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Q14 How shattered flakes were used: Micro-wear analysis of quartz flake fragments

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A B S T R A C T

Prehistoric quartz assemblages have always posed a special problem for archaeologists. Due to its brittle nature, quartz is hard to understand within the lithic classification systems normally constructed based on formally varied flint assemblages. In this paper we explore how to get around this problem on the basis of two analytical domains, fracture analysis and use-wear analysis. A sample of 544 unmodified quartz flakes and flake fragments from Mesolithic and Neolithic sites in Sweden and Finland was analysed. It can be concluded that both whole and fragmented flakes were used as tools. The type of use was correlated to variation in edge qualities rather than the formal characteristics of flakes.

The results of this investigation will have major impact on the way quartz assemblages with low formal variation Q17 are approached in the future. To be able to make behavioural inferences from quartz assemblages, the materials have to be approached with a focus on functional types.

1. Introduction

Quartz, as a raw material for making sharp edged tools during prehistory, has long been poorly discussed in archaeological research. This is because of what Callahan (1987 in Driscoll 2010) described as the gravel effect — many quartz assemblages on first glance appear to be comprised of amorphous pieces, not easily recognised as humanly modified 'tools'. Recently we have, however, seen a rising interest in the subject as shown by a number of publications (see Driscoll, 2010, 2011 for an overview of research) and sessions arranged at international conferences. The importance of quartz to prehistoric toolmakers and users has on a worldwide basis started to be recognised within the archaeological community. The reasons for this vary, but originally it was simply the result of necessity. In some areas quartz was, if not the only, the dominant lithic component in prehistoric assemblages. This is true for Sweden and Finland where the assemblages discussed in this paper have been excavated.

Among lithic analysts it must have been the apparent irregularity of the fracturing of quartz that made studies such as attribute analysis seem futile in previous years (Callahan et al., 1992; Knutsson, 1998; Tallavaara et al., 2010). This problematic quality of most quartz assemblages is accompanied by the problem of identifying tool types traditionally defined by archaeologists as 'formal', i.e., retouched pieces (Lindgren, 2004). Furthermore, formal types are lacking in most quartz assemblages, which are dominated by flakes and flake fragments. The real difficulty is to identify the tools among the unretouched portion of the assemblage, and not just bracketing them off as 'debitage' or 'waste' (Knutsson, 1988). It is within the frame of this debate the present paper was developed. We will in our analysis focus on and merge two recently discussed and seemingly valuable analytical domains, fracture analysis (Callahan et al., 1992; Tallavaara et al., 2010) and functional analysis (Knutsson, 1988; Taipale et al., in press).

2. Materials and methods

2.1. Archaeological quartz data

The backbone of our data is formed by quartz assemblages from 21 archaeological sites from Sweden excavated between 2004 and 2010. These sites date to between 6700 and 2300 cal BC, covering the Late Mesolithic, Early Neolithic and Middle Neolithic periods (Ahlbäck and Isaksson, 2007; Björck and Hjärthner-Holdar, 2008; Guinard and Q18 Groop, 2007; Guinard and Vogel, 2006, 2007; Holm and Lindgren, Q19 2008; Knutsson, 2008a,b; Knutsson and Knutsson, 2009; Stenbäck, Q20 2007). In addition, quartz material from two Late Mesolithic sites from Finland was analysed (Pesonen and Tallavaara, 2006; Rankama and Kankaanpää, 2011; Taipale, 2012). The sites included in this study vary in size and complexity from what seemed to be small activity

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areas with around 100 flakes and flake fragments to larger sites with hearths, cooking pits and flaked quartz assemblages comprising up to c. 48,000 artefacts. Altogether 98,582 quartz artefacts were subjected to sampling for micro-wear and fracture analysis, and the total sample finally amounted to 544 pieces. The proportion of sampled flakes and flake fragments varied between 0.16% and 50% of the total assemblage of an individual site, mainly due to the variation in the absolute numbers of finds from the different sites.

Most of the analyses that contributed to this study were done for cultural resource management projects and therefore aimed at answering specific questions related to tool and site function. For this reason, instead of random sampling, the pieces that were most likely to show use-wear evidence were targeted in the sampling. The selection criteria were guided by earlier results as well as experimental work and relevant ethnographic data. The flakes and flake fragments were in general selected among the larger pieces in the assemblages since these were considered more likely to have served as tools (cf. Sandén, 1998). These criteria pose certain limitations to the representativeness of our sample and will have consequences for how far we can use the results in statements about the use of unmodified flakes and flake fragments in the past.

2.2. Fragment classification

The fragmentation of quartz flakes during knapping is caused by radial and bending fractures, and combinations of these can result in quite complex fragmentation patterns. The high rate of fragmentation can probably be explained by the raw material's relatively low tensile and compressive strength and its large number of internal flaws (Cotterell and Kamminga, 1990:129; Domanski et al., 1994; Tallavaara et al., 2010). As a result of experimental studies, Callahan et al. (1992) suggested that instead of being chaotic, the fragmentation of quartz follows certain rules of fracture mechanics of brittle solids and therefore is, to a certain degree, predictable. Building on their experimental results, they created a schematic classification system for quartz flake fragments (see Figs. 1 and 2) and further stated that the frequency distributions of fragment types vary systematically according to the knapping method (bipolar/platform on anvil/freehand platform) used.

Recently, Tallavaara et al. (2010) identified a central problem in the fracture analysis method: the predictability and distinctiveness of the fragment ‘profiles’ produced by different core reduction methods need to be tested statistically. Further variables to focus on were suggested: indenter hardness, flake dimensions, and individual knapping styles. Their work demonstrated that there is significant variation in fragmentation introduced by these variables. Driscoll's (2011) experimental work has also shown that variation in quartz raw material qualities also affects fragmentation, although to a limited extent.

Despite these issues, the recognition of the high rate of fragmentation in flakes is a prerequisite for the technological and functional analysis of quartz assemblages. Callahan et al.'s (1992) classification scheme also serves as a useful tool for distinguishing among different types of fragments observed in the assemblages (Fig. 1, Table 1; see also Rankama, 2002; Sandén, 1998; Tallavaara et al., 2010).

One of the key problems discussed in the literature (Driscoll, 2010 with refs.) and one of the goals of our study was to investigate whether there is a systematic relationship between the degree of fragmentation and the probability of the fragment being selected for use. Because differentiation among various fragment types (Callahan et al., 1992) is not always easy, we also wanted to design a simpler classification system that is based on the number of breaks observed on fragments. When flakes shatter during production, they fall into one, two or several pieces, where the number of break surfaces created is positively correlated to the degree of fragmentation. We thus determined the typical number of breaks for each fragment type, and then reclassified our material using break count categories (see Fig. 2) where a split flake (type B6, Fig. 1) has one break surface, a broken split flake (types B1 and B3, Fig. 1) has two such surfaces, etc. Basically, more breaks equal more right-angled edges, ultimately with four breaks representing a fragment with only right-angled edges.

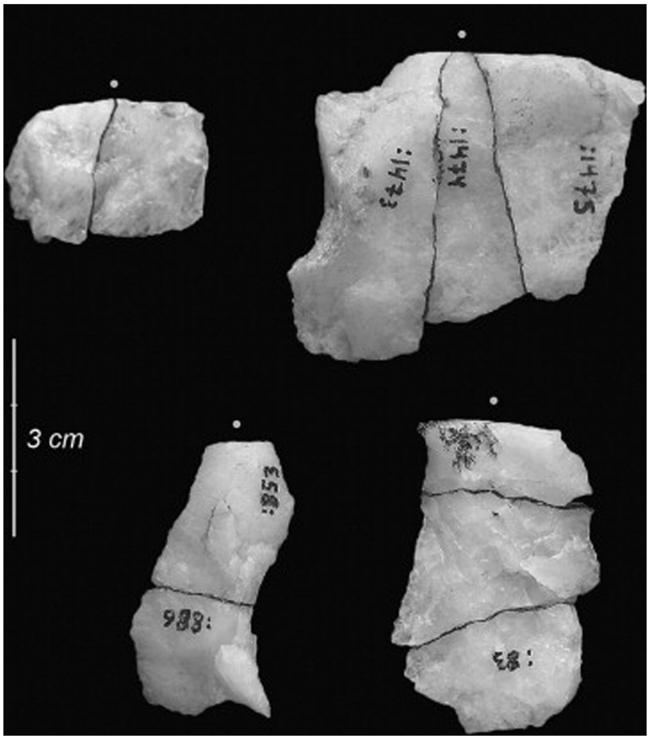

Fig. 1. Refitted or mended flakes from a prehistoric site in Finland. In the upper left a split flake and in the upper right a whole mended platform flake consisting of one middle fragment (type D2 see Fig. 2) and two side fragments (type A2). In the lower left a broken flake consisting of a proximal and distal fragment (types F1 and F3) and in the lower right a broken flake consisting of a proximal, a central and a distal fragment (types F1, F2 and F3). From Tallavaara et al., 2010, fig. 2.

In addition to the fragmentation classification, length and width were measured for each flake and flake fragment since previous functional analyses of flint assemblages have shown that size is one important selection criterion. Length was measured along the longest axis and width was measured perpendicular to length.

2.3. Micro-wear analysis and tool classification

The extensive experimental work done by Knutsson (1988a) has shown that wear forms on quartz tool edges as a result of use and that the characteristics of the microscopic traces vary systematically according to different use situations. The wear traces on quartz edges are easily visible with an incident light microscope equipped with Nomarski prisms at magnifications between 200× and 400× and can be defined in more detail using SEM with magnifications of 400–2000×. Processes like micro-fracturing, material fatigue, silica precipitation, dissolution, plastic deformation, polishing and phase transformation have been found to be important in wear formation. Different combinations of wear features seem to be systematically related not to the type of tool use, but to the variability in the characteristics of the worked materials and the related third body (i.e., the material created between the tool surface and the worked material, Knutsson, 1988a: 85ff).

Different types of linear features accompanied by edge wear in the form of rounding (micro-fracturing) (Fig. 3D and H) or plastic deformations (Fig. 3D) are typical of used quartz edges. The linear features can be formed as linear arrays of microscopic cracks, i.e., brittle fracture wear (striations) (Fig. 3E), or as a result of plastic deformations (sleeks and broad plastic deformations) (Figs. 3D and 7J) (Knutsson, 1988a). Polishes also occur, especially in the context of working silica-rich raw

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