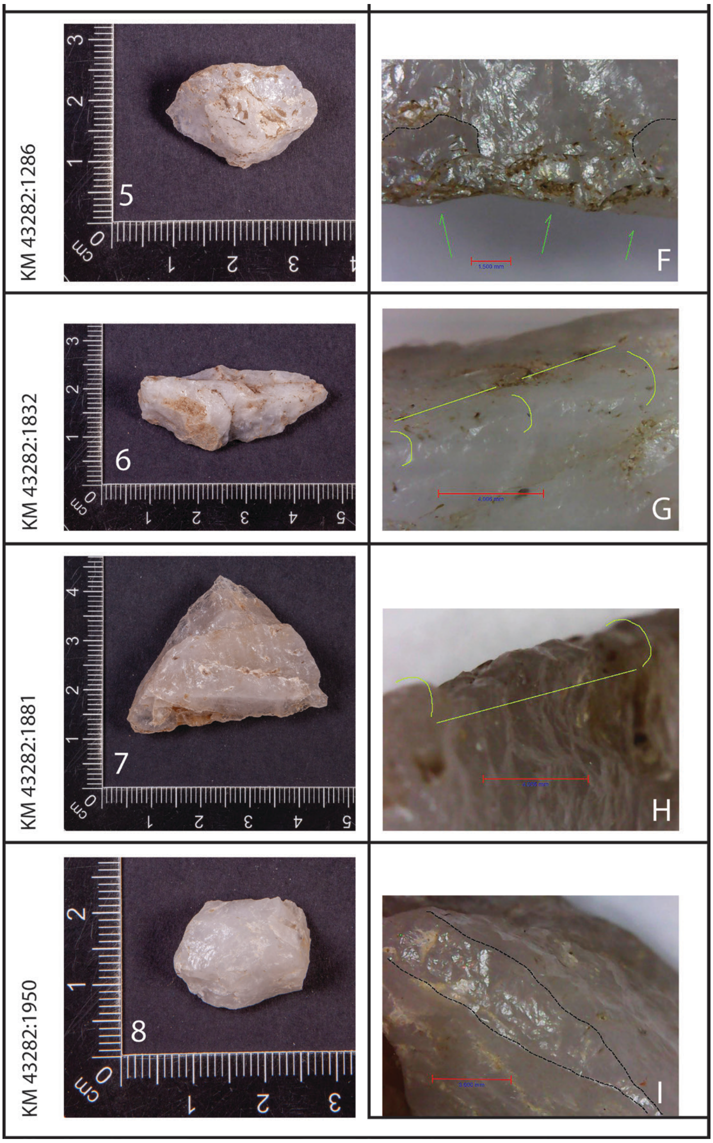
KM 43282	Species identification	Diagnostic features	Identification references
548: K1	Unidentified mammal (Mammalian)	Possibly highly degraded, cuticular scales strongly profiled, medulla uniserial/tubular. Width 16.8 µm, length 1.2 mm.	
802: K1	Possibly red squirrel (*Sciurus vulgaris*)	GH, tip section. Cuticular scales not preserved, medulla multiserial, medullar cells rounded. Width 17.7 µm, length 3.2 mm.	Tóth 2017, 132-133
802: K2	Unidentified mammal (Mammalian)	UH, cuticular scales strongly profiled, medulla empty. Width 10.7 µm, length 0.2 mm.	
941: K1	Possibly fibre	Highly degraded hair or feather fragment. Length 0.14 mm.	
1286: K1	Unidentified mammal (Mammalian)	GH, highly degraded, cuticular scales figureless waved, no medulla. Width 35.5 µm, length 1.2 mm.	
1286: K3	Unidentified mammal (Mammalian)	GH, degraded, cuticular scales irregular mosaic, medulla uniserial regular. Width 34 µm, length 0.8 mm.	
1450: K1	Unidentified mammal (Mammalian)	GH, highly degraded, fragment tip rounded. Cuticular scales not preserved, medullary canal hollowed out by fungi. Width 48.3 µm, length 0.48 mm.	
1450: K2	Possibly seal (Phocidae)	GH, highly degraded. Cuticular scales not preserved, no medulla. Width 130.8 µm, length 2.8 mm.	Reference collection
1450: K3	Unidentified mammal (Mammalian)	GH, highly degraded, fragment tip diagonally cut. Cuticular scales not preserved, no medulla. Width 26.9 µm, length 0.26 mm.	
1450: K4	Unidentified mammal (Mammalian)	GH, highly degraded. Cuticular scales not preserved, no medulla. Width 39.8 µm, length 0.26 mm.	

1450: K5	Unidentified mammal (Mammalian)	Highly degraded, fragment tip diagonally cut. Cuticular scales not preserved, no medulla. Width 16.8 µm, length 0.32 mm.	
1450: K6	Unidentified mammal (Mammalian)	Highly degraded, fragment tip diagonally cut. Cuticular scales not preserved, no medulla. Width 46.8 µm, length 0.63 mm.	
1450: K7	Unidentified mammal (Mammalian)	Highly degraded, fragment tip possibly cut. Cuticular scales not preserved, no medulla. Width 28.8 µm, length 0.32 mm.	
1450: K8	Unidentified mammal (Mammalian)	Highly degraded, fragment tip diagonally cut. Cuticular scales not preserved, no medulla. Width 36.8 µm, length 0.52 mm.	
1832: K1	Unidentified bird (Aves)	Barbule fragment with prongs at the distal end. Length 0.51 mm.	
1832: K2	Unidentified bird (Aves)	Barbule with prongs at the distal end. Length 0.74 mm.	
1881: K1	Unidentified bird (Aves)	Barbule with prongs at the distal end. Length 0.51 mm.	
1881: K2	Unidentified mammal (Mammalian)	Degraded, cuticular scales coronal, medulla uniserial. Width 18.3 µm, length 1.2 mm.	
1950: A1	Possibly fibre	Possibly highly degraded hair or feather fragment. Length 0.32 mm.	
2194: K1	Waterfowl (Anseriformes)	A plumulaceous barbule fragment with triangular-shaped nodes and prongs at the distal end. Length 0.5 mm.	Dove & Koch 2010
2194: K2	Unidentified bird (Aves)	Barbule with prongs at the distal end. Length 0.6 mm.	
2194: K3	Unidentified bird (Aves)	Barbule with prongs at the distal end. Length 0.54 mm.	
2194: K4	Unidentified bird (Aves)	Barbule with prongs at the distal end. Length 0.68 mm.	

2194: K5	Unidentified bird (Aves)	Barbule. Length 0.73 mm.	
2241: K1	Unidentified mammal (Mammalian)	Degraded, root section. Cuticular scales coronal, medulla uniserial/ tubular. Width 17.8 μm, length 1.6 mm.	
2247: K1	Unidentified mammal (Mammalian)	Highly degraded, cuticular scales not preserved, no medulla. Width 17.9 μm, length 0.9 mm.	

Appendix 2. Quartz artefacts and the macroscopic use-wear analysis by O. Eranti. Photos: O. Eranti and V. Laulumaa.




KM 43282:1286
5
F
KM 43282:1832
6
G
KM 43282:1881
7
H
KM 43282:1950
8
I